Science and Mathematics Education Centre

The Effectiveness of Constructivist Teaching on Improving Learning Environments in Thai Secondary School Science Classrooms

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ABSTRACT

This study describes the first study conducted in Thailand that resulted in changes in science teachers' classroom environments. The aim of this study was to assess the effectiveness of constructivist teaching on improving learning environments in Thai secondary school science classrooms. The study involved three phases. First, the Constructivist Learning Environment Survey (CLES), an instrument for assessing students' perceptions of the actual and preferred classroom environment through the constructivist perspective, was validated for use in Thailand. Second, typical Thai secondary school science classrooms were described using quantitative and qualitative methods. Finally, the effectiveness of constructivist teaching on promoting improvement in classroom environments was evaluated through an action research process, involving the use of feedback on actual and preferred classroom environments. The sample consisted of seven secondary school science teachers and their 17 classes of 606 students in Nakornsawan Province, Thailand. Student Actual and Preferred Forms of the CLES, assessing Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation, were administered. Factor analysis and internal consistency reliability measures supported a five-factor structure for both actual and preferred forms. Students' attitudes to science were also measured. The actual and preferred environments of different classes were described based on profiles of classroom environment scores. The results suggested that the average classroom in this study had relatively high levels of student perceived actual Uncertainty, Student Negotiation, and Personal Relevance, but the levels of Shared Control and Critical Voice were consistently lower. On all five scales, students preferred a more favourable classroom environment than what they perceived as being actually present. Three teachers, selected from the original sample, then participated in an attempt to improve their classroom environments through the use of a constructivist teaching approach. Changes in classrooms did occur, thus supporting the effectiveness of constructivist teaching in improving classroom learning environments and students' attitudes towards science in Thailand.

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TABLE OF CONTENTS

CHAPTER 3 METHODOLOGY

CHAPTER 6 EFFECTIVENESS OF CONSTRUCTIVIST TEACHING ON IMPROVING LEARNING ENVIRONMENTS

LIST OF APPENDICIES 202

LIST OF FIGURES

Figure		Page

LIST OF TABLES

Table		Page

CHAPTER 1

INTRODUCTION

Today, to have a positive classroom environment is a valuable goal of education (Fraser, 2002). The curriculum of schools and universities should consist "not just of content and outcomes, but also of classrooms where the business of learning takes place" (Fraser, 2002, p.vii). Since 1997, constructivist teaching in Thai schools has increased during the age of Thai national education reform. However, in Thailand, there are no published reports on the effectiveness of constructivist teaching on improving learning environments in secondary school science classrooms. Therefore, this study is desirable in that it provides an initial insight into the effects of constructivist teaching on improving learning environments in Thai secondary school science classrooms.

1.1 BACKGROUND TO THE STUDY

At the global level, in 2000, UNESCO proposed a project named INSITE (Education Sector, UNESCO, 2003) to encourage countries around the world to provide science education for all people in order to let them have sufficient science knowledge to be able to live in happiness and safety in this age of globalization.

Similar to the UNESCO's goal, is a statement in section 81 of the Thai National Constitution B.E. 2540, on the on role of science, which states that; "The government must pay great attention to developing science and technology in order to develop the country" (p. 23). To reach such a goal requires strong development in science education.

In addition, the latest Thai National Education Act of B.E. 2542 (1999, p.12) section 22 states that:

> …Education shall be based on the principle that all learners are capable of learning and self-development, and are regarded as being most important. The teaching-learning process shall aim at enabling the learners to develop themselves at their own pace and to the best of their potential.

Furthermore, some parts of section 23 go on to note that Thai science education needs to focus on scientific and technological knowledge and skills, as well as knowledge, understanding and experience in management, conservation, and utilization of national resources and the environment, in a balanced and sustainable manner.

Although teaching and learning in Thailand, particularly in science classrooms, tries to follow the above important principles, there are still problems. The low quality of the provided education is one of the current critical problems in Thailand. Actual practices in classrooms have been dominated by teacher-centered and lecture-type instruction. One significant research study of the Thai Ministry of Education has shown that Thai students at grade 12 can pass only one of eight subjects in the examination with a score of more than 50% (Ministry of Education, 2000). So, it can be said that the quality of education in the upper secondary school level is low and should be improved, particularly in science and mathematics.

In order to overcome this critical problem, recent national education reform movements in Thailand have been grounded in a constructivist approach to learning. That is, students should find personal relevance in their studies, share control over their learning, feel free to express concerns about their learning, view science as ever changing, and interact with each other to improve comprehension (Taylor, Dawson, & Fraser, 1995a; Taylor, Fraser, & Fisher, 1997).

1.2 RATIONALE OF THE STUDY

This study is timely and valuable due to the importance of constructivist teaching in influencing classroom environments. It also adds needed research data on

constructivist teaching and its influence on students' perceptions of their classroom learning environments in Thai upper secondary school science classrooms. The study is desirable to provide an initial insight into the effects of constructivist teaching on improving these classrooms. Because of the critical needs in Thai education to develop science teaching and learning in all schools, especially at the upper secondary level, this research is also useful for showing ways in which teachers can use constructivist teaching to improve classroom environments in the hope of facilitating improved students' academic achievement, attitudes towards science learning activities and self-efficacy.

Constructivism has become a leading theoretical position in education and has become a powerful driving force in science education (Steffe & Gale, 1995; Tobin, 1993). The appeal of constructivism is that it provides a plausible, functional framework for understanding and interpreting experiences of learning and teaching. In this way, constructivism acts as a powerful theoretical referent "to build a classroom that maximizes student learning" (Tobin & Tippins, 1993, p.7). Furthermore, constructivism also has had a strong impact, internationally, on the educational field for over 20 years. In particular, science educators have been concerned with teaching strategies based on the notions of constructivism in an attempt to enhance students' conceptual understanding in science subjects. In many cases, these notions have been utilised as basic frameworks to reform traditional educational practices.

Fraser (1989a) noted that students spend a great amount of time (more than 15,000 hours) in the classroom environment. Therefore, he argued that the quality of the environment of these classrooms has a significant impact on students' learning. Classroom environments involve the shared perceptions of the students and teachers in a particular environment (Fraser, 1986). Although the concept of classroom environment is subtle, much progress has been made in conceptualising it, measuring and analysing it, and mapping its effects on students (Fraser, 1986, 1994, 1998a, 1998b). Studies have indicated that students' perceptions of their classroom learning environments affect students' cognitive and affective outcomes (Fraser, 1986, 1989b, 1994; Fraser & Fisher, 1982; Walberg, 1976). Also, students have been found to

achieve better in the types of classroom environments which they prefer (Fraser & Fisher, 1983a, 1983b).

Now international research efforts involving the conceptualization, assessment, and investigation of perceptions of social and psychological aspects of the classroom environment have firmly established classroom environment as a thriving field of study (Fraser, 1998b; Fraser & Walberg, 1991). For example, recent classroom environment research has focused on constructivist classroom environments (Aldridge, Taylor, Fraser & Chen, 2000; Lee & Fraser, 2001a), measuring culturally sensitive factors of classroom learning environments (Fisher & Waldrip, 2002), learning environments in technology-rich classrooms (Khine & Fisher, 2003; Zandvliet, 2002), and studies of learning environments in different countries (e.g., Khine & Fisher, 2002; Lee & Kim, 2002).

Much of the learning environment research over the last four decades has involved the development and use of instruments to assess the qualities of the science classroom learning environments from the perspective of the students (Fraser, 1986, 1994; Fraser & Walberg, 1991) and the association between learning environment variables and student outcomes, which has provided a particular rationale and focus for the use of learning environment instruments. In a meta-anlysis which examined 823 classes in eight subject areas and representing the perceptions of 17,805 students in four nations, Haertel, Walberg, and Haertel (1981) found enhanced student achievement in classes where students felt they had greater Cohesiveness, Satisfaction, and Goal Direction and less Disorganization and Friction. Other research studies in science classrooms have supported the exsistence of associations between classroom environment variables and student outcomes (Fraser, 1998b).

About 20 years ago, research involving science students' outcomes focussed primarily on educational objectives in the cognitive domain but, in more recent times, attention has been paid to outcomes in the affective domain (Weinburgh, 1995). Consequently, the study of student attitudes was one of the objectives of this study. Shulman and Tamir (1972) suggested that affective outcomes of education are at least as important as cognitive outcomes. Acknowledgement of the importance of

affective outcomes is also reflected in the increased emphasis of the affective domain in curricula (Gardner & Gauld, 1990; Hough & Piper, 1982).

Studies have also shown that learning environments in Asian countries such as Singapore, Brunei Darussalam, Korea, Taiwan and Indonesia, are accurate predictors of the quality of student learning (Aldrige & Fraser, 2000; Aldridge, Taylor, Fraser, & Chen, 2000; Fraser & Chionh, 2000; Goh & Fraser, 1998, 2000; Khine & Fisher, 2001, 2002; Lee & Fraser, 2001a, 2001b, 2002; Soerjaningsih, Fraser, & Aldrige, 2001a, 2001b). Not only have classroom environments been used as independent variables in predicting student outcomes, but they have also been used as dependent variables in numerous previous research applications, including the evaluation of educational innovations (Sinclair & Fraser, 2001; Teh & Fraser, 1994; Wooten, 1999).

Although much research has been conducted on students' perceptions of classroom learning environments, relatively little has been done to help teachers to improve the environments of their own classrooms (Fraser, 1986; Fraser & Deer 1983; Thorp, Burden, & Fraser, 1994; Yarrow, Millwater, & Fraser, 1997). It is not enough simply to inform teachers about their classroom environments. Teachers must take time to reflect on the feedback information, brainstorm ways to improve their environment, implement new techniques in their classrooms, and re-assess whether changes have occurred. Only with this information, support and desire can teachers be expected to change their teaching and classroom management techniques in order to improve their learning environments. So, it will be better for teachers to improve their own classroom environments by using constructivist teaching and action research with essential support, such as coaching.

Many research studies have shown the effectiveness of coaching. For example, coaching promotes changes in teachers' pedagogical practices (Showers & Joyce, 1996; Wolfe & Robbins, 1989), improves teachers' ability to plan and organize classroom activities (Koballa, 1992; Munro & Elliot, 1989), uses effective teaching behaviours (Showers, 1985), and enhances teachers' abilities to employ classroom behaviour management strategies (Pugach & Johnson, 1995; Vail, Tscantz, & Beviel, 1997).

Also, teachers need to do action research in their own classes. Action research offers participants a flexible approach to classroom improvement through actions and reflections. Lederman and Niess (1997) emphasise that action research is the most direct route to facilitating teachers' development into reflective practitioners, and that it helps them to become lifelong learners of pedagogy. The systematic collection of classroom data presents teachers with a view that could "catalyse" a change and facilitate informed decision making with regard to curricula and instructional issues.

Educators in Thailand also have been concerned with these constructivist notions in their quest to improve education. They can do this within government policies, since reforming teaching and learning with a constructivist approach was one of the key educational policies of the current Thai government. Consequently, it is very necessary for all schools and educational organizations, to enhance the quality of teaching and learning, to investigate the effectiveness of constructivist teaching and to improve classroom learning environments in Thailand.

In Thailand, there is a number of research studies reporting on important problems in science teaching and learning. Some of these are the reports from the Curriculum Development Centre of the Ministry of Education (1995) and the Office of the National Education Commission (1997). The Curriculum Development Centre (1995) summarized these problems indicating that almost all schools lacked skillful science teachers and materials for students' experimentation, used ineffective small-group learning activities, taught students inappropriate skills for using experimental instruments and so on. The National Education Commission (1997) noted that a teacher-centred approach was the most popular method for science teaching, in fact it could be said that the lecture was the main model of science teaching. Furthermore, the reports indicated that student science learning achievement was very low.

From 1999 to 2003, the strong current of the National Plan for Instructional Reform of Thailand (Office of the National Education Commission, 2003) and a large number of positive research results, based on classroom learning environments (Fraser 1998b) were significant pressures for all Rajabhat Institutes to improve students' learning environments especially in science classrooms.

It would be rare, however, for teachers to include classroom environment measures among their evaluation procedures. Typically, teachers concentrate exclusively on the assessment of academic achievement, and devote little attention to other factors that might be related to their students' performance.

With the needs of teachers to implement constructivist teaching in their classrooms, it is a critical time to improve the quality of teacher preparation (Darling-Hammond, 1996; Sinclair & Fraser, 1998a, 1998b). When approximately 120 graduate students from the curriculum and instruction stream — who were the students in the researcher's classrooms — were asked if they had heard of the term 'constructivist teaching' during their previous experiences, none were able to provide an accurate explanation or definition. Because the differential treatment of students within classrooms, whether intentional or not, could lead to different students' environmental perceptions, outcomes, attitudes, and self-esteem (Tobin & Malone, 1989), teacher education concerning constructivist teaching was an essential part of this study.

As teacher educators in Rajabhat Institutes, our mission is to help teachers improve their classroom environments to support student learning through inservice programs. This mission is reflected in the Thai educational policy in the current National Education Act (Office of the National Education Commission, Office of Prime Minister Kingdom of Thailand, 1999). This Act encourages teachers to change their style of teaching from teacher-centred to student-centred. So, one of the various effective ways to support the strong current of reforming students' learning in Thailand is that teachers of Rajabhat Institutes should help teachers improve their own classroom environments through providing inservice programs on strategies of using constructivist teaching, classroom learning environment instruments and teacher action research. Therefore, it was considered necessary to investigate the effectiveness of constructivist teaching on improving the learning environments in Thai secondary school science classrooms.

1.3 SIGNIFICANCE OF THE STUDY

This study is significant in that it is the first study conducted in Thailand that resulted in changes in science teachers' classroom environments. It is also significant as the first published article to report Asian science teachers' attempts to use learning environment assessments to guide improvements in their classroom environments. In more detail, this study is significant for four reasons. First, it is likely to provide credible findings specifically in Thailand based on teachers using constructivist teaching through action research processes to improve learning environments in secondary school science classrooms. Secondly, it is likely to provide data on the validity and reliability of the *Constructivist Learning Environment Survey* (CLES) questionnaire used for the first time in Thailand. Thirdly, it is likely to supply significant data to teachers, researchers, Rajabhat Institutes and other organizations which deal with the development of science teaching and curriculum to suggest concepts, ideas and directions for making choices or decisions in increasing the degree of using constructivist teaching and action research in the classroom. Finally, the results of the study could stimulate further studies, both in quantitative and qualitative research for in-depth studies of new research topics.

1.4 METHODOLOGY

1.4.1 Aim and Objectives of the Study

The overall aim of this research study was to determine whether teachers can use constructivist teaching through an action research process in order to improve their classroom environments. This study attempted to answer the following four research questions:

1. Is the Constructivist Learning Environment Survey (CLES) a valid and reliable questionnaire for use in Thailand?
2. What are students' perceptions of their actual and preferred learning environments from a constructivist perspective?
3. Are teachers able to make use of learners' responses to the CLES to improve their own classroom learning environments?

4. Does constructivist teaching improve students' attitudes towards science learning activities and self-efficacy?

1.4.2 Method of Data Collection and Interpretation

The methodology used to answer the research questions was a multi-method approach utilizing both quantitative and qualitative methods. Four measures were employed to obtain an understanding of students' perceptions of their constructivist science classroom learning environment: survey, interview, observation and case-study approach. In this study, the questionnaires provided quantitative data to answer the research questions. Classroom observations and student interviews were used in order to explain and clarify the quantitative data. This multi-method approach is explained in more detail in Chapter 3.

1.5 OVERVIEW OF THESIS

This study was divided into three phases, namely, the validation of the CLES in Thailand, the description of science classroom environments in Thailand, and the effectiveness of constructivist teaching on improving classroom environments. The organization of this thesis thus reflects these three distinct phases.

Chapter 2 provides a literature review relevant to the topic of this study and is composed of four major parts. The first part is about constructivism, the constructivist teacher and constructivist teaching, whereas the second part is about the historical background of educational environment research in assessing, describing and improving classroom environments. The two final parts are about the attitude questionnaire and research in Thailand on relationship among constructivist teaching, classroom learning environments and attitude outcomes.

Chapter 3 includes details of the overall methodology adopted for this research. The chapter includes a description of the research design, research instruments (the CLES and two scales of an attitude questionnaire: Attitudes to Science Learning Activities and Self-Efficacy), scoring procedures, data collection, data analysis and data interpretation for each of the three phases of the study.

Chapter 4 describes the validation of the classroom environment instrument for assessing Thai science classroom environments from a constructivist perspective — the Constructivist Learning Environment Survey (CLES). The sample of this study consisted of seven teachers and their 606 students in the upper level of secondary science classes in Nakornsawan Province. Actual and Preferred Forms of the CLES, were administered to assess Personal Relevance, Uncertainty, Critical Voice and Shared Control. This chapter reports the factor analysis, and the internal consistency reliability of the Actual and Preferred Forms of the CLES.

Chapter 5 describes typical science classroom environments, as identified by this study, in Thailand in the Nakornsawan Province setting. These actual and preferred classroom environments are based on both quantitative profile scores on the CLES and qualitative data collected by the researcher via classroom observations and student interviews. The comparisons between the average students' perceptions and preferences of each teacher are also described.

In Chapter 6, the effectiveness of constructivist teaching on promoting improvement in classroom environments was evaluated and described in terms of teachers' participation in action research processes involving the use of feedback on actual and preferred classroom environments. The participation of teachers in an attempt to use constructivist teaching to improve their classroom environments is also described. Furthermore, changes in the pretest and posttest scores of the attitude questionnaire were analysed to determine whether constructivist teaching can improve students' attitudes towards science learning activities and self-efficacy.

Finally, Chapter 7 provides an overview and summarises the major finding of the study. Limitations of this study, implications for science classroom teachers and teacher education, and suggestions for further research conclude this chapter. The suggestion of the possibilities of successfully implementing a constructivist teaching approach and the CLES in science classrooms in Thailand is also given in this Chapter.

CHAPTER 2

LITERATURE REVIEW

Internationally, constructivism has made a strong impact on the education for over 20 years. In particular, science educators have been concerned with adopting constructivist teaching strategies. Consequently, it can be said that constructivist teaching has become a significant innovation in science education in order to improve science classroom environments. Research also continues to suggest ways in which classroom teachers can be helped to engage in action research in attempts to improve their classroom environments (Fraser, 1998a, 1998b).

For this study, it was necessary to review literature concerning the implementation of constructivist teaching to improve students' perceptions of science classroom learning environments. This review is reported in this chapter which contains twelve sections. The first section is about the basic principles and implications of constructivism for learning and teaching. The second part describes the effectiveness of constructivist teaching, some well-known constructivist teaching models and strategies. The third and fourth parts describe a case study on using the constructivist teaching approach and summary of constructivist teaching. Following, in the fifth part, an historical background of educational environment research is provided. This part consists of the methodology for assessing classroom environments, classroom environment instruments, the Constructivist Learning Environment Survey (CLES), actual and preferred forms of classroom environments and class and personal forms. The sixth part is about past research on classroom environments, associations between student outcomes and the environment, and the evaluation of educational innovations. The seventh and eighth parts refer to literature on describing and

improving classroom environments. The ninth and tenth parts discuss the two scales of the Attitude Questionnaire (Attitude to Science Learning Activities and Self-Efficacy Scale) and research in Thailand on relationships among constructivist teaching, classroom learning environment and attitudinal outcomes. Finally, a concluding summary is provided.

2.1 CONSTRUCTIVISM

2.1.1 Basic Principles of Constructivism

Constructivism is described as consisting of two basic principles (Treagust, Duit, & Fraser, 1996), one psychological and the second epistemological, and stresses that knowledge cannot be separated from knowing. The first principle states that knowledge is not passively received, but is actively built up by the cognising subject. Ideas and thoughts cannot be communicated in the sense that meaning is packaged into words and "sent" to another who unpacks the meaning from the sentences. We cannot put ideas in students' heads; they will and must construct their own meaning. Our attempts at communication do not result in conveying meaning but rather our expression evokes meaning in another resulting in different meanings for each person. The second principle states that the function of cognition is adaptive and serves the organisation of the experimental world, not the discovery of ontological reality. Truth cannot be found. We can only construct viable explanations of our experiences. We have no 'God's eye' view of a real world, we can only know the world through our experiences.

2.1.2 Implications of Constructivism for Learning and Teaching

The constructivist view of learning has had a most noticeable influence on curriculum thinking in science since 1980 (Wubbels & Brekemans, 1997). This view has important consequences for the development of new teaching and learning approaches that focus on students' understanding of science rather than recall of facts and formulae. The constructivist approach to learning is based on the idea that the learner constructs his or her own knowledge through negotiation of meaning (Hand, Treagust, & Vance, 1997). Tobin and Tippins (1993) suggested that constructivism

has been used as a referent for building a classroom that maximises student learning. In such a classroom, the teacher takes account of what students know, maximises social interactions between learners so that they can negotiate meaning, and provides a variety of sensory experiences from which learning is built. Duit and Confrey (1996) noted the following five assumptions shared by mathematics and science educators for reorganising the curriculum and teaching to improve learning in school science and mathematics from a constructivist perspective: first, more emphasis is usually given to the applicability of science and mathematics knowledge in situations in which students are interested; second, introduction into the curriculum of issues of meta-knowledge about science and mathematics is needed; third, extinguishing students' everyday conceptions is impossible and inadvisable; fourth, constructivist approaches are student-centred; and, fifth, the norms and patterns of classroom interaction are a fundamental influence on the effectiveness of reform efforts. They also suggested that innovation processes could be implemented in terms of developing new media, including science textbooks, revising traditional content structures, and using a range of constructivist teaching strategies.

A very clear example of implications of constructivism for teaching and learning was provided in a study reported by Yager (1995). This study focused on the science, technology and society (STS) instructional approach and works through inservice and other training programs to introduce teachers to the constructivist approach in implementing reform. The research aim was to explore both teacher changes and student learning outcomes. In his study, Yager compared 133 teachers involved with the constructivist program with 48 teachers involved in another inservice training program, but not one using constructivist principles. Results indicated that teachers using constructivist principles had increases in teacher confidence, higher levels of using constructivist techniques, and more student-centered classrooms. In terms of student achievement, there were significant differences in 105 more traditional classrooms. The students in constructivist classrooms had a significant advantage over students in traditional classrooms in these domains: concept, process, application, creativity, attitude, and the world view domain. In other words, students had higher scores in all six of the domains that were tested.

Yager's work seems to demonstrate significant benefits to both teachers and students for the use of constructivist teaching. Teachers exhibited more confidence, while there were positive effects on students' learning outcomes. Yager's study is very credible because it worked with a larger population than other studies on constructivist teaching, and had the added benefit of a qualitative method. This is very significant and helpful in working with more traditional educators and school districts, demonstrating to them in a measurable fashion how constructivist teaching can improve both teaching and learning.

2.2 CONSTRUCTIVIST TEACHING

This section describes effectiveness of constructivist teaching, some constructivist teaching models and a number of strategies for constructivist teaching. There are various kinds of models of, and strategies for, constructivist teaching. The constructivist classroom is a child-centered classroom in which the past experience of the student is respected, and student experiences and student knowledge guide instruction. It requires the teacher to be flexible. The teacher acts as a facilitator, guiding students through experiences, helping students refine their thinking, and providing students with opportunities to construct meaning out of their experiences. Students are given opportunities to test their beliefs, and guided in incorporating the test results into their personal theories. The teachers provide many opportunities for dialogue so students can give words to their theories and connect new experiences and ideas to old ones. This section describes three important ideas on constructivist teaching: 1) effectiveness of constructivist teaching, 2) constructivist teaching models, and 3) strategies for constructivist teaching.

2.2.1 Effectiveness of Constructivist Teaching

The effectiveness of constructivist teaching can be explained in term of the influence of constructivism on education. Constructivism has become a leading theoretical position in education and has become a powerful driving force in science education (Steffe & Gale, 1995; Tobin, 1993). The appeal of constructivism is that it provides a plausible, functional framework for understanding and interpreting experiences of learning and teaching; in this way, constructivism acts as a powerful theoretical

referent "to build a classroom that maximizes student learning" (Tobin & Tippins, 1993, p. 7).

Constructivism has made a strong impact, internationally, on the educational-field for over 20 years. In particular, science educators have been concerned with teaching strategies based on the notions of constructivism in an attempt to enhance students' conceptual understanding in science subjects. In many cases, these notions have been utilised as basic frameworks to reform traditional educational practices.

2.2.2 Constructivist Teaching Models

2.2.2.1 Problem Learning Centred Model

Wheatley (1991) proposed a model of constructivist teaching using the problem-centred learning approach. Wheatley (1991) quotes Kozmetsky (1980) stating that "each student must be encouraged to build his/her own conceptual constructs that will permit the ordering of knowledge into useful problem solving schema" (p. 152). Wheatley proposed that the teacher's role is to "provide stimulating and motivational experiences through negotiation and act as a guide in the building of personalized schema" (p.14). This problem-centred learning approach has three components: tasks, groups, and sharing. Wheatley (1991) goes in to further detail on the selection of tasks based upon student prior knowledge and that the tasks should contain the following 10 attributes: 1) be accessible to everyone at the start; 2) invite students to make decisions; 3) encourage "what if" questions; 4) encourage students to use their own methods; 5) promote discussion and communication. 6) be replete with patterns; 7) lead somewhere; 8) have an element of surprise; 9) be enjoyable; and 10) be extendable.

Wheatley's (1991) problem-centred approach to learning is a simple and open-ended approach that many teachers already use or could adapt their current learning activities to fit within. The bonus of Wheatley's model is that the metacognitive skills used by students to understand how they solve problems may be compared with those used by others in the classroom.

2.2.2.2 Constructivist Teaching Sequence Model

Scott, Dyson, and Gater (1987) suggested that a constructivist teaching sequence could consist of three phases as follows:

Phase 1: Elicitation of ideas from students. The teaching commences with orientation or a question (involving exploring student ideas, discussing the differences among ideas of students, carrying out experiments, and trying to explain the observed phenomena). Students usually become aware of their own and others' points of view. This really sets the scene for the work to come by introducing the context of the study and hopefully raising interest in what is to follow.

Phase 2: Restructuring and application of ideas. During the restructuring phase, students' ideas can be clarified, challenged, and exchanged through discussion with others, or the teacher can promote conceptual conflict through the use of a disconfirming experiment or demonstration. Consequently, in this phase, students are given the opportunity to consolidate and reinforce new conceptions by using them in both familiar and novel situations.

Phase 3: Review of change in ideas. The students are invited to reflect on how their ideas have changed by drawing comparisons between their new thinking and their initial thinking at the start of the unit.

2.2.2.3 The Learning Cycle Model

The learning cycle approach has been proposed as a means to enhance conceptual change (Stepans, Dyche, & Beiswenger, 1988). There are three phases in this model, namely, *exploration, term introduction,* and *concept application.* Gallos, Treagust, and Berg (2001) have created six steps of teaching in science classes relevant to the leaning cycle model as follows:

1) Review, check previous days work and reteach if necessary,
2) Present new academic content or skills,
3) Provide initial but guided student practice and check for understanding,
4) Provide continual feedback and correctives,
5) Provide students with opportunities for independent practice and,
6) Conduct weekly and monthly reviews.

Steps one and two would be combined in the plenary lecture phase of the learning cycle which would include a short presentation of new information or a mini-lecture, after the teacher initiates a brief review or check on the last session activities. The second phase, which is known as the seatwork activity, consists of students working on problems, questions or activities with the teacher moving around the classroom, and should be implemented twice or more in an hour or one and a half-hour session. The seatwork activity is guided student practice (step 3) after which the teacher gives feedback and corrections (step 4). This is followed by independent practice by students through homework assignments (step 5). During the guided activity phase, the students would apply skills and hold discussions with other students, while continuing to receive assistance from the teacher who would monitor each group. In this learning cycle approach, the seatwork phase can be cyclical and incremental developing on the level of difficulty of lesson content. Finally, the teacher terminates the seatwork activity and conducts a closure of the entire academic exercise (step 4) or discusses the learning difficulties that students had encountered.

Stepans, Dyche and Beiswenger (1988) advocated that this model should focuse on four conditions for conceptual change to take place. There has to be dissatisfaction with existing ideas and the new conception must be intelligible, initially plausible, and fruitful.

2.2.2.4 Five Guiding Principles of Constructivism

Another model for constructivist teaching in science was created by Brooks and Brooks (1999). One of the most reader-friendly works entailing best practices for a constructivist classroom is the book written by Brooks and Brooks (1999), *A Case for the Constructivist Classroom.* They explain that the "constructivist vista…is far more panoramic and, therefore, elusive. Deep understanding, not initiative behaviour, is the goal… We look not for what students can repeat, but for what they can generate, demonstrate, and exhibit" (p. 16).

Brooks and Brooks (1999) have stated five guiding principles of constructivism. The first is to use the problems of relevance to students in instruction. The second is that learning be structured around primary concepts. The third is to value the students'

points of view. The fourth is to adapt the curriculum to address students' suppositions and the fifth is to assess students' learning in the context of teaching.

The following represents a summary of some suggested characteristics of a constructivist teacher (Brooks & Brooks, 1999, p. 103-118).

1) Become one of many resources that the student may learn from, not the primary source of information.
2) Engage students in experiences that challenge previous conceptions of their existing knowledge.
3) Allow student responses to drive lessons and seek elaboration of students' initial responses. Allow student some thinking time after posing questions.
4) Encourage the spirit of questioning by asking thoughtful, open-ended questions. Encourage thoughtful discussion among students.
5) Enquire about students' understandings of concepts before sharing their own understandings of these concepts.
6) Encourage students to engage in dialogue, both with the teacher and with one another.
7) Using cognitive terminology such as "classify," "analyze", and "create" when framing tasks.
8) Encourage and accept student autonomy and initiative. Be willing to let go of classroom control.
9) Engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion.
10) Using raw data and primary sources, along with manipulative, interactive physical materials.
11) Don't separate knowing from the process of finding out.
12) Insist on clear expression from students. When students can communicate their understanding, then they have truly learned.

2.2.2.5 Constructivist Learning Model

Yager (1991) also proposed a "Constructivist Learning Model" for use in science teaching. Yager suggested the following constructivist teaching procedures for science teachers:

1) Seek out and use student questions and ideas to guide lessons and whole instructional units.
2) Accept and encourage student initiation of ideas.
3) Promote student leadership, collaboration, location of information and taking actions as a result of the learning process.
4) Use student thinking, experiences and interests to drive lessons.
5) Encourage the use of alternative sources for information both from written materials and experts.
6) Use open-ended questions and encouraging students to expand on their questions and their responses.

7) Encourage students to suggest causes for event and situations and encourage them to predict consequences.
8) Encourage students to test their own ideas.
9) Seek out student ideas before presenting teacher ideas or before studying ideas from textbooks or other sources.
10) Encourage students to challenge each other's conceptualizations and ideas.
11) Use cooperative learning strategies that emphasise collaboration, respect individuality, and use division of labour tactics.
12) Encourage adequate time for reflection and analysis; respect and use all ideas that students generate.
13) Encourage self-analysis, collection of real evidence to support ideas and reformulation of ideas in light of new knowledge.

(p. 55-56)

Also offered by Yager (1991) are the following strategies for implementing a constructivist lesson.

1. *Starting the lesson:* 1) Observe surroundings for points of curiosity. 2) Ask questions. 3) Consider possible responses to questions. 4) Note unexpected phenomena. 5) Identify situations where student perceptions vary.
2. *Continuing the lesson*: 1) Engage in focused play. 2) Brainstorm possible alternatives. 3) Look for information. 4) Experiment with materials. 5) Observe a specific phenomenon. 6) Design a model. 7) Collect and organize data. 8) Employ problem-solving strategies.9) Select appropriate resources.10) Students discuss solutions with others. 11) Students design and conduct experiments. 12) Students evaluate and debate choices. 13) Define parameters of an investigation.
3. *Proposing explanation and solutions:* 1) Communicate information and ideas. 2) Construct and explain a model. 3) Construct a new explanation. 4) Review and critique solutions. 5) Assemble appropriate closure. 6) Integrate a solution with existing knowledge and experiences.
4. *Taking action:* 1) Make decisions. 2) Apply knowledge and skills. 3) Transfer knowledge and skills. 4) Share information and ideas. 5) Ask new questions. 6) Develop products and promote ideas. 7) Use models and ideas to illicit discussions and acceptance by others.

(p. 55)

He also noted that the above format of the constructivist lesson is not intended to be a rigid set of rules.

2.2.2.6 Five E Learning Cycle

The Biological Science Curriculum Study (BSCS), a team whose Principal Investigator is Roger Bybee (1997) developed an instructional model for constructivism, called the "Five Es".

This model suggests that a natural learning process contains five elements. The Five "E"'s are used and are: Engage, Explore, Explain, Elaborate and Evaluate.

1) *Engage*: This stage is designed to help students understand the learning task and make connections to past and present learning experiences. It should stimulate interest and prompt students to identify their own questions about the topic. Students explore the questions raised after they gain more understanding of the topic and the tools needed to investigate the ideas. Typical activities in this stage include posing a question, defining a problem, or demonstrating a discrepant event, then using small group discussions to stimulate and share ideas. Teachers help students connect previous knowledge to the new concepts introduced in the unit.
2) *Explore*: In the Exploration stage the students have the opportunity to get directly involved with phenomena and materials. Involving themselves in these activities they develop a grounding of experience with the phenomenon. As they work together in sharing and communicating. The teacher acts as a facilitator, providing materials and guiding the students' focus. The students' inquiry process drives the instruction during an exploration.
3) *Explain*: In this stage, students are encouraged to explain concepts in their own words, ask for evidence and clarification of their explanation, listen critically to one another's explanation and those of the teacher. At this stage teacher should provide definitions and explanations using students' previous experiences as a basis for this discussion. If students have unresolved questions, they may continue to look for solutions in the elaborate stage.
4) *Elaborate*: In the Elaborate stage, students expand on what they have learned and apply their newfound knowledge to a different situation. They test ideas more thoroughly and explore additional relationships. Providing

closure to the lesson and verifying student understanding is critical at this point.

5) *Evaluate*: The learning cycle provides opportunities for the teacher to continually observe students' knowledge and/or skills, application of new concepts and a change in thinking. Teacher asks students to assess their own learning. More formal evaluation can be conducted at this stage. The assessment should be aligned with the styles and content of the learning experience. Traditional assessments in the form of quizzes and ideas for alternative assessments such as using concept maps or having students create summary projects and reports. The multiple choice quizzes were designed and used primarily for assessing changes in student understanding as part of the evaluation of the materials.

2.2.3 Strategies for Constructivist Teaching

It can be seen that each of the constructivist teaching models provides a number of steps for the teaching process and these different steps or processes may use the same or different strategies for conducting constructivist learning activities. There are a number of strategies for constructivist teaching described by 231 teachers of the Collaborative for Excellence in Teacher Preparation (CETP) (2003). Following are some strategies for constructivist teaching, suggested by the CETP with their characteristics and ways of implementation:

1) *Oral Discussion:* Using a focus question, a teacher can elicit the ideas and theories of students in an open discussion. This discussion can begin with a "think, pair, share" by asking students to take five or ten minutes to think about their answer and jot down some notes, then to explain their answer to a partner and listen to the partner's ideas before opening the discussion to the whole class.
2) *KWL(H) Chart:* (What We **K**now. What we **W**ant to Know. What We Have **L**earned. **H**ow We Know It.) One way to start off a new topic is to ask students to list what they already know. This can be done as a whole class, but asking the students to respond first in small groups allows more children to participate and provides more time to think of ideas. Adding the "How we know it" allows the teacher to learn about the previous experiences of the students and how they think. The "What we want to know" engages the students in planning their own learning. The "What we have learned"

section helps brings closure at the end of the topic. The "How we how it"can help students reflect on a topic as it concludes.

3) *Mind Mapping* (concept mapping, webbing): Mind-mapping is the listing and organizing of concepts, ideas or things related to a particular topic. After brainstorming a list of words and phrases related to a topic, the students organize the words into groups and draw lines to show relationships between the groups.
4) *Hands–on Activities:* Hands-on activities, often called hands-on, minds-on activities, engage students investigating a concept or problem by using tools or manipulating objects. To assess these activities, a teacher may create a checklist list of the behaviors for which he or she is looking. Class discussions in which students reflect on the activity also provide insight into the way students are thinking.
5) *Paper and Pencil Pre-tests*: Using the objectives of the unit as a guide, develop a test. The Assessment Section of this handbook provides information about formulating questions. You can administer the test in the traditional fashion or you might give each student a slate or white board, asking the student to write the answers on the slate and hold it up. This gives a quick way to find out what students know. You can follow each question with discussion to allow students to describe how they determined the answer. To make this type of assessment a stronger part of the learning process, you may review the questions and answers with the students shortly after giving the test.
6) *Experimentation:* Design experiments that allow the students to test their theories. Since it may be necessary to conduct a variety of tests, small learning labs, or learning centres, can be set at which student can work individually. The class can meet later as a whole to discuss findings.
7) *Observation*: Collect data in an organized way about an occurrence. For example, when discussing the water cycle and evaporation, have students observe a puddle in the school yard. At regular intervals draw a chalk line around the edge of the puddle. Record the conditions. What was the weather? What was the temperature of the surface? Was the puddle in the sun or the shade? Repeat the exercise several times under different conditions and compare the results. Develop theories and then test those theories with further observations.
8) *Research:* Students research a topic. Research will provide the students with information from outside experts.
9) *Field Trips*: Seeing ideas and knowledge put to use in real-situations provides a context and value for learning. Speaking to people who use the skills and concepts in their daily work gives validity to the concept. Have students prepare questions to be asked during the field trip. After the field trip, conduct a class discussion of the findings.
10) *Films:* When it is impossible to visit a site, films can provide a virtual visit. Preview the film and prepare questions for your students to answer as they view the film. Present the film topic to

the students and ask them to prepare some questions that might be answered by the film. If there are a lot of questions, individual students can be assigned to answer just one or two. The results can be shared in a class discussion.

11) *Discovery:* The teacher presents the students with a variety of experiences on a topic and then, through discussion, links the experiences and provides the students with terms that help them to discuss their experiences. For example, the teacher might provide students with a variety of tools that use the principle of the lever. As students begin to explain how the tools work and what they have in common, the teacher can present the terms: load, effort, fulcrum, and lever. The students have discovered the concepts themselves. The teacher then presents the words for those concepts.
12) *Discrepant Event*: A discrepant event is one that seems to disobey the rules we have for the way things work. A discrepant event can be used to generate ideas about why the event happened the way it did. For example, pulling the table cloth out from beneath the dishes can be used to begin a discussion of inertia.
13) *Brainstorming and Testing*: Even though students have little understanding about a concept, they often have some experiences and ideas about the concept. Brainstorming can generate ideas about a concept that can then be organized and tested. For example, in brainstorming about clouds, students might connect clouds with rain. Through scientific observation the students can test that connection.
14) *Problems:* Students can be given a problem that uses the objective concept in its solution. For example, the students can be given the materials to create a lever and asked to lift a heavy weight with a lighter weight, or students might be given a set of data and asked to find patterns. After the students have shared their solutions, the teacher can guide the class in a discussion of the concept and present vocabulary that will facilitate the discussion.
15) *Graphic Organizers*: The teacher presents the students with a variety of pictures or words that will help the students understand a concept. Using Venn diagrams the student can organize the pictures. For example, if the concept is insects, the teacher might present a variety of animal pictures and ask the students to compare and contrast various characteristics using Venn diagrams.
16) *Investigation:* The teacher presents the student with an investigation in which the students change one of the variables in the situation, record the results, and draw conclusions. For example, the student might be asked to vary the height of a ramp, and compare the amount of effort needed to move an object up the ramp.
17) *Journals:* Journals are a good way to begin the process of reflection with students. Writing in a journal gives students time to think about their thinking. It is often a good way to start off a discussion or a *"think, pair, share."* Students can respond in journals to guiding questions or to scenarios. They can be asked to define a term or describe a concept with words and pictures.

18) *Discussion:* Discussion has been part of each of the strategies. It is very important that children be able to voice their ideas. A discussion can be started by asking students to reflect on a scenario in which the concept is presented in a new context. Students might be asked to write their ideas in a journal or just to think for two or three minutes about the idea, question or concept before beginning the discussion. In any discussion, the teacher must establish a guiding format that includes "wait time" and gives everybody the chance to present ideas. The discussion can be a *think-pair-share* activity.
19) *Role Playing:* Have students work in groups to respond to a real-world problem or task. Ask each person in the group to take on a specific role, for example, inventor, tour guide, parent, sales person, or business manager. In the role, each child explains how the concept product works. Students can be asked to include specific terms in their descriptions, and to define those terms if it is necessary for the audience that would be addressed by that type of person.
20) *Reports*: Reports help students organize information and make connections. The teacher must work with the students to establish guidelines and focus for the report. It is important that students understand exactly what is expected and what the product is to look like. As these guidelines are created, the class can also begin creating a scoring guide that describes what is satisfactory work for each element of the report.
21) *Presentations:* A presentation can be a secondary product of a report or an investigation. Doing reports in groups allows each report to be presented in more depth since the available time is divided into fewer parts. Guidelines and scoring guides need to include the roles of each of the group members.
22) *Skits:* Students can develop a skit in which group members take on the roles of specific community members as they address a problem related to the concept.
23) *Application:* Students can be asked to apply their new knowledge to a new problem. As they respond, they should not only provide a solution to the problem, but also describe how they arrived at the solution. This description will provide insight into the thinking of the student. For example, after studying airplane design, students might write a letter to an airplane manufacturer that describes a design that meets a specific need.

(adapted from CETP, 2003, p. 8-14)

2.3 A CASE STUDY ON USING THE CONSTRUCTIVIST TEACHING APPROACH

Appleton and Asoko (1996) provided a research report described how one teacher implemented constructivist teaching in an elementary science classroom. They used

the interpretive case study method to describe a teacher's implementation of constructivist teaching for a short period of time. The teacher in the study had participated in an in-service training session on the application of constructivist teaching and learning concepts in science teaching. The teacher attempted to implement some of these ideas in his classroom, but the implementation was affected by his own background, habits and understanding of constructivism.

In this case study, the teacher was expected to have a classroom that exhibited certain characteristics, including clearly defined conceptual goals, teaching strategies which develop the learner's prior knowledge, creation of an open classroom atmosphere, awareness of student opinions and concepts, and provision of various situations designed to enable students to produce new ideas.

After he had been trained in a 20-day in-service training program about constructivist teaching, he implemented this teaching strategy in a classroom of 27 ten-year old science students in a church school in a middle class urban area. Appleton acted as the participant observer in the study, helping students to learn and providing suggestions and support to the teacher. His observations showed that Robert, the teacher, could use many principles from the training experience for identifying his students' prior knowledge about the topic, for involving students in creating learning situations, and for helping students in developing science concepts. The authors also suggested that for the effective application of constructivist teaching in classrooms, teachers needed to have access and be experts in the subjects they teach in order to have enough understanding to help their students developed learning concepts.

2.4 SUMMARY OF CONSTRUCTIVIST TEACHING

In summary, the constructivist teaching approach reviewed suggest that there is a close relationship between constructivist teaching models and constructivist teaching strategies. There are various models for constructivist teaching that teachers are able to employ them in their classrooms. Furthermore, it is necessary for teachers to select constructivist teaching strategies that are relevant to the learning activities for each step in the teaching process. In the constructivist classroom, learning is a filter through which each student creates personal meaning through peer negotiation of the

sensory experiences that are provided. The teacher's role in this type of classroom changes from someone who typically provides information on a certain topic to someone who orchestrates the environment and provides opportunities for students to create meaning through active and relevant experiences. In a constructivist classroom, student questions and input are highly valued and encouraged, as opposed to a more traditional classroom where the existing curriculum (often a science textbook) dictates student learning.

It would appear that in many of these studies the creation of a good learning environment is important. Therefore, it was decided to examine the research on learning environments.

2.5 HISTORICAL BACKGROUND OF EDUCATIONAL ENVIRONMENT RESEARCH

The study of learning environments, in part, is dedicated "to conceptualizing, assessing, and investigating what happens to students during their schooling" (Fraser & Fisher, 1994, p. 23). Literature reviews (Fraser, 1986, 1994, 1997; Fraser & Walberg, 1991) show that science education researchers have led the world in the field of classroom environment for about 30 years, and that this field has contributed much to understanding and improving science education. For example, classroom environment assessments provide a means of monitoring, evaluating and improving science teaching and curriculum. A key to improving student achievement and attitudes is to create learning environments which emphasise those characteristics which have been found to be linked empirically with student outcomes. As well, the use of appropriate classroom environment scales has the potential to contribute to our understanding of why science classes typically result in greater success and positive students' attitudes and self-efficacy towards the learning activities.

This section describes the methodology for assessing classroom environments, various existing instruments used to measure classroom environments, particularly the Constructivist Learning Environment Survey (Taylor, 1991) which pertains most to this study. Differences between 'actual' forms and 'preferred' forms are also

described. As well, the differences between 'class' and 'personal' forms for assessing classroom environments are discussed.

2.5.1 Methodology for Assessing Classroom Environments

Three distinct approaches for assessing and studying learning environments may be identified (Fraser & Walberg, 1991):

1) One of these includes techniques of naturalistic inquiry or case study, in which outside researchers record qualitative data involving occurrences in the classroom and also conduct interviews. Stake and Easley (1978) provide in-depth descriptions of naturalistic classroom settings in '*Case Studies in Science Education'*. The present study includes three case study analyses of teachers, their students, and their attempts to change their classroom environments.
2) The second approach includes both private or consensual beta press which focus on students and/or teacher perceptions of psychosocial factors in a classroom. This has the advantage of characterising the classroom through the eyes of the actual participants. The present study used students' perceptions using the Actual and Preferred Forms of the CLES (Taylor, 1991) to assess the constructivist classroom learning environments.
3) Interaction analysis has also been used and this involves observation and systematic coding of classroom communication events according to some category system (Brophy & Good, 1986; Dunkin & Biddle, 1974; Peterson & Walberg, 1976).

Other studies in the field of learning environment research employed several different methodologies such as survey (perceptual measurement), interview, observation and case study (Fraser, 1994). These approaches are described in the following sections.

2.5.1.1 Survey

A survey (perceptual measurement) typically involves gathering data at a particular setting and time with the intention of describing the nature of a certain phenomenon,

through well-defined stages (Cohen, Manion, & Morrison, 2000). In a survey, normally large numbers of people are involved to enhance the representation of the target population via rigorous sampling procedures and statistical analysis. So, the main aim of a survey is to get a broad picture of a certain situation.

Perceptual measures have several advantages. First, survey instruments are more economical than classroom observation techniques, which require trained outside observers. Second, student perceptions of class climate characteristics are more credible in describing student outcomes than are inferences made by trained observers. This is so because the presence of an outside observer can influence the teacher's behavior in the classroom. Third, perceptual measures are based on students' experiences in many classes, rather than a small sampling of observed classes. Lastly, observation methods can involve the view of a single observer, where as perception measures provide joined judgements of all students (Fraser, 1994).

In a survey, the use of questionnaires is one of the more frequent methods for the research of classroom environments. In the present study, a survey with the CLES questionnaire was used for assessing science classroom environments in Thailand with the idea of improving constructivist classroom environments.

2.5.1.2 Interviews in Learning Environment Studies

An interview is defined as a specialized form of communication between people for a specific purpose associated with some agreed subject matter. Thus, the interview is a highly purposeful task which goes beyond mere conversation. The interview format may be unstructured, semi-structured or structured. Interview methods have also been reported as useful tools in studies dealing with learning environment. The types of interview reported in this field are often complementary to the perceptual measurement using a questionnaire.

In the present study, during the early stage, interviews were used in order to check the questionnaires (such as confirming the interpretive validity in the process of translation). Later on, the researcher utilized the interview as one of the main tools in this study and integrated the results with the findings from the other approaches that were used.

2.5.1.3 Observation in the Field of Learning Environment Research

Classroom observations have been widely used in educational research and can be used to validate other sources of data. When multiple methodologies are used, observation is often used with interviews in studies dealing with learning environments. Observation is considered as a method that can capture the vivid dynamics of the target. There are two main approaches to observations: structured and unstructured. In the structured approach, schedules or coding systems are systematically planned before the researcher approaches the setting. This information may be analysed in a quantitative manner. In contrast, in the unstructured approach the researcher observes the situation as it emerges as much as possible. An unstructured approach is often used by ethnographers and referred to as 'participant observation'. In this study, it was decided that unstructured observation was the most appropriate method to use.

2.5.1.4 Case Study

Definition

Case study is a familiar term, but there is little agreement on what exactly constitutes a case study (Merriam, 1988). A case study is a holistic research method that uses multiple sources of evidence to analyze or evaluate a specific phenomenon or instance (Anderson & Arsenaut, 1998). Most case study research is interpretive and seeks to bring a case to life. It often, but not exclusively, occurs in a natural setting and it may employ qualitative and/or quantitative methods and measures (Anderson & Arsenaut, 1998). Generally, case studies are a useful way to systematically look at a specific case, collect data, analyze and interpret findings within their context and report results. The emphasis is on understanding and no value stance is assumed. Case study research is highly data based and strives for the same degree of reliability and validity as any good research.

In this present study, the researcher used the case study method to answer the third and fourth research questions which were: 1) Are teachers able to make use of learners' responses to the CLES to improve their own classroom learning environments? and 2) Does constructivist teaching improve students' attitudes towards science learning activities and self-efficacy?

Several case study definitions exist and they vary in their degree of detail. Stake (1996), an education evaluation expert, succinctly stated that "as a form of research, case study is defined by interest in individual cases, not by the methods of inquiry used" (p. 236). A more elaborate definition of case study comes from Yin (1994), an experimental psychologist. His two-part technical definition reads as follows:

1. A case study is an empirical inquiry that
    - investigates a contemporary phenomenon within its real-life context, especially when
    - the boundaries between phenomenon and context are not clearly evident.
2. The case study inquiry
    - copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result
    - relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
    - benefits from the prior development of theoretical propositions to guide data collection and analysis (p. 3).

Procedure

From the definitions of case study above, it can be seen that the case study method is not easy for the researcher to employ because it requires: selecting a type of case study; establishing boundaries for the case; the knowledge and ability to collect data skillfully from multiple sources; the capacity to interpret, synthesize and recast information during data collection; and expertise to triangulate multiple sources of information and place the findings into a context, supported by prior theoretical knowledge, which will enhance understanding.

According to Anderson and Arsenaut (1998), a case study should be made up of six steps as follows:

1. *Selecting a Case Study*When selecting a case the researcher may first want to consider whether the case is intrinsic, instrumental, or collective (Stake, 1996). Intrinsic studies are used to gain a better understanding of a specific case, whereas instrumental case study helps refine theory or provide insight into an issue. Finally, collective case studies examine a number of cases jointly to seek understanding of a population.
2. *Sources of Data*
   In conducting case studies, one often uses seven sources of evidence: documentation, file data, interviews, site visits, direct

observation, participant observation and physical artifacts. As with all research methods, the case study researcher must maintain meticulous field notes and record all types of data collected.

3. *Instrument*
   To maximize the findings in a case study, the researcher needs to incorporate a full range of formal and informal instruments, from questionnaires to observation schedules.
4. *Data collection*
   As in any methodology, one should have a work-plan that defines what will be done, who will do it, when it will be done, and how. However, as case study research often involves extensive field work, one must remain flexible and be prepared to add or alter opportunities to collect data from new sources.
5. *Data Analysis*
   Generally, there are two approaches to analyzing the data. One approach is to use an analytical strategy which takes the literature and theoretical background of the case and uses it as an organizational framework. The second approach, the qualitative research approach, organizes the data into descriptive themes that emerged during the data collection and preliminary analysis.
6. *Reporting*
   In reporting the case study, a great deal of multiple-source evidence must be organized, reduced and only the most salient, descriptive examples reported. The content of the report and the presentation format will depend largely on the purpose of the study.

(p. 154-159)

2.5.1.5 Multiple Methodologies

The notion of multiple methodologies has been elaborated in the field of social science, including education and the terms triangulation or crystallization have been used (Cohen, Manion, & Morrison, 2000; Howe, 1988). These writers claim that a social situation can be represented well when several methods are used in a cooperative manner.

The present study was conducted, relying on the concept of mixed (combined) methodologies, in order to answer four different research questions. These four research questions contributed to an explanation of the effectiveness of constructivist teaching to improve learning environments in Thai secondary school science classrooms. This approach is in keeping with the suggestions given by previous researchers (Kim, Fisher, & Fraser, 1999; Lee & Fraser, 2001a; Sinclair & Fraser,

2001). These researchers used various kinds of classroom environment instruments in their studies.

2. 5. 2 Classroom Environment Instruments

Several different instruments have been devised for assessing classroom environments (Fraser, 1998a). Examples of classroom environment instruments include: the *Learning Environment Inventory* (LEI) (Fraser, Anderson, & Walberg 1982; Walberg & Anderson, 1968), the *Classroom Environment Scale* (CES) (Hirata & Sako, 1998; Moos & Trickett, 1987), the *Individualised Classroom Environment Questionnaire* (ICEQ) (Asghar & Fraser, 1995; Rentoul & Fraser, 1979), the *My Class Inventory* (MCI) (Fisher & Fraser, 1981; Sinclair & Fraser, 2001), the *College and University Classroom Environment Inventory* (CUCEI) (Fraser & Treagust, 1986; Nair & Fisher, 2001), the *Questionnaire on Teacher interaction* (QTI) (Wubbles & Brekelmans, 1997; Wubbels & Levy, 1993), the *Science Laboratory Environment Inventory* (SLEI) (Fraser & McRobbie, 1995; Fisher, Henderson, & Fraser, 1997), the *Constructivist Learning Environment Survey* (CLES) (Taylor, Dawson, & Fraser, 1995a; Taylor, Fraser, & Fisher, 1997) and the *What Is Happening In This Class* (WIHIC) (Chionh & Fraser, 1998; Fraser, Fisher, & McRobbie, 1996).

An overview of questionnaires and their constituent scales for nine classroom learning environment instruments below is presented in Table 2.1 (Fraser, 1998b). In addition to the name of each scale in the nine instruments, Table 2.1 also shows the level (primary, secondary, higher education) for which each instrument is suited, the number of each items contained in each scale, and the classification of each scale according to Moos' (1974) scheme for classifying human environments. The instruments that have been used in studies of learning environments often are related to the theoretical framework for human environments proposed by Moos (1974), in clinical and family therapy, who identified three sets of broad dimensions.

Table 2.1

Overview of Scales Contained in Nine Classroom Environment Instruments (LEI, CES, ICEQ, MCI, CUCEI, QTI, SLEI, CLES and WIHIC)

			Scales Classified According to Moos's Scheme		
Instrument	Level	Items per scale	Relationship dimensions	Personal development dimensions	System maintenance and change dimensions
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal Direction Disorganisation Democracy
Classroom Environment Scale (CES)	Secondary	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order and Organisation Rule Clarity Teacher Control Innovation
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalisation Participation	Independence Investigation	Differentiation
My Class Inventory (MCI)	Elementary	6--9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
College and University Classroom Environment Inventory (CUCEI)	Higher Education	7	Personalisation Involvement Student Cohesiveness Satisfaction	Task Orientation	Innovation Individualisation
Questionnaire on Teacher Interaction (QTI)	Secondary/Primary	8--10	Helpful/Friendly Understanding Dissatisfied Admonishing		Leadership Student Responsibility and Freedom Uncertain Strict
Science Laboratory Environment Inventory (SLEI)	Upper Secondary/ Higher Education	7	Student Cohesiveness	Open-Endedness Integration	Rule Clarity Material Environment
Constructivist Learning Environment Survey (CLES)	Secondary	7	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation
What Is Happening In This Classroom (WIHIC)	Secondary	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity

(Fraser, 1998a, p. 10)

Moos' three basic types of dimensions are *1) Relationship Dimensions* which identify the nature and intensity of personal relationships within the environment and assess the extent to which people are involved in the environment and support and

help each other, such as focuses on the connection of school science to students' out-of-school experiences, and with making use of students' everyday experiences as a meaningful context for the development of students' scientific knowledge); 2) *Personal Development Dimensions* which asses basic directions along with personal growth and self-enhancement tend to occur, such as to examine the extent to which a social climate has been established in which students feel that it is legitimate and beneficial to question the teacher's pedagogical plans and methods, and to express concerns about any impediments to their learning; and 3) *System Maintenance and System Change Dimensions* which involves the extent to which the environment is orderly, clear in expectations, maintains control and responsive to change, such as to assess the extent to which opportunities exist for students to explain and justify to other students their newly developing ideas, to listen attentively and reflect on the viability of other students' ideas and, subsequently, to reflect self-critically on the viability of their own ideas.

Studies which built on Lewin's (1936) influential field theory and Walberg's (1981) theory of educational productivity found that students' perceptions of the classroom psychosocial environment as measured by these questionnaires are associated with, and actually could predict, their affective, behavioural and cognitive learning (Fraser, 1986, 1994; Fraser & Fisher, 1982a; Haertel, Walberg, & Haertel, 1981).

For school–level environment, one often-used instrument is the *School Level Environment Questionnaire* (Fraser & Fisher, 1986), although the *Work Environment Scale* (Moos, 1974), which was designed for any work milieu, also has been adapted to use for assessing school learning environment.

2. 5. 3 Constructivist Learning Environment Survey (CLES)

2.5.3.1 Basic concepts

The Constructivist Learning Environment Survey (CLES) was developed based on constructivist philosophy which has had a major impact on science education for over 20 years. According to the constructivist view, meaningful learning is a cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed, and this sense-making process

involves active negotiation and consensus building. The CLES (Taylor, Fraser, & Fisher, 1997) was developed to assist researchers and teachers to assess the degree to which a particular classroom's environment is consistent with a constructivist epistemology, and to assist teachers to reflect on their epistemological assumptions and reshape their teaching practice. Initially, Taylor (1991) constructed this instrument based on social and personal notions of constructivism whose main concerns are to enhance students' conceptual understanding. Through an extensive and rigorous process, this version was found to be valid and reliable for use within classroom situations. However, the developers concluded that this version did not include some important points. Therefore, they elaborated and revised the CLES by adding the notions of radical constructivism and critical theory (Taylor, Fraser, & Fisher 1997). This new version was thought to be useable with a wide range of samples, including different subjects and year levels. The new version has five six-item scales, namely, Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation. In contrast to the cyclic arrangement of scale items in the original version, the latest version of the CLES has the items in their respective scales. This 30-item version has been recently shortened by omitting four items which showed poor item-scale correlations in previous studies and one which had negative wording. This resulted in a final 25-item version which was used in the present study.

2.5.3.2 Past research on the CLES

According to literature on past studies involving the CLES, during the development stage, classroom-based collaborative studies and larger scale studies were conducted in the USA and Australia (Dryden & Fraser, 1998; Taylor, Fraser, & Fisher, 1997). Each of these studies supported the statistical validity of the CLES. The CLES also has been used to explore the effect of special programs designed to improve the students' learning, attitude and learning environment (Taylor, Dawson, & Fraser, 1995a), and in several studies involving non-Western countries (Aldridge, Taylor, Fraser, & Chen, 2000; Idiris & Fraser, 1997; Lee & Fraser, 2001a; Soeharto, 1998; Wilks, 2000). Kim, Fisher, and Fraser (1999) translated the CLES, using the more original recent version of the five-factor structure, into the Korean language and investigated Korean students' perceptions of their science classroom learning environment. Similarly, Lee and Fraser (2001a) replicated the five-factor structure

of a Korean-language version of the CLES to obtain an image of high school science classroom environments in Korea. With the same version, Aldrige, Taylor, Fraser and Chen (2000) conducted a cross-cultural study involving Australian and Taiwanese junior high school science students. Wilks developed the CLES for use among students studying English in Junior colleges in Singapore. Until then, studies in non-Western countries tended to use earlier versions of the CLES (Cho, Yager, Park, & Seo, 1997; Idiris & Fraser, 1997; Soeharto; 1998). In South Africa, the CLES was used to investigate whether teachers were able to make use of student responses to the CLES, to develop and implement action research strategies to improve the learning environment (Sebela, Fraser, & Aldridge, 2003). On the other hand, studies in Western countries (e.g., USA, Australia) have used both versions, namely, the version developed in 1991 with a weaker conceptual framework (Taylor, 1991) and the version elaborated in 1997 (Taylor, Fraser, & Fisher 1997), depending on the purpose of their studies (Beckett, 1999; Koury, 1994; Poh, 1996).

In keeping with this previous research, in this study, the latest 25-item version of the CLES was selected to investigate the extent to which the Thai upper secondary school science classrooms in Nakornsawan Province had indeed been influenced by constructivist teaching.

2. 5. 4 Actual and Preferred Forms

An area of interest in past research on classroom environments has been the difference between student and teacher perceptions of actual and preferred environments (Fraser, 1998b). The Actual Forms assess perceptions of the actual classroom, whereas Preferred Forms measure perceptions of the ideal or desired classroom environment. The wording of items for Actual and Preferred Forms are similar, but different directions are used for each. For example, if an item on an Actual Form is “I get the chance to talk to other students”, the parallel item on the Preferred Form would read “I wish that I got the chance to talk to other students” (Taylor & Fraser, 1998).

Using both Actual and Preferred Forms of educational environment instruments permits exploration of whether students achieve better when there is a higher

similarity between the actual classroom environment and that preferred by students (Fraser, 1998b). By using a person-environment interaction framework, it is possible to investigate whether student outcomes depend, not only on the nature of the actual classroom environment, but also on the match between students' preferences and the actual environment (Fisher & Fraser, 1983a, 1983b). The practical implication of the findings is that class achievement of certain outcomes might be enhanced by attempting to change the actual classroom environment in ways, which make it more congruent with that preferred by the class. This study used the student actual and preferred forms of the CLES to assess the science classroom environment.

2.5.5 Class and Personal Forms

Many existing classroom environment instruments are not ideal for collecting data from class subgroups or individuals because they are phrased in order to assess the point of view of the entire class rather than individuals (Fraser & Tobin, 1991). The difference between personal and class forms is influenced by Lewin (1936) and Murray (1938). Lewin assumed that human behaviour is mainly determined by the environment and its interaction with the person. This understanding of human behaviour was extended by Murray, with his needs-press model. According to Murray, personal needs refer to motivational personality characteristics representing tendencies to move in the direction of certain goals, while environmental press provides an external situational counterpart which supports or frustrates the expression of internalised personality needs. This model, which was developed within the field of psychology, was extended to the teaching-learning situations (Anderson & Walberg, 1974; Moos, 1974; Rentoul & Fraser, 1979), using a view of the class as a social system provided by Getzels and Thelen (1960). Murray (1938) also introduced the term *alpha press* to describe the environment as assessed by outside observers and the term *beta press* to describe the environments perceived by the inhabitants of a particular setting. The difference between personal and class forms is illustrated in studies by Stern, Stein, and Bloom (1956). The term 'private' beta press is the unique perception that each person has in an environment and 'consensual' beta press involves the shared environmental perceptions of members of a group. Private and consensual beta press could differ from each other, and both could differ from the detached view of alpha press of trained participant observer. In

classroom environment research, this notion has been applied to the distinction between two levels of analysis, namely, the individual student level and the class level.

Earlier classroom environment studies were based on the assumption that there is a unique learning environment in the classroom that all students in a class experience. Variations in scores on learning environment instruments were considered as error variance, with the class mean representing a good measure of the learning environment in the classroom. However, this assumption was challenged in qualitative interpretive studies in the latter half of the 1980s (Fraser & Tobin, 1991). For example, groups of students (termed 'target' students), who were involved more extensively in classroom discussions than the other students, had more favourable perceptions of the learning environment than those students less involved, suggesting that there could be discrete and differently-perceived learning environments within the one classroom (Tobin, 1987). Therefore, there is a problem with using the traditional 'class form' of learning environment instruments when studying differences between groups of students in a classroom (e.g., males and females) because these instruments elicit the student's perception of the class as a whole rather than the student's personal perception of his or her role in that classroom (Fraser & Tobin, 1991). These studies and influences led Fraser, Giddings, and McRobbie (1995) to propose a different form of a learning environment instrument which asked students for their personal perceptions of their role in the classroom environment rather than their perceptions of the learning environment of the class as a whole; this form of the questionnaire was called the 'Personal Form'. Thus, Personal Forms can give a more accurate account of individual students' perceptions.

Careful attention is paid to item phrasing in these Personal Forms. The items are phrased in such a way that they ask for an individual student student's perceptions of the class as a whole or his/her perceptions of his/her role in the classroom (Fraser & Tobin, 1991; McRobbie, Fisher, & Wong, 1998). For example, traditional 'Class Forms' contain statements such as 'The work of the class is difficult,' or 'The teacher is friendly towards me'. The 'Personal Form' would contain parallel statements such as 'I find the work of the class difficult,' or 'The teacher is friendly towards me' (Fraser, 1998b). The questionnaires in this study were in the 'Personal Form' rather

than the 'Class Form' and parallel statements were used in the Students' Actual and Preferred Forms.

2.6 PAST RESEARCH ON CLASSROOM ENVIRONMENTS

During the first two decades of learning environments research in Western countries, there was a strong emphasis on the use of numerous validated and robust questionnaires to assess students' conceptions of their classroom learning environment (Fraser, 1998a). In Asian countries, during the past decade, there is evidence of a similar pattern. In order to show the many and varied applications of classroom environment instruments that have proven valid and useful in Asian countries, this section focuses on six types of past classroom environment research reviews as identified by Fraser (2002).

1) Associations between student outcomes and the nature of the classroom environment (Aldridge & Fraser, 2000; Aldridge, Fraser, Huang, 1999; Aldridge, Taylor, Fraser, & Chen, 2000; Fraser & Chionh, 2000; Goh & Fraser, 1998, 2000; Khine, 2002; Khine & Fisher, 2001, 2002; Kim, Fisher, & Fraser, 1999, 2000; Lee & Fraser, 2001a, 2001b, 2002; Quek, Fraser, & Wong, 2001; Riah & Fraser, 1998; Scott & Fisher, 2001, Soerjaningsih, Fraser, & Aldrige, 2001a; 2001b; Teh & Fraser, 1995; Waldrip & Wong, 1996; Wong & Fraser, 1996)
2) Evaluation of educational innovations (Fisher, Aldridge, Fraser, & Wood, 2003; Khoo & Fraser, 1998; Teh & Fraser, 1994)
3) Differences between student and teacher perceptions of actual and preferred environment (Fraser & Chionh, 2000; Margianti, Fraser, & Aldrige, 2001; Wong & Fraser, 1996)
4) Determinants of classroom environment (Fraser & Chionh, 2000; Goh & Fraser, 1998; Khine & Fisher, 2001, 2002; Khoo & Fraser, 1998; Kim, Fisher, & Fraser, 2000; Lee & Fraser, 2001a, 2001b, 2002; Margianti, Fraser, & Aldrige, 2001; Quek, Fraser, & Wong, 2001; Soerjaningsih, Fraser, & Aldrige, 2001a, 2001b; Wong & Fraser, 1996)

5) Use of qualitative research methods (Fraser, 1999; Khine, 2002; Khine & Fisher, 2001, 2002; Lee & Fraser, 2001a, 2001b, 2002; Margianti, Fraser, & Aldrige, 2001; Soerjaningsih, Fraser, & Aldrige, 2001a, 2001b; Wilks, 2000; Wong, 1993, 1996).
6) Cross-national studies (Aldridge & Fraser, 2000; Aldrige, Fraser, & Huang, 1999; Fisher, Goh, Wong, & Rickards, 1997; Fraser, 1997; She & Fisher, 2000)

Two of the above types of research most relevant to this thesis, namely, associations between classroom environment and student outcomes, and the use of classroom environment dimensions in the evaluation of educational innovations, are reviewed in the following two subsections of this thesis.

2.6.1 Associations between Student Outcomes and Environment

When classroom environment perceptions have been used as dependent variables, associations between students' cognitive and affective outcomes and learning environment have been found. Fraser (1994) provided a broad overview of these results, which indicate that classroom environment perceptions can influence students' outcomes. Fraser suggested that the strongest tradition in past classroom environment research has involved investigation of associations between students' cognitive and effective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Fraser, 2002). Furthermore, in a tabulation of previous research studies listed in the previous section, Fraser (2002) confirmed that Asian researchers also have investigated associations between student outcomes and students' perceptions of their classroom environment. These studies involved a wide range of learning environment instruments, student outcomes, school subjects and grade levels. These Asian studies have involved not only English-language versions of questionnaires, but also learning environment questionnaires that have been translated into various Asian languages.

Recently, in Korea and Taiwan, there were investigatigation on associations between student outcomes and environment (Fraser, 2002). Fraser indicated that in Korea, outcome-environment associations have been reported for: students' attitudes to

science and a Korean-language version of the SLEI, CLES and QTI (Lee & Fraser, 2001a); student attitudes and Korean-language versions of the CLES (Kim, Fisher, & Fraser, 1999) and of the QTI and WIHIC (Kim, Fisher, & Fraser, 2000). He also noted that in Taiwan, outcome-environment relationships have been found for student satisfaction and a Chinese-language version of scales for both the WIHIC and CLES (Aldridge & Fraser, 2000; Aldridge, Fraser, & Huang, 1999; Aldridge, Taylor, Fraser, & Chen, 2000).

2.6.2 Evaluation of Educational Innovations

Classroom environment instruments can be used as a source of process criteria in the evaluation of educational innovations (Fraser, 2002). An evaluation of the Australian Science Education Project (ASEP) revealed that, in comparison with a control group, ASEP students perceived their classrooms as being more satisfying and individualised and having a better material environment (Fraser, 1979). The significance of this study is that classroom environment variables differred between curricula, although various outcome measures indicated negligible differences (Fraser, 1998b). Recently, in two studies in Singapore, classroom environment measures were used as dependent variables in evaluations of computer-assisted learning (Teh & Fraser, 1994) and computer application courses for adults (Khoo & Fraser, 1997). Dryden and Fraser (1996) use the CLES to describe the lack of success in achieving constructivist-oriented reform of science education in an urban systemic reform initiative in the USA.

In this study, the constructivist teaching approach was employed as instructional instruments to improve science classroom environments and the CLES was used as the most appropriate instrument to assess the effectiveness of constructivist teaching on improving science classroom learning environments.

2.7 DESCRIBING DIFFERENCES BETWEEN STUDENTS' ACTUAL AND PREFERRED CLASSROOM ENVIRONMENTS

Fisher and Fraser (1983a) reported an investigation of differences between students and teachers in their perceptions of the same actual classroom environment and of differences between the actual environment and that preferred by students or teachers. In this report, students preferred a more positive classroom environment than was actually present for five different environment dimensions. Also, teachers perceived a more positive classroom environment than did their students in the same classrooms on four of the dimensions. In prior studies, the students' actual classroom environment fell short of the environment that they would prefer (Fisher & Fraser, 1983a; Fraser 1982). This section describes prior research findings concerning the differences in the students' actual and preferred classroom environments.

In the USA, a study by Sinclair (Sinclair & Fraser, 2001), with a sample of 10 middle-grade teachers and their 43 classes of students in an urban North Texas school setting, reported that Perceived and Preferred forms of the Inventory of Classroom Environments were administered to assess Cooperation, Teacher Equity, Involvement and Task Orientation. The perceived and preferred classroom environments of different classes were described based on the profiles of classroom environment scores. The result shows that students' preferred scores are higher than their corresponding perceived scores on all ICE scales. This pattern of the result in which students are not completely satisfied with their classroom environments replicated past research (Fraser, 1998b).

Additionally, in Asian countries, the pattern in which students prefer a more positive classroom learning environment than the one perceived has been replicated using the WIHIC and QTI among Singaporean high school students (Fraser & Chionh, 2000; Wong & Fraser, 1996), and using the WIHIC among 2,489 university students in Indonesia (Margianti, Fraser, & Aldridge, 2001).

The results from these studies provide valuable information about how to assess students' perception of their own classroom environment in which student are more likely to achieve. These results also indicated the influence of the learning

environment on students' students' cognitive and affective outcomes; and demonstrated numerous variables that could affect the achievement and attitudes of students.

In this present study, the Actual and Preferred Forms of the CLES were used to describe the science students' perceptions of their actual and preferred classroom learning environments.

2.8 IMPROVING CLASSROOM ENVIRONMENTS

2.8.1 Teacher Action Research

For the purpose of this study, the term 'teacher action research' is defined as a means of classroom environment assessment, followed by a teacher-designed action plan to bring about change, if desired. Teacher action research is a way of empowering a classroom teacher with the ability to assess a problem within the classroom, and take action to improve or eliminate the problem (Schön, 1983).

More than 20 years ago, Stenhouse (1975) proposed, at that time, a novel idea: teachers should become researchers in their own classrooms. In the following years, this concept became more accepted, as seen in the writings on teacher action research (McNiff, 1993) and the reflective practioner (Schön, 1983). From the original teacher-as-researcher definition by Stenhouse, several definitions have developed, all with differing viewpoints about the type and amount of teacher research performed, the presence of university researchers, and the type of studies conducted. Some of these definitions are known as 'teacher action research', 'teacher-as-researcher' and 'reflective teaching'.

Recently, an increasing number of teacher-researchers have been involved in collaborative research (Fraser & Hoffman, 1995; Geelan, 1997; Taylor, Dawson, & Fraser, 1995b). Tobin and Fraser (1998) argued that the inclusion of a teacher-researcher in classroom environment research provides a different perspective for describing the richness and complexity of classroom life. Also, by involving a teacher-researcher in classroom environment research, the teacher becomes more

reflective about her/his own classroom actions and attempts at bringing about innovations in teaching, and becomes more alert to possible counter-productive aspects of the innovations.

Oberg and McCheon (1990) explained that the teacher-as-researcher movement has flourished since the 1980s due to the positive focus on teachers as reflective practitioners, rather than as passive facilitators of academic knowledge. Erickson (1986, p. 157) stated that "if classroom teaching is to come of age as a profession then teachers need to take the adult responsibility of investigating their own practice systematically and critically, by methods which are appropriate to their practices". Therefore, teacher action research is a necessary component in today's classrooms.

Action research is a deliberate, solution-oriented investigation that is group or personally owned and conducted. It is characterised by spiraling cycles of problem identification, systematic data collection, reflection, analysis, data-driven action taken, and, finally, problem redefinition. The linking of the terms 'action' and 'research' highlights the essential features of this method: trying out ideas in practice as a means of increasing knowledge about and/or improving curriculum, teaching, and learning (Kemmis & McTaggart, 1988).

Allen and Mitler (1990) support the use of appropriate models of action research for individual schools and teachers that encourage teachers to solve problems that they feel are imperative. If successful implementation occurs, Oja and Smulyan (1989, p.1) believe teachers should attain the following:

1) an increased understanding of the classroom,
2) competence in problem solving and decision making related to teaching and learning,
3) discovery and development of theories underling teacher practice, and
4) development of theory, based on classroom realities, that generalises to other educational settings.

Figure 1 illustrates Oja and Smulyan's 'Action Research Spiral' (1989, p. 19). This model leads a teacher from 'what is happening now' to 'understanding' and classroom change. The model stresses the continuous steps of planning, monitoring, evaluating and replanning while teachers follow during their action research process.

Elliott (1987, p. 163) described this process of action research as “reflection on action followed by action on reflection”.

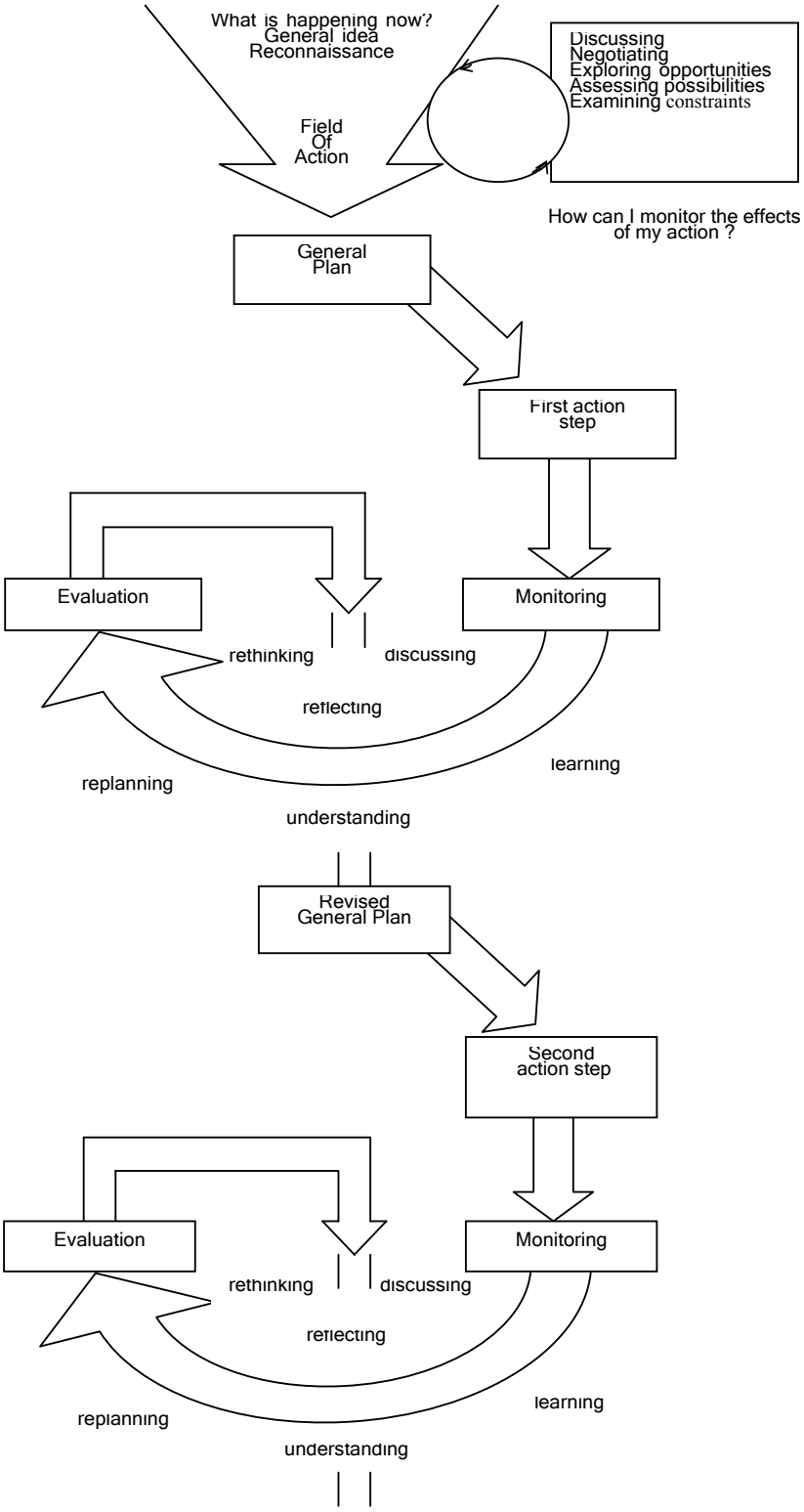

Figure 2.1. The 'Action Research Spiral' (Oja & Smulyan, 1989, p. 19).

Action-based research has much to offer teachers who desire to improve their performance effectiveness in the classroom. Previous studies have shown that teachers are successful in monitoring aspects of their classroom environment through reflective teaching (Adler, 1991; Brown & McIntyre, 1993; Connelly & Clandinin, 1990; Munby & Russel, 1992; Yaxley, 1993). However, many researchers encourage teachers to have an outside person with whome collaborate to prevent self-bias and false conclusions (Groundwater–Smith, 1991; Huberman, 1990; Kemmis & McTaggart, 1988; McCutcheon & Jung, 1990; Sparks-Langer & Colton, 1991).

Classroom environments are a natural focus for teachers' action research. Providing information about learning environment ideas in teacher education can encourage a reflective, teacher-as-researcher, action-reaction stance among teachers (Fraser, 1994). The individual teacher is the only one with the ability to improve his/her environments. He/she must learn to use self-reflection, evaluate, and take action to change the situation.

2.8.2 A Model for Improving Classroom Environment

Fraser (1986) reported that simply educating teachers about aspects of a positive classroom environment successfully led to improved environments. Providing teachers with feedback information concerning the students' and teachers' perceptions can be used as a basis for reflection, discussion and systematic attempts to improve classroom environments (Fraser, 2002). A model for promoting improvement in classroom environments was suggested by Fraser and Fisher (1986). This approach involves:

1) assessing the classroom environment;
2) providing feedback to the teacher;
3) providing opportunities for the teacher to reflect and discuss ways in which he/she can improve his/her current classroom environments;
4) intervention by the teacher, with possible assistance from a researcher when needed; and
5) re-assessment.

The basic logic underlying this approach was described for school classrooms by Fraser and Fisher (1986) and is based largely on Moos' work (1979) on changing a variety of other human environments. The model is similar to Oja and Smulyan's (1989) 'Action Research Spiral'.

The model for improving classroom environment (Fraser, 1986; Fraser & Fisher, 1986) has been used in a number of classroom studies. Fraser (1986) stated that "promising findings from three case studies were that appreciable changes in environment were perceived for those dimensions on which improvement had been attempted by the teacher" (p. 179). The model's proposed methods for change were successfully applied in primary level classrooms (Fraser & Deer, 1983; Yarrow & Millwater, 1995; Yarrow, Millwater, & Fraser, 1997). The model also proved successful in secondary level classrooms (Fraser, Seddon, & Eagleson, 1982; Thorpe, Burden, & Fraser, 1994; Wood & Fraser, 1996).

2.8.3 Previous Attempts to Improve Classroom Environments

Wood and Fraser (1995) used this approach to improve the classroom environment of 16 teachers using both Actual and Preferred Forms of the Classroom Interaction Patterns Questionnaire. The study showed that teachers who received feedback, compared with teachers who did not receive feedback, achieved more reductions in actual-preferred differences on most of the dimensions assessed (Wood & Fraser, 1995). This indicated the benefits of using the model for change.

A study by Yarrow, Millwater, and Fraser (1997) explored the impact of action research and the use of reflective practices to improve the learning environments of primary school classes during their preservice training. In this study, 117 preservice primary teachers assessed their learners' actual and preferred perceptions of the classroom environment using the My Class Inventory (MCI). Overall, improvements in the classroom environments were noted by the preservice teachers. The teachers generally valued the inclusion of the topic on learning environments in their preservice program and the opportunity to be involved in action research aimed at improving classroom environments (Yarrow, Millwater, & Fraser, 1997).

Recently, Sinclair (Sinclair & Fraser, 2001) used this model (as described in section 2.8 of this Chapter) to assess the effectiveness of teachers' action research involving the used of feedback on their students' perceptions of actual and preferred classroom environments in promoting changes in their classroom environments. Changes in the classroom learning environment occurred in each case, thus supporting the efficacy of this model.

In the present study, three case study teachers used this action research approach by applying constructivist teaching principles in order to improve their own classroom environments.

2. 9 ATTITUDE QUESTIONNAIRE

One of the major aims of science education is the promotion of positive science-related attitudes. Mager (1968) suggested three reasons for promoting positive attitudes in students. First, research has indicated associations between positive attitudes and enhanced academic achievement. Second, a positive attitude is more likely to sustain interest in the field of study in the future. Third, peers are influenced by the attitudes of others. Shulman and Tamir (1972) suggested that affective outcomes of education are at least as important as cognitive outcomes; acknowledgement of the importance of affective outcomes is reflected in their increasing emphasis in curricula (Hough & Piper, 1982).

2.9.1 Attitude Studies Related to Research on Learning Environments

As indicated earlier, a strong tradition of past classroom environment research has involved investigation of associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (e.g.,Fraser & Butts, 1982; Fraser & Fisher, 1982, 1983c; Haladyna, Olsen & Shaughnessy, 1982; Kim et al., 1999, 2000; Lee & Fraser, 2001a, 2001b, 2002). Almost all these studies have reported positive associations between students' attitudes towards science and classroom environments. In a more recent study using the SLIE to investigate students' perceptions of their science laboratory environment, McRobbie and Fraser (1993) reported overall positive associations between the

outcomes of inquiry skills and attitude and the classroom environment variable on Integration (the degree in which non-laboratory theory classes are integrated with laboratory lessons). Other strong correlations were found between achievement and attitudes and reported studies by Marjoribanks (1976) and Tamir (1987).

Several attitude studies have been undertaken in Asia in conjunction with classroom environment instruments. Some of these are from Singapore including Goh and Fraser (1998), Khoo and Fraser (1997), Teh and Fraser (1995), Chionh and Fraser (1998) and Wong and Fraser (1996), from Korea including Lee and Fraser (2001a) and Kim, Fisher and Fraser (2000), and from Brunei including Riah and Fraser (1998).

Therefore, it was decided to assess students' attitudes in this study and the following two scales were selected.

2.9.2 Attitude to Science Learning Activities Scale

This attitude scale has been used extensively in research on science laboratory classes, and was based on the TOSRA (Fraser, 1981b). The scale measures student attitudes to important aspects of the classroom environment, including their anticipation to the activities; their sense of worthwhileness of the activities; and the impact of the activities on student interest, enjoyment and understanding. The reliability of the scale has been confermed in a number of studies (e.g., Kim, Fisher, & Fraser, 1999; Taylor, Dawson, & Fraser, 1995b). There were 7 items in this scale as follows:

- I look forward to the learning activities.
- The activities are among the most interesting at this school.
- The activities make me interested in science.
- I enjoy the learning activities.
- I feel confused in this class.
- The learning activities are a waste of time.
- I feel tense in this class.

Taylor, Fraser and White (1994) used this scale with the CLES for monitoring the development of constructivist learning environments. In the present study, this scale was change a little by adding one more item (I dislike learning activities in this subject.).

2.9.3 Self-Efficacy Scale

Self-efficacy is people's confidence in their ability to achieve a specific goal in a specific situation (Schaler, 1995). If people believe they are powerful, they become powerful. Technically, self-efficacy is people's confidence in their ability to achieve a specific goal in a specific situation. It refers to the capability people believe they possess to effect a specific behavior or to accomplish a certain level of performance. Self-efficacy is not the skills one has but rather one's judgement of what one can do with those skills (Bandura, 1977, 1986). Social learning theorists define perceived self-efficacy as a sense of confidence regarding the performance of specific tasks. For example, Bandura (1986, p. 391) defines the construct as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with the judgments of what one can do with whatever skills one possesses."

Self-efficacy influences several aspects of behaviour that are important to learning. Among these are the choice of activities that a student makes, the effort put forth and persistence in accomplishing a task (Bandura, 1977, 1982, 1989; Schunk, 1989a, 1989b; Zimmerman, Bandura, & Martinez-Pons, 1992). The most frequently cited self-efficacy theorist, Bandura, theorises that individuals develop particular beliefs about their ability to cope with situation-specific constructs. If such theories are applied to the study of children's beliefs about learning, it would be logical to predict that children with high academic self-efficacy would be likely to demonstrate greater success.

Similar to the claim made by Fraser and Fisher (1994) that student perceptions account for appreciable amounts of variances in learning outcomes, the literature related directly to children's academic self-efficacy supports the link between self-efficacy and academic performance. For example, Schunk (1981, 1982) showed that

efficacy accounted for increments in the variance in children's achievement gain in mathematics. He also stated that "a heightened sense of efficacy sustains task involvement and results in greater achievement"… and … "lower perceptions of efficacy lead to less persistence and lower achievement" (Schunk, 1983, p. 92). Collins (1982), Bouffard-Bouchard (1990) and Bouffard-Bouchard, Parent, & Larivee (1991) also demonstrate the independent contribution of self-efficacy to learning outcomes.

Tobin (1998) examined how perspectives on learning environments associated with the Internet promoted elementary and middle school teachers' understandings of science teaching. He showed that individuals possessing low self-efficacy tended to give up easily to Tobin's questions about how the program was perceived by low self-efficacy students and how the program addressed the particular needs of such low self-efficacy students would have been helpful.

More recently, Jinks and Morgan (1996) reported relationships between elementary students' perceptions of self-efficacy and self-reported grades, with these relationships holding constant across urban, suburban, and rural school environments. The apparent dynamic is that self-efficacy beliefs are "not simply inert predictors of future behavior", but that those with more efficacious beliefs "things happen" (Bandura, 1989, p. 731).

There are few research studies on the influence of learning environments on student self-efficacy. One of these was the work of Aldridge, Fraser, and Fisher (2003). This research reports the reliability and validity of a generally-applicable instrument, designed to monitor the evolution of technology-rich, outcomes-focused learning environments, as well as its use in exploring how the learning environment created by teachers influences students' achievement, attitudes and self-efficacy. The other was the work of Doman, Adams, and Ferguson (2003). This research was conducted on associations between classroom psychological environment in mathematics classrooms and academic efficacy. Results showed that classroom environment relates positively with academic efficacy.

In this study, an attitude scale, namely, "Self-Efficacy" scale is based on a scale developed by Jinks and Morgan (1999) (see Appendix F) was used to assess science students' attitudes towards their academic self-efficacy.

2.10 RESEARCH IN THAILAND ON RELATIONSHIP AMONG CONSTRUCTIVIST TEACHING, CLASSROOM LEARNING ENVIRONMENT AND ATTITUDE OUTCOMES

The earlier literature reviews in this Chapter indicated that the learning environment has a positive effect on student's academic and attitudinal outcomes (section 2.6.1). Furthermore, classroom environment instruments can be used as a source of process criteria in the evaluation of an educational innovation (section 2.6.2); and multiple methodology: both qualitative and quantitative approaches should be used in educational research (2.5.1.5). However, the present researcher's experiences of more than 30 year working in an institute for the promotion of teaching and learning (Rajabhat Institute Nakornsawan) for all learners (e.g., higher educational students, secondary and elementary pupils), is that currently in Thailand, no research on this area has been reported. Focusing on constructivist teaching in Thailand, no studies describe the effectiveness of this teaching method on the improvement of the classroom environment. In addition, no research has been reported on using a learning environment instrument to measure the effectiveness of constructivist teaching as instructional innovation. Furthermore, no research has reported on the effective model for teachers to improve their constructivist classroom environment. Therefore, this present research study was an original report describing the ues of constructivist teaching as an instructional innovation to improve science classroom environment. Therefore, the approach to this study was to: 1) use constructivist teaching in order to improve classroom environment; 2) use learning environment assessments to guide attempts to improve science teachers' classroom environments; 3) use a classroom environment instrument as a source of process criteria in an evaluation of an educational innovation; 4) use a simply and useful model for improving constructivist classroom environment; 5) using both qualitative and quantitative method in educational research study, and 6) investigate relationships between attitudinal outcomes and constructivist teaching. Furthermore, this study is

the first to report Asian science teachers' attempts to use learning environment assessments to guide improvements in their classroom environment.

2.11 SUMMARY

To increase the probable success of the present study, it was necessary to review literature concerning implementing constructivist teaching to improve students' perceptions of science classroom learning environments which explained about the constructivist teaching and classroom learning environments. This chapter provided background about the basic principles, implications of constructivism for learning and teaching and the effectiveness of constructivist teaching. Some well-known constructivist teaching models and strategies and a case study on using the constructivist teaching approach are also discussed. The historical background of educational environment research, approaches for assessing classroom environments, classroom environment instruments, Constructivist Learning Environment Survey (CLES), Actual and Preferred Forms of classroom environments, and Class versus Personal Forms then were explained. Furthermore, research was reviewed on past research on classroom environments, associations between student outcomes and environment, evaluation of educational innovations, describing and improving classroom environments, and two scales of the Attitude Questionnaire (Attitude to Science Learning Activities and Self-Efficacy Scale).

Some significant constructivist teaching models and strategies were examined in order to provide the researcher with a better understanding of how to help the case study teachers improve their constructivist classroom environments.

The review of literature about evaluation of educational innovations (Fraser, Williamson, & Tobin, 1987) has provided a paradigm of using the constructivist teaching as educational innovation to improve classroom environments and using the CLES to evaluate the effectiveness of this teaching approach to improve classroom environments (Dryden & Fraser, 1996).

Background information about the history of educational environment research, associations between student outcomes and classroom environments, use of

classroom environment measures in evaluations of education innovations and differences between students' actual and preferred classroom environments has provided ideas for using the CLES and the Attitude Questionnaire to assess the effectiveness of constructivist teaching on improving classroom learning environments.

The review of literature described different approaches to improving classroom environments, including background information about teacher action research and models for improving classroom environments (i.e., Oja & Smulyan, 1989; Stenhouse, 1975). Fraser's model (1986) for improving change in the classroom was described. Fraser (1986) has proposed a simple approach by which teachers can use information obtained from classroom environment questionnaires to guide attempts to improve their classrooms. The basic approach involves two aspects. First, assessments of students' perceptions of both their actual and preferred classroom environments are used to identify differences between the actual classroom environment and that preferred by students. Second, strategies aimed at reducing these differences are implemented. The present study followed this model.

Research about the use of attitude questionnaires provided ideas for assessing students' attitudes towards science. Finally, research in Thailand on relationship among constructivist teaching, classroom learning environment and the attitude questionnaire have influences on this study.

The review of literature in this chapter has provided a theoretical foundation for the following chapters in which the account of the methodology of the present study is described, then the validity and reliability of the CLES for use in Thailand was investigated, and after that the CLES was used to describe the perceptions and preferences of a sample of students, and used to improve classroom environments. Furthermore the Attitude to Science Learning Activities and Self-Efficacy Scales also were used to assess science students' attitude as the pretest and posttest when constructivist teaching was implemented in their classrooms.

CHAPTER 3

METHODOLOGY

The previous chapter was primarily devoted to a review of literature concerning the implementation of constructivist teaching to improve students' perceptions of science classroom environments. The investigation described in this thesis was divided into three phases. Phase one involves the validation of the Thai version of the CLES for assessing secondary school science students' actual and preferred classroom environments. Phase two describes the science classroom environments in Thailand. The final phase discusses assessing and describing the effectiveness of constructivist teaching on improving science learning environments. This chapter describes the aim and objectives of the study, the research design, instruments, scoring procedures, data collection, data analysis and data interpretation of each phase of the study.

3.1 AIM AND OBJECTIVES OF THE STUDY

The constructivist teaching approach has demonstrated significant benefits to both teachers and students (Yager, 1995). In addition, research on the field of classroom environment has contributed much to understanding and improving science education (Fraser, 1986, 1994, 1997; Fraser & Walberg, 1991). However, in Thailand, there are no reports on the effectiveness of constructivist teaching on improving learning environments. Therefore, the overall aim of this research study was to determine whether teachers can use constructivist teaching through an action research process in order to improve their classroom environments.

From the literature review for this study, it was apparent that classroom environment instruments can be used as a source of process criteria in the evaluation of

educational innovations (Fraser, 2002). Thus, in this study, a constructivist learning environment instrument was employed to assess attempts to improve science classroom environments. The Constructivist Learning Environment Survey (Taylor, Fraser, & Fisher, 1997) was developed to assist researchers and teachers to assess the degree to which a particular classroom's environment is consistent with a constructivist epistemology and to assist teachers to reflect on their epistemological assumptions and reshape their teaching practice. The CLES was thus considered the most appropriate instrument to assess the effectiveness of constructivist teaching on improving science classroom environments. Overall, the purpose of this study was to determine whether teachers are able to make use of learners' responses to the CLES to improve their own classroom environments. Because the CLES had not been used previously in Thailand, it was necessary to investigate its validity and the reliability. If the CLES is valid for use in Thailand, it could be used in the future to assess Thai students' perceptions of their actual and preferred learning environments from a constructivist perspective.

Other writers have discussed reasons for promoting positive attitudes in students (e.g., Hough & Piper, 1982; Mager, 1968). Consequently, when using an instructional innovation in science classrooms, it could be of benefit to investigate its influence on students' science-related attitudes.

The following four research questions were derived from the aim.

1. Is the Constructivist Learning Environment Survey (CLES) a valid and reliable questionnaire for use in Thailand?
2. What are students' perceptions of their actual and preferred learning environments from a constructivist perspective?
3. Are teachers able to make use of learners' responses to the CLES to improve their own classroom learning environments?
4. Does constructivist teaching improve students' attitudes towards science learning activities and self-efficacy?

3.2 RESEARCH DESIGN

The methodology used to answer the research questions was a multi-method approach utilizing both quantitative and qualitative methods. Four measures were employed to obtain an understanding of students' perceptions of their constructivist science classroom learning environment: survey, interviews, observations and case-study. The questionnaires provided quantitative data to assist in answering the research questions. Classroom observations and student interviews were then used in order to explain and clarify the quantitative data.

3.2.1 Quantitative Method

3.2.1.1 Survey

Pior to the data collection, the survey was used in pilot-testing the CLES and the Attitude Questionnaire. Following this it was used in all phases of this study. In Phase One, the survey was used to collect data in order to validate the CLES for use in Thailand while in Phase Two it was used to collect data about the science classroom environments in Thailand. Finally, in Phase Three, the CLES and the Attitude Questionnaire were used to provide data related to the three case-study classes.

3.2.2 Qualitative Method

3.2.2.1 Interviews

Student interviews also were used in all phases of the study. In Phase One they were used in the pilot test of the CLES and the Attitude Questionnaire before data collection. In Phases Two and Three, they were used to complement the quantitative findings from the survey.

3.2.2.2 Observations

Classroom observations were used in Phases Two and Three of the study in order to uncover any aspects which might have been missed using the survey and interview methods.

3.2.2.3 Case study approach

Case studies were used in Phase Three of the study in the collection and presentation of detailed information about classroom environments and student attitudes.

3.3 INSTRUMENTS

Two questionnaires were chosen to be implemented in this research study. The first one was the CLES used for investigate students' perceptions of their learning environments through constructivist views. The second one was an Attitude Questionnaire consisting of two scales. One scale was 'Attitude to Science Learning Activities' and the second scale was 'Self-Efficacy'. In addition to the basic description provided in Chapter 2, a more comprehensive explanation, including previous studies with these questionnaires, is provided in sections 3.3.2 and 3.3.3. All instruments were translated from the English version into a Thai version for use in science classes in Thailand, following the procedures described in section 3.3.1. Copies of the CLES, both Actual and Preferred Forms, are provided in Appendices A and B. A copy of the Attitude Questionnaire is given in Appendix F.

3.3.1 Translation and Back-Translation

The English version of the CLES was translated into Thai, using a method involving translation and back-translation. The researcher translated the questionnaire into the Thai language. It was then back-translated into English by a person not involved in the original translation. By comparing the original English questionnaire with the back-translated version, it was possible to ensure that both versions conveyed the same meaning as the original version. Once this was finished, the Thai version was pilot tested using a small sample of students to ensure its comprehensibility and readability. Similarly, the two scales of the Attitude Questionnaire were also translated from the English version into a Thai version.

3.3.2 Constructivist Learning Environment Survey (CLES)

The CLES was developed specially with an emphasis on the constructivist learning environment to enable teachers to measure the extent to which they adopt

constructivist ideas in their classes (Taylor, Fraser, & Fisher, 1997). In this study, the new version of the CLES was used to investigate students' perceptions of their learning environments from constructivist views and assist teachers to reshape their teaching practice.

Two forms of the CLES, the Student Actual and Student Preferred (Taylor, Dawson, & Fraser, 1995b), were adopted to gather students' perceptions of science classrooms. Although item wording is almost identical in the Actual and Preferred Forms, words such as 'I wish' were included in the Preferred Form to remind students that they were rating their preferred or ideal classroom, rather than the actual classroom environment. For example, the statement, "In this class, I learn about the world outside of school" in the Actual Form of the CLES is changed in the Preferred Form to, " In this class, I wish that I learned about the world outside of school". It was decided to investigate the differences between students' perceptions of their actual and preferred constructivist learning environments in this study.

The CLES (both the 30-item version and the 25-item version) was designed to measure the five key elements of a critical constructivist learning environment from the students' perceptions: the degree of personal relevance in their studies; whether students have shared control over their learning; the degree to which students feel free to express concerns about their learning; the degree to which students are able to interact with each other to improve their understanding; and the extent to which science is viewed as ever changing (Taylor, Dawson, & Fraser, 1995a; Taylor, Fraser, & Fisher, 1997). These elements are assessed by five scales specially related to corresponding aspects of constructivism, namely; Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation. Table 3.1 provides a description of each of these scales together with a sample item.

Table 3.1

Scales and Sample Items for the CLES

Scale Name	Description	Sample Item
Personal Relevance	Relevance of learning to students' lives	In this class, I get a better understanding of the world outside of school.
Uncertainty	Provisional status of scientific knowledge	In this class, I learn about the world outside of school.
Critical Voice	Legitimacy of expressing a critical opinion	In this class, it's OK for me to ask the teacher "Why do I have to learn this?"
Shared Control	Participation in planning, conducting and assessing of learning	In this class, I help the teacher to plan what I'm going to learn.
Student Negotiation	Involvement with other students in assessing viability of new ideas.	In this class, I explain my ideas to other students.

3.3.3 Attitude Questionnaire

For the purpose of better understanding students' responses to the classroom learning environment, an attitude questionnaire was included in this study to assess students' attitudes towards their science learning activities and their sense of self-efficacy in learning science.

The Attitude Questionnaire consists of 16 items in two scales, namely, Attitude to Science Learning Activities and Self-Efficacy. The first scale (Taylor, Dawson, &

Fraser, 1995a) measures student attitudes to important aspects of the classroom environment, including: their anticipation to the activities; their sense of worthwhileness of the activities; and the impact of the activities on student interest, enjoyment and understanding. The second scale assesses students' sense of their own ability in learning science. The first scale, Attitude to Science Learning Activities, is based on a scale from the Test of Science-Related Attitudes (TOSRA) (Fraser, 1981b) whereas the second scale, Self-Efficacy, is based on a scale developed by Jinks and Morgan (1999). More details of these two scales are given in the following sections.

3.3.3.1 Attitude to Science Learning Activities Scale

This attitude scale has been used extensively in research, and has an established reliability (e.g., Kim, Fisher, & Fraser, 1999; Taylor, Dawson, & Fraser, 1995b). In this study, this scale had a minor change with the addition of one more item (I dislike learning activities in this subject.).

3.3.3.2 Self-Efficacy Scale

The Morgan-Jinks Student Efficacy Scale (MJSES) was developed to gain information about student efficacy beliefs that might relate to school (Jinks, & Morgan, 2003). In Jinks and Morgan's study, this scale was administered to a total of 570 students from two schools. The reliability coefficient for the overall scale was 0.82. There was a positive and significant correlation between self-reported science performance and the Self-Efficacy scale. This result suggests that understanding more about students' sense of academic efficacy and the role those beliefs may play in science achievement may have important implications for both curriculum and instruction.

3.4 SCORING PROCEDURES

All CLES forms were individually scored by the researcher, then data entry allowed for computer-generated statistics and graphics. For the CLES items, a selection of answer choice *Almost Never* receives a score of 1, *Seldom* receives a score of 2, *Sometimes* receives a score of 3, *Often* receives a score of 4, and *Almost Always* receives a score of 5. Average item means were obtained for each scale by adding the

scores for all items in a scale, and then dividing by the number of items in that scale. Average item means were calculated in preference to total scale scores in order to allow for the different number of items, contained in different scales when comparing scale means. The scale scores could then be used for the other statistical procedures or in the graphical representations described later in this thesis.

Similar to the scoring procedure of the CLES, in order to investigate the fourth question of this research study, the 16 items in the two scales of the Attitude Questionnaire were also used. The responses *Almost Never, Seldom, Sometimes, Often* and *Very Often* are given the scores of 1, 2, 3,4 and 5, respectively. But, for the items 3, 4, 6, 8 and 14, reverse scoring is used so that 5 is given for *Almost Never* and 1 is given for *Very Often*, etc.

3.5 DATA COLLECTION

3.5.1 Pilot Study

Prior to the data collection, both the Actual and Preferred Forms of the Thai student version of the CLES and the Attitude Questionnaire were pilot-tested using a small sample of students to ensure its comprehensibility and readability. This pilot-testing contained two steps. First, these two questionnaires were tried out with two students in each school. This was followed by the researcher's interviewing the students about the readability and comprehensibility of the items and checking whether students were responding to survey items on the basis intended by the researcher. Second, students of one classroom were interviewed in a similar way. The data gathered from the second step were used in slightly modifying the Thai versions of the CLES and the Attitude Questionnaire to a more readable and comprehensible form.

3.5.2 Phase One of the Study

This phase of the study was conducted during the first semester of the 2002 academic year which is from May to October. The purpose of this phase was to validate the Thai version of the CLES in order to answer the first research question. Two methodologies were employed to obtain an understanding of students' perceptions of

classroom environments: survey and interview. Therefore, the purposes of the data collection in Phase One were to:

1) assess the students' perceptions of actual and preferred classroom environments using the CLES;
2) collect qualitative data from students about the validity of the CLES for use in Thailand; and
3) establish the reliability and validity of the Actual and Preferred Forms of the CLES using quantitative and qualitative data.

This phase of the study involved both quantitative and qualitative data collection as recommended by Fraser (1994, 1998a). In the past, researchers in educational evaluation have claimed that there are benefits in moving beyond the traditional practice of choosing either quantitative or qualitative studies and, instead, combining the two methods (Cook & Reichardt, 1979; Firestone, 1987; Fraser, 1988; Howe, 1988; Smith & Fraser, 1980). In order to draw more accurate conclusions, it is important to triangulate all the data collected. 'Triangulation', a term coined by Webb, Campbell, Schwartz, and Sechrest (1965), supports a finding by showing that independent measures of it agree or, at least, do not contradict it (Miles & Huberman, 1984). The quantitative data were obtained by students' completion of the Actual and Preferred versions of the CLES, while the qualitative data, from student interviews and classroom observations, were collected by the researcher during school visits.

3.5.2.1 Sample

The Phase One sample consisted of 606 students in upper science secondary school classes in Nakornsawan Province. Nakornsawan Province, covering an area of 9,597.7 square kilometres is situated in the north of the central part of Thailand, 240 kms. from Bangkok. It was selected purposefully to be the sample area of this study for three reasons. First, it was one of the educational network areas of the Rajabhat Institute Nakornsawan in which the researcher works. Second, it was convenient for the researcher to collect data especially the qualitative data from classroom observations and student interviews. Third, it was necessary to select three upper secondary school science teachers from this sample to be case-study teachers in Phase three of this study. These students were representative of science students in the large, middle and small secondary schools in Nakornsawan Province. In this

study, seven, six, and four science classes were selected from the large, middle and small secondary schools, respectively. These students came from the classrooms of seven participating teachers. These teachers were selected from 15 teachers who volunteered to participate in the study. During a workshop on constructing the school-based curriculum, after the researcher had presented the information about the objectives and the process of conducting the research, science teachers of upper secondary classes, who had been trained on using constructivist teaching in classrooms, were invited to participate in this research study. In this workshop, five teachers volunteered to participate in the study. Five other teachers volunteered to participate after informally hearing about the research study from the part-time graduate students of Rajabhat Institute Nakornsawan. Another five teachers were the researcher's own graduate students.

3.5.2.2 Instrument

In this phase 25-item version of the CLES was used in both Students' Actual and Preferred Forms.

3.5.2.3 Survey

In this phase, a survey with the Thai version of the CLES questionnaire was conducted to obtain the validation data on the CLES for use in Thailand. The CLES was administered to the 606 student sample. This questionnaire initially had been pilot-tested to ensure that the translated items were interpreted by Thai students as originally intended. Then, students were asked to complete the Actual and Preferred Form of the CLES.

3.5.3 Phase Two of the Study

This phase of the study was conducted during the first semester of the 2002 academic year, from May to October. The Actual and Preferred Forms of the CLES in the Thai version had been administered to get a general image of Thai secondary school science classes. The collected data were used to answer the second research question: What are students' perceptions of their actual and preferred learning environments from a constructivist perspective? Three methodologies were employed to obtain an

understanding of students' perceptions of classroom environments: survey, interview and observation.

3.5.3.1 Sample

The sample in this phase was the same as the one in the first phase. The total sample of 606 science students in 17 classes was used to explore differences in student actual and preferred scores on the CLES scales.

3.5.3.2 Instrument

The instrument in this phase was the CLES as described in 3.3.2.

3.5.3.3 Survey

The survey data in the first phase were used to describe the constructivist learning environments and scale scores from the students' average actual and average preferred forms of the CLES questionnaires were tabulated and reported to each teacher in a graphic format. These charts provided comparisons of student actual and preferred environment.

3.5.3.4 Interviews

Several students from the total sample were interviewed to complement the quantitative findings from the survey in a semi-structured manner. For instance, interview questions were based on the questionnaire items and were slightly rephrased to make it easier for interviewees to respond (see Appendix I: Student Interview protocol).

3.5.3.5 Observations

Selection of specific lessons for observation was done by the researcher. The observations served to crystallise a comprehensive image of constructivist classrooms through an unstructured approach and referred to as 'participant observation'. For the observations, three classes from different schools were selected, based on the teachers' willingness to participate. Furthermore, the observations were used as a means of ethnographic inquiry where by the natural setting was the classroom. The observations were also used to examine aspects which might have

been missed using the survey and interview methods. During observations, data were collected in the form of field notes.

3.5.4 Phase Three of the Study

This phase of the study was conducted during the second semester of the academic year 2002, from the last week of October, 2002 to the end of February, 2003. The investigation of this phase was to answer the third and fourth research questions: Are teachers able to make use of learners' responses to the CLES to improve their own classroom learning environments? and Does constructivist teaching improve students' attitudes towards science learning activities and self-efficacy? In this phase, four methodologies were employed to obtain an understanding whether teachers were able to make use of learners' responses to the CLES to improve their own classroom learning environments and whether constructivist teaching improved students' attitudes towards science learning activities and self-efficacy. These methodologies were survey, interviews, observations and case studies.

3.5.4.1 Sample

The total sample comprised three upper Thai secondary school science teachers and all the students in each of one of their classes. These teachers and students were selected from seven teachers and their 17 classes described in section 3.5.2.1. The teachers were selected to continue in the third phase of the research. This selection was based on the teachers' readiness to implement constructivist teaching in their classrooms, their strongly-expressed intention to improve their own classroom learning environments, the feasibility of the researcher to visit their classrooms, and the permission of the principals to let the researcher conduct the study in their schools. As criteria for selecting students to be interviewed, willingness to participate in the study and patterns in their answers to the questionnaires were considered.

3.5.4.2 Instruments

Two instruments were used: the student Actual and Preferred Form of the CLES and Attitude Questionnaire as described in sections 3.3.2 and 3.3.3. The CLES was selected to investigate the extent to which the constructivist teaching approach had indeed influenced the constructivist nature of classroom learning environments in

three case study classrooms and the Attitude Questionnaire was used to assess students' attitudinal learning outcomes.

3.5.4.3 Case Studies

Three case-study teachers, all of whom were female, were invited to improve their classroom environments. Each of these teachers chose one of her classes that she believed needed a better classroom environment. Students in this study were taught with a constructivist approach. In addition, the teachers also used action research processes as ways to promote improvement in the classroom environment. Teachers in this study followed the methodology for promoting change used in prior studies (Fraser & Fisher, 1986; Sinclair & Fraser, 2001; Yarrow, Millwater, & Fraser, 1997). The students completed the Actual and Preferred Forms of the CLES. Based on the questionnaire results, each teacher developed an action plan in an attempt to alter her own classroom environments. This method involved:

1. assessing the students' perceived and preferred classroom environments;
2. providing the results to the teacher and assisting the teacher in making action plans to improve teacher's own classroom environment;
3. collecting qualitative data from students about the class, activities and the teacher;
4. holding weekly individual meetings with the teacher concerning class occurrences and specific techniques that could be used in an attempt to change the actual environment; and
5. re-assessing the students' actual environments.

Each teacher selected an area of specific concern, based on the differences between the scale means of the students' actual and preferred scores from the CLES, and the discussion with the researcher, to design a plan of action for improvement. The researcher visited each class about once a week during the semester prior to the posttest at the end of the semester, in order to observe classes and interview the students. Teachers were assisted by the researcher who acted as a coach in implementing constructivist teaching in their classrooms. All students completed the Student Actual version of the CLES as a posttest. The results were analysed by the

researcher who presented them to each teacher privately. Each teacher discussed the results with the researcher and provided possible explanations.

Students were asked to complete the CLES and the Attitude scale as a pretest during the fourth week of the school term, and as a posttest two weeks before the end of the school term. Students were requested to include their names on the questionnaires so that the researcher could choose students who had interesting and/or extreme views for interviews to elaborate and explain their answers.

3.5.4.4 Survey

Students' perceptions about the degree of constructivist teaching in their science classrooms were investigated with the student Actual and Preferred Forms of the CLES. Eight items of an 'Attitude to Science Learning Activities' scale and eight of a 'Self-Efficacy' scale were used to measure student attitudes to their learning activities and self-efficacy.

3.5.4.5 Interviews

During each classroom visit, the researcher interviewed up to five students about his/her learning activity, both in and out of class. A different student was chosen each time, and the data collected from these interviews served as an additional source of data to enrich the description of what was occurring in the classroom. The interviews were done using a face-to-face approach. (see Appendix I: Student Interview Protocol)

3.5.4.6 Observations

Observations of science lessons in the case-study teachers' classrooms were employed to gather information about the constructivist classroom environments and students' perceptions of their learning activities and self-efficacy which might have been missed during the survey and interviews. The selecting of specific lessons for observation was done weekly or bi-weekly depending on the teacher's willingness.

3.6 DATA ANALYSIS AND INTERPRETATION

In the pilot-testing of the Thai version of the CLES and the Attitude Questionnaire, student comments about the items on both questionnaires were collected.

To analyse and interpret data from phase one of this study, the data were analysed to check the *a priori* factor structure of the CLES, the internal consistency of each of the scales, the discriminant validity, and the ability to differentiate between classes. Factor analysis was undertaken to validate the scale structure of the CLES, using the data obtained from a sample of respondents completing the CLES instrument. The internal consistency of each scale of the CLES was established using the Cronbach (1970) alpha coefficient using the individual student as the unit of analysis. In order to examine whether there was differentiation between students' perceptions in different classes, a one-way analysis of variance (ANOVA) was computed for each scale of the CLES with class membership as the main effect and using the individual student as the unit of the analysis. The proportion of variance accounted for by class membership was calculated using the eta^2 statistic (the ratio of 'between' to 'total' sums of squares).

Furthermore, in phase two, students' perceptions of their actual and preferred environments (from the CLES) of different classes were described based on profiles of classroom environment scores. Descriptive statistics were used to characterise the average constructivist classroom environments. The standard deviation of each scale of the CLES was computed to provide a measure of the extent to which the scores deviated from the mean for each scale. The average item mean is simply the mean score for a scale divided by the number of items in that scale. A *t*-test for pair samples was conducted for each scale in order to ascertain the statistical significance of differences between students' actual and preferred scores on each CLES scale.

Finally, in phase three, the effectiveness of constructivist teaching in promoting improvement in classroom environments was evaluated in terms of the teachers' abilities to make use of the learners' responses to the CLES to improve their own classroom learning environments. The differences between the pretest and posttest mean score of scales from 'Attitude to Science Learning Activities' and 'Self-

Efficacy' were used to investigate student improvement of attitudes towards science learning activities and students' feeling of self-efficacy. T-tests were again used to identify significant differences between each pretest and posttest mean scores on the Attitude Scales in each case-study class.

In all phases of this study, quantitative data were tabulated and reported in graphical format while qualitative data were used to explain and support the quantitative data. Qualitative data (classroom descriptions, interviews with students) were compiled by the researcher and written into a narrative of the classroom environments, thus adding richness to the overall findings. The interviews were completely transcribed and the draft transcripts were then given to the interviewee in order for member checking to review the validity of content of the conversations.

3.7 SUMMARY

This chapter describes the methodologies employed in this study which was divided into three phases. The Thai version of the CLES was pilot-tested before the beginning of phase one of this study which involved the validation of the Thai version of the CLES for assessing secondary school science students' actual and preferred classroom environments. Phase two provided data in order to describe science classroom environments in Thailand. The final phase involved an investigation of whether the effective constructivist teaching could improve science learning environments.

The total samples of phases one and two were the same 606 upper secondary school science students in 17 different science classes from Nakornsawan Province in Thailand. In phase three, there were three upper secondary school science teachers and all the students in each of one of their classes.

A description has been given of how the English version of the Constructivist Teaching Environment Survey (CLES), based on prior studies (Chapter 2), was translated and back-translated into a Thai version. Then, the two questionnaires (the CLES and Attitude Questionnaire) and scoring procedures were discussed.

The methodology used to answer the research questions was a multi-method approach utilizing both quantitative and qualitative approaches: survey, interviews, observations and case studies. The data from the questionnaires were used to guide the collection of qualitative data which involved classroom observations and interviews of students. Students in the case-study classes were taught with a constructivist teaching approach. In addition, teachers' participation in action research processes, involving the use of feedback on perceived and preferred classroom environments from the CLES, was evaluated in terms of the effectiveness of constructivist teaching in promoting improvement in classroom environments. The next chapter describes the validation of the CLES in Thailand.

CHAPTER 4

VALIDATION OF THE CLES IN THAILAND

This chapter draws on the methodologies described in the previous chapter and reports the results of phase one of the study which was related to the first research question of this study: "Is the Constructivist Learning Environment Survey (CLES) a valid and reliable questionnaire for use in Thailand?" Consequently, this chapter describes the validation and the reliability of the student Actual and Preferred Form of the CLES (Taylor, Dawson, & Fraser, 1995a, 1995b; Taylor, Fraser, & Fisher, 1997) for use in Thailand. This chapter describes the result from the pilot study to ensure the comprehensibility and readability of the CLES, factor analysis, and the internal consistency reliability of the Actual and Preferred Forms. In this phase of the study, the sample consisted of seven Thai teachers and their 606 students in the upper level of secondary science classes in Nakornsawan Province, Thailand.

4.1 RESULT FROM PILOT STUDY

The qualitative data derived from student responses during the questionnaire administration and student interviews were used in identifying some items which required minor revision in their wording to enhance their comprehensibility.

4.1.1 CLES

Table 4.1 contains the item number, item wording and comments made by some of the students for the CLES items.

Table 4.1

Student Comments about Items from the CLES

Item Number	Item Wording	Student Comments
1.	I learn about the world outside of school.	1. What is the meaning of 'the world'? 2. Why do you ask me about learning about 'the world'? I think I learn it in social study, not in science subject. 3. Could you tell me about the meaning of 'the world'? 4. Is it OK. that this item means I can understand better about the natural phenomena in my daily life?
9.	I learn that modern science is different from the science of long ago.	1. You mean that the science knowledge may be changed when the time is go on, don't you? 2. You want to ask me that scientific knowledge is not absolute truth, that's right or not? 3. I don't understand the meaning of 'modern science'. 4. I'm not sure if what I understand about the 'modern science' is correct or not.
13.	It was OK for me to complain about activities that are confusing.	1. I think you know that students usually complain about their learning activities if they feel confused. But they do not tell this to the teacher. They prefer to tell their friends. I am not sure whether this item asks about to whom I complain: my friends or my teacher.
14.	It's OK for me to complain about anything that prevents me from learning.	1. If I ask teacher many questions, my friend will hate me because they felt that they lost the time to study. 2. I'm not sure whether you want to ask me about how often I can complain to my teacher about anything that prevents me from learning or complain about this to my friends.

(cont.)

Item Number	Item Wording	Student Comments
16.	I help the teacher to plan what I'm going to learn.	1. I think my teacher had already a suitable plan for me to learn. Does this item mean that I can help my teacher plan for school lessons? 2. You want to ask me about how often I can help my teacher plan what I want to learn. That's right!!
19.	I help the teacher to decide how much time I spend on activities.	1. I don't understand the word 'activities' in this item. Does it mean the learning activities? 2. I think that in this item you want to ask me about the degree to which I help my teacher to plan about my learning activities, don't you? 3. In this item, I understand that you want to ask me about how often I help my teacher decide how long I can I spend on each learning activity. Is this right or not?

Table 4.1 indicates that the students did have some misunderstanding of some items of the CLES. These results led to some modification to the CLES items. There were four items that were slightly changed to be more understandable for students. Table 4.2 showed the differences of wording between the English original wording and the Thai wording of the CLES. In the case of items 1 and 9, no changes were made to the items but the terms 'the world' and 'modern science' were explained to the students before they completed the questionnaire.

Table 4.2

Modification of Four Items of the Original English Version of the CLES

Item Number	English Version		Thai Version
13.	It's OK for me to complain about activities that are confusing.	13.	I can complain to my teacher about activities that are confusing.
14.	It was OK for me to complain about anything that prevents me from learning.	14.	I can complain to my teacher about anything that prevents me from learning.
16.	I help the teacher to plan what I'm going to learn.	16.	I help my teacher plan what I want to learn.
19.	I help the teacher to decide how much time I spend on activities.	19.	I help my teacher decide how long I spend on each learning activity

4.1.2 Attitude Questionnaire

When students were asked whether they had any problems about their understanding on the Attitude Questionnaire, most of them said that they understood the meaning of each item quite well. The followings were examples of students' comments on the Attitude Questionnaire items.

No problems, I feel easy about getting the meaning of its items.

It's OK, I am sure I understand its meaning.

I think the Attitude Questionnaire items are easy to read.

Therefore, it can be indicated that the Thai version of the Attitude Questionnaire in this study is appropriate for use.

Following the pilot-testing, the researcher first visited each of the seven participating teachers' classes during the day when the students completed the Actual and Preferred versions of the CLES. In order to ensure confidentiality for the students, the teachers left the room, thus allowing the researcher to administer the questionnaire, monitor its completion and secure its enclosure in a sealed envelope. The researcher explained the purpose of the inventories, read the instructions and

answered any individual questions that the students asked. Assurance for complete anonymity of answers was given. It was explained that names were to be placed on the forms so that the students' actual and preferred answers could be compared. To further ensure confidentiality, the researcher assigned each student a 'security monitor' to seal and sign each envelope containing the completed questionnaire.

In each class, after some students had finished completing their questionnaires, the researcher interviewed them using the questions related to the questionnaire items (see Appendix I). When all students had completed their questionnaires, the teacher returned to the classroom and returned to the usual classroom activities. Any remaining time was spent by the researcher in observing interactions between the teacher and her class and student behaviour. The researcher made additional visits to collect more qualitative data from the students concerning aspects of the classroom environment during different types of activities. Occasionally, unplanned visits by the researcher also provided a more realistic picture of student learning.

4.2 PROCEDURES AND RESULTS FOR STATISTICAL VALIDATION OF CLES

To validate the Actual and Preferred versions of the CLES for use among science students in Thailand, statistical analyses in terms of factor structure, internal consistency reliability (alpha reliability) and discriminant validity (mean correlation of a scale with the other four scales) was used.

4.2.1 Factor Analysis

To confirm the *a priori* conceptual structure of the Thai version of the CLES, a factor analysis was conducted using the sample of 606 students. A principal component analysis with varimax rotation was used to generate orthogonal factors. Since the instrument was designed with five scales, a five-factor solution was considered. The factors were then rotated to maximize their variance. The analysis was run using SPSS 10.00 for Windows. An examination of the items that are loaded strongly on each factor was then made to see if these items actually fit together in their appropriate scale. Table 4.3 shows the results of the factor analysis of the Thai

version of the CLES for the student Actual and Preferred Form for the sample of 606 students.

Table 4.3
Factor Loadings for Student Actual and Preferred Forms of the CLES

Item No.	Factor Loading									
	Personal Relevance		Uncertainty		Critical Voice		Shared Control		Student Negotiation	
	Actual	Prefer	Actual	Prefer	Actual	Prefer	Actual	Prefer	Actual	Prefer
1	0.76	0.65								
2	0.76	0.56								
3	0.72	0.60								
4	0.65	0.67								
5	0.67	0.67								
6			0.66	0.61						
7			0.65	0.47						
8			0.60	0.53						
9			0.79	0.66						
10			0.71	0.70						
11					0.70	0.68				
12					0.63	0.63				
13					0.81	0.79				
14					0.72	0.64				
15					0.47					
16							0.75	0.67		
17							0.58	0.70		
18							0.78	0.77		
19							0.74	0.63		
20							0.68	0.72		
21									0.66	0.73
22									0.80	0.72
23									0.77	0.65
24									0.75	0.59
25									0.71	0.58
cumulative% of variance										
Actual	13.35		26.55		39.18		50.86		62.01	
Preferred		13.76		23.74		33.36		42.76		51.57

The sample consisted of 606 science students in 17 classes in Thailand.

Factor loadings less than 0.40 have not been shown.

Generally, the results support the notion that the 25-item translated version of the CLES assesses five different aspects of constructivism within the science classroom environment in Thailand schools. In this analysis of the factor structure, 62.01% and 51.57% of the Actual and Preferred Forms, respectively, of the variance could be accounted for by the five factors, namely, Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation (see Table 4.3).

4.2.2 Reliability of the CLES

The internal consistency of each scale of the CLES was investigated by running a Cronbach alpha reliability analysis. Cronbach alpha is based on the idea that items within a factor are really measuring the same thing, which is, in this case, the extent to which all of the items in a particular scale are measuring the same thing. (Pedhazur & Schmelkin, 1991). Alpha reliability coefficients range from 0 to 1.00, with higher values indicative of higher internal consistency. While there is no set value that must be obtained, coefficients of 0.60 and higher are generally considered to be adequate for this type of instrument (Nunnally, 1978).

Table 4.4 shows that the reliability estimate (Cronbach alpha coefficient) for each CLES scale in the Actual and Preferred Forms with the individual student as the unit of analysis. Alpha reliabilities range from 0.81 to 0.85 for the Actual Form and from 0.62 to 0.84 for the Preferred Form. This suggests that all the scales of the Thai version of the CLES possess satisfactory internal consistency.

Table 4.4
Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with Other Scales) and Ability to Differentiate between Classrooms (ANOVA Results) Using the Individual Student as the Unit of Analysis for the CLES

CLES Scales	Alpha Reliability		Mean Correlation with Other Scales		ANOVA eta^2
	Actual	Preferred	Actual	Preferred	
Personal Relevance	0.84	0.68	0.49	0.34	0.18***
Uncertainty	0.81	0.62	0.48	0.34	0.15***
Critical Voice	0.82	0.78	0.49	0.43	0.18***
Shared Control	0.85	0.84	0.50	0.45	0.16***
Student Negotiation	0.85	0.78	0.45	0.41	0.23***

*** $p<.001$
The sample consisted of 606 students in 17 science classes in Thailand.

Another feature considered important in a classroom environment instrument is the discriminant validity of each scale of the instrument, that is, the extent to which the scale measures a dimension different from that measured by any other scale. In this study, when the individual is used as the unit of analysis, the mean correlation of one scale with the other four scales ranged from 0.50 to 0.45 for the Actual Form and from 0.45 to 0.34 for the Preferred Form (see Table 4.4). Most of these values can be regarded as small enough to confirm the discriminant validity of the CLES, indicating that each scale measures distinct, although somewhat overlapping, aspects of the classroom environment. This has been confirmed by the factor analysis (see Table 4.3).

Another desirable characteristic of the Actual Form of any instrument like the CLES is that it is capable of differentiating between the perceptions of students in different classrooms. That is, students within the same class should perceive it relatively

similarly, whereas the mean within-class perceptions should vary from class to class. This characteristic was explored for each scale of the CLES using a one-way ANOVA, with class membership as the main effect. Table 4.4 shows that each CLES scale differentiated significantly ($p<.001$) between classes and that the eta^2 statistic (the amount of variance accounted for by class membership) ranged from 0.15 to 0.23.

4.3 SUMMARY

In this chapter, the Thai version of the CLES has been validated. The next chapter will use these data to describe typical upper secondary school classroom environments in Nakornsawan Province, Thailand.

The quantitative data consisted of students' responses to the Actual and Preferred Forms of the CLES. The data collected from 606 students in 17 science classes were applied to validate the 25-item, five-scale instrument of the Thai version of the CLES. A principal components factor analysis with varimax rotation indicated that this Thai version of the CLES, which assesses Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation is able to assess five unique aspects of constructivism within the classroom environment. The alpha reliability values were considered satisfactory. Another desirable characteristic is that students within the same class perceive the learning environment similarly while differences between classes can be detected and this was confirmed.

The qualitative data for this study came from interviews with individual students to provide feedback about the readability, clarity and relevance of questionnaire items. Pilot testing of the CLES indicated that students had some minor misunderstandings of some items of the CLES. This qualitative information was also used to support patterns that emerged from the quantitative data. Additional interviews were continuously conducted until the end of the study. With the teacher absent, informative data were collected by questioning entire classes of students about their interpretations of and responses to particular questionnaire items. The next chapter describes some of the typical classroom environments of the present sample. Following this, Chapter 6 reports three case studies in which attempts were

undertaken to implement constructivist teaching in classrooms in order to improve the classroom environment.

CHAPTER 5

DESCRIPTION OF SCIENCE CLASSROOM ENVIRONMENTS IN THAILAND

As documented in several sources (e.g., Fisher & Fraser, 1983c; Sinclair & Fraser, 2001), students often have different perceptions of their actual and preferred environments. The pattern in which students prefer a more positive classroom learning environment than the one perceived as being currently present has been replicated using the What is Happening in This Classroom and Questionnaire on Teacher Interaction (Fraser & Chionh, 2000; Margianti, Fraser, & Aldridge, 2001; Wong & Fraser, 1996). The data used in Chapter 4 to validate the Thai version of the Constructivist Learning Environment Questionnaire (CLES) also were used to provide a profile of a typical upper secondary school science classroom environment in Nakornsawan Province, Thailand. The total sample comprised 606 Thai science students in 17 different classes in Nakornsawan Province.

The present chapter is devoted to answering the second research question of this study: What are students' perceptions of their actual and preferred learning environments from a constructivist perspective? First, the students' perceptions of their actual and preferred learning environments from a constructivist perspective are described. This is followed by a description of how feedback was provided to teachers in the first phase of the study.

5.1 STUDENTS' ACTUAL AND PREFERRED CLASSROOM ENVIRONMENTS

In past studies, students' perceived classroom environments fell short of the preferred environment (Fisher & Fraser, 1983b; Fraser 1982). In this study

differences in student actual and preferred scores on the CLES scales — Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation — were investigated. As explained in Chapter 4, differences in the number of items in different CLES scales were taken into account when considering average classroom environment by using the average item mean. The average item mean is simply the mean score for a scale divided by the number of items in that scale. A detailed explanation of the scoring of the CLES has been described earlier in Chapter 3.

Table 5.1 contains the average item mean and the average standard deviation for each classroom environment scale in the CLES using the individual student mean as the unit of analysis for the whole sample of 606 students. Figure 5.1 provides a graphical representation of the actual and preferred scale means.

Table 5.1
Average Item Mean and Standard Deviations for Each Classroom Environment Scale for the Individual Student as the Unit of Analysis for CLES Scales (N=606)

Scales	Mean		Differences	Standard deviation	
	Actual (A)	Preferred (P)	(P-A)	Actual (A)	Preferred (P)
Personal Relevance	2.90	3.97	1.07	0.79	0.53
Uncertainty	3.28	4.04	0.76	0.78	0.51
Critical Voice	2.20	3.58	1.38	0.79	0.80
Shared Control	2.01	3.57	1.56	0.88	0.83
Student Negotiation	3.01	3.95	0.94	0.85	0.65

Table 5.1 and Figure 5.1 show that, for the Actual Form, the average item mean is higher for Uncertainty (3.28), Student Negotiation (3.01) and Personal Relevance (2.90), but noticeably lower for Critical Voice (2.20) and Shared Control (2.01). A similar pattern is obtained for the Preferred Form with mean scores for Uncertainty

(4.04), Personal Relevance (3.97) and Student Negotiation (3.95) being much higher than for Critical Voice (3.58) and Shared Control (3.57).

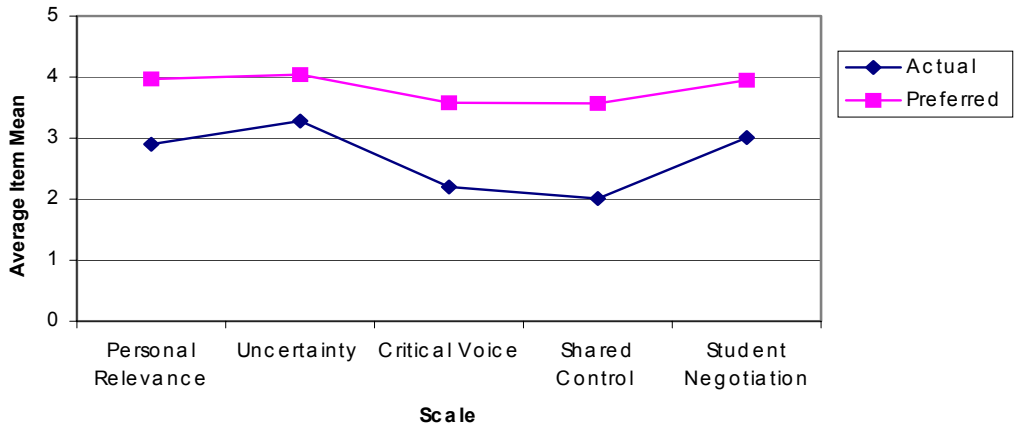

Figure 5.1 Thai secondary school science students' average actual and preferred classroom environments for the whole sample (*N* =606).

Furthermore, Table 5.1 and Figure 5.1 clearly show that students' preferred scores are higher than their corresponding actual scores on all the CLES scales. These actual-preferred differences in average item means range from 0.76 for Uncertainty to 1.56 for Shared Control. This difference of 1.56 for Shared Control represents approximately 0.88 of a standard deviation. This pattern in which students are not completely satisfied with their classroom environments replicates past research (Fraser, 1998b).

In addition, Table 5.1 shows that secondary school students perceive only higher levels of Personal Relevance, Uncertainty and Student Negotiation in their classrooms because values of each of these three dimensions is close to 3 which means only *Sometimes*. The other two perceptions of aspects of constructivism, Critical Voice and Shared Control, even less and are close to 2, which means *Seldom*.

It is also noteworthy that the actual mean score for Shared Control is lower than for the other scales suggesting that students perceived that their teachers were not sharing aspects of learning science with their students. The CLES data for the Shared

Control scale indicate that, as a whole, the class perceived that relatively infrequently they shared control with the teacher on the management of the classroom learning environment (mean=2.01). In general, students perceived that *Seldom* were they able to help the teacher plan the learning activities (item 16).

In order to ascertain the statistical significance of the differences between students' actual and preferred scores on each CLES scale, a *t*-test for paired samples was conducted for each scale and reported in Table 5.2. There were statistically significant differences between the students' actual and preferred classroom environments on all five CLES scales (see Table 5.2).

Table 5.2
Average Item Mean and Standard Deviations for Each Classroom Environment Scale for the Individual Student as the Unit of Analysis for CLES Scales[a]

Scales	Mean		Standard deviation		*t*
	Actual (A)	Preferred (P)	Actual (A)	Preferred (P)	
Personal Relevance	2.90	3.97	0.79	0.53	27.5***
Uncertainty	3.28	4.04	0.78	0.51	20.4***
Critical Voice	2.20	3.58	0.79	0.80	29.7***
Shared Control	2.01	3.57	0.88	0.83	29.8***
Student Negotiation	3.01	3.95	0.85	0.65	21.0***

[a] The sample (N =606) was from 17 classes of students in Thailand.
***p<.001

5.2 QUALITATIVE DATA

In this section, the data from the survey were used to guide the collection of qualitative data. Collection of qualitative data, from classroom observations and interviews with students, were carried out from three classes across three different schools selected from the large, middle and small upper secondary schools based on

the teachers' willingness to participate. The qualitative data enabled the researcher to interpret the survey data more meaningfully and provide richer insights into the results.

The field notes from each observation were re-constructed as a story soon after the observation. At least three students from each of the three classes observed in each school were interviewed about the observed lesson. Students were asked to comment on activities that took place during the observation. Student responses to selected survey items were used to form part of an interview schedule. The interviews were used to identify aspects of the constructivist learning environment that could not be found out through observations and survey alone. In this phase of the study, selected students were interviewed to complement the quantitative findings from the survey in a semi-structured manner. For instance, interview questions were based on the questionnaire items and were slightly rephrased to make it easier for the interviewees to respond. Examples of questions used during the interviews can be seen in the interview protocol in Appendix I. Sometimes the researcher also asked the whole class questions to provide opportunities for every student to answer. The following sections report the data from the three classrooms.

5.2.1 Qualitative Data from Class 1

The first classroom visited was one in a small secondary school, where there was a total of 25 students of male and female students from the science-agriculture stream. The science academic achievement of these students was in the middle and low level. The teacher of this class said that these students were likely poor, almost all of them came from middle and low social-economic status, however almost all of them wanted to study in the large school of the province with high cost was needed to be paid. The students were having a chemistry lesson with their teacher. Their desks were facing towards their teacher. When the lesson started, the teacher smiled at the children and wrote the topic of the lesson on the blackboard. She told her students about an experiment on solutions and wrote details about it on the blackboard. The students paid attention but it was noticeable that all the students were silent. There were a few students at the back of the class who did nothing. Although the teacher asked questions of the students, she did not require them to answer. Instead, she

herself answered those questions. There were no other observable instructional processes other than traditional chalk and talk. In this class, it appeared that it was a teaching activity rather than an effective learning activity. On the whole, the students of this class only listened to their teacher, took notes and read textbooks.

During the observation, the teacher encouraged students to listen to her explanations and do notetaking. She said, *"Please be quiet when I am explaining. Your important tasks in learning are trying to listen and make a short-note"*. The researcher perceived that this teacher did not use any strategies to help students develop some understanding of concepts in the lesson. She only 'told' and 'wrote' about the content. For example, she often asked her students this question, *"Does anybody understand what I have explained?"* but she did not provide enough time for students to think and ask. Furthermore, details of the content were only about the formula for calculation and the results. The students did not have opportunities to work together to solve the problems.

The following were some students' comments about their opportunities to comment on their teacher about their teaching:

> R: During the lesson of this class, can you ask your teacher anything whenever you want?
>
> *No, 'never'. One who asks questions is not a student. My teacher does not want us to ask many questions. She said that we have not enough time to study in order to cover the curriculum.*
>
> *No, ' never'. My teacher wants us to keep quiet.*
>
> *No, she's the teacher, you know… If she wants us to do any learning activities, and we didn't do them, we would get low scores.*
>
> R: In this class, how often does your teacher provide you with an opportunity to express your comments on her teaching or your difficulties in learning?

My teacher 'never'provides me with those opportunities. But if she does we dare not do it. I think that we are students if we do so, it can be thought that we are not paying any respect to her. I am sure that all students in my class think the same as me.

R: In this class, to what extent do you have the opportunity to express your comments to your teacher in your lessons?

'Not frequently', I am afraid of my teacher.

'Sometimes'. However, when I ask her some questions, my friends always laugh at me. So I do not want to ask her frequently.

R: How often do you express your opinion about the fact that you do not like doing certain things very much in your science class?

'Never'. I always control myself to do the learning tasks. I have no power to do so. I think my teacher doesn't want us to share control with her.

'Not frequently'. I think that my questions may make my friends bored with me and this may annoy my friends.

It appeared that students did not learn in small groups or work cooperatively on their learning tasks. They would rather learn on their own. However, the results from interviews indicated that on a few occasions there was some student negotiation in this class.

R: In this class, how often does your teacher provide you the opportunities to explain and justify to other students the newly developing ideas?

'Sometimes' when she asks us to work in small groups.

I 'almost never' share any ideas with my friends. I feel that I am very poor in science.

We do this 'infrequently'. We have no time to do it. Almost all of the time is used for listening and note taking.

I have not enough time to speak with others, I have to finish my assignment in time.

R: Please think about the degree of your cooperation with your friends in your lessons.

'Not often' because I have to listen to the explanation of my teacher.

'Sometimes' when we work in a small group.

'Infrequently'. In this class my teacher does not provide the situation for us to share our ideas. Doing notetaking is my important learning activity.

I' never' do it. I am not smart in this subject. I prefer to keep quite in this class.

Although the topic of the lesson was about solutions, the teacher did not relate students' prior knowledge to student learning or provide examples. It seemed that this content was not useful to students' everyday lives. These results from the observations were congruent with the following responses given in the students' interviews:

R: In this class, do you think that it is important for teachers to relate your classroom studies to outside world?

Yes, I feel that it is easier for me to understand science content if my teacher gives me the examples from my experiences.

One hundred percent, sure.

Yes, this is a very good idea. I will be happy if my teacher does this.

Yes, it is an excellent idea. Please tell this idea to my teacher.

I think, all students in my class want the teacher to do so.

R: In this class, how often does your teacher relate science lesson content with your everyday experiences?

My teacher should let us understand the relationship between what we are learning with what is happening in real life. However, she never does. She always told us a large amount of content without explanations. We want her to pay more attention to our understanding.

'Never'. In this class, my teacher always asked us to do the labs as written on the blackboard. She didn't care about our understanding. In addition, she always told us a lot of content and never asked us about our understanding.

R: How often does your teacher reflect the perspectives from modern philosophy of science in your lessons?

'Seldom'. When she talks about how scientists discover new findings.

'Never', because she always tells us everything and summarizes it on the board.

'Not frequently'. We want to do lab experiments, but we can not do this because my school is poor.

The interview data indicated that students did not share control with their teacher about their learning. Typical responses to the researcher's question were:

R: In this class, how often does your teacher invite you to share with her control of the learning environment?

'Never'.

'Not often'. She does this only when she wants to compromise us about our assessments topic and date.

In summarising, the data from interviews and observation of class 1 indicated that, although it was observed that the topic of the lesson should have been relevant to students' real life, students in fact said that what they had learned was not relevant, because their teacher did not give them examples from their own experiences and usually introduced a large amounts of content without explanation. As for the Uncertainty dimension, during the observation, the teacher did not use inquiry methods or problem solving in the learning situations and her style of teaching seemed to be traditional chalk and talk. She did not use hands-on activities at all. Nor did she use any other learning materials other than the textbook. Interviews with some students supported these observations. It was also observed from the teacher's behaviour that in this class students did not tell their teacher about the difficulties they faced. Interview data indicated that students thought that the teacher might think that they did not respect her if they asked for assistance in this regard. Thus, they appeared to be afraid of their teacher. The classroom observation and students' interviews showed that students did not share control with their teacher about their learning (except about the assessment topic and date). There was some evidence from interviews that there were occasions when student negotiation occurred in this class. Finally, it was observed that students did not frequently learn in small groups or work cooperatively on their learning tasks. They would rather learn on their own.

5.2.2 Qualitative Data from Class 2

The second class was one in one of the most well-known secondary schools of Nakornsawan Province. In this class, there were males and females who were selected to be high ability in science students from the science-mathematics stream. Normally they came from middle and high economic status. It was known that

almost of them intended to pass the university entrance. During one visit, these students sat in groups of four or five to learn biology. They appeared to have more room to move around. The teacher used hand-on activities to engage her students in an investigation of a concept by using various tools for an experiment in small groups. The teacher had already provided students in each group with the materials needed for the experiment. The teaching style of this teacher was in keeping with constructivism because she used an inquiry approach to teach problem solving. When asked whether their teacher reflected the perspectives of modern philosophy of science in this class, students confirmed that their teacher did this. They said:

> *Yes, 'often'. In this class, we have to do more labs and we must use inquiry skills to solve the problems.*

> *Yes, in this class, my teacher always asks us to solve the problems in the text. She said that these problems are very good for assessing our understanding. We always use small groups to learn how to cooperatively solve these problems.*

The teacher explained the directions about the learning activities in this learning unit and invited students to comment on the learning activities and assessment tasks. She said to her students:

> *This unit has six hours of study, your learning tasks consist of both individual and group work such as…, you have to write the report of the experiment and present it to the rest of the class. The quiz will be in the next two weeks. Do you have any comments on what I have planned?*

In response to this question, students did not comment on the learning tasks and learning activities. However, half of the students raised their hands in order to express their opinions about the assessment. Generally, they did not want to have the examination two weeks later, and wanted to be assessed the week after that. The teacher smiled and asked three students to give their reasons for this. In this case, five students tried to add more reasons to help their friends. The teacher listened to these reasons and finally agreed with them. She said:

I accept your ideas. I feel happy to see that you have such a high response to your learning. Your ideas about my teaching behaviour or the learning activities in this course are very useful for us to create the expected classroom learning environment.

When the researcher asked a group of students whether, during other lessons in this class, they had also shared control with their teacher about their learning, such as talking with their teacher about the expected learning outcomes, learning activities and assessment which she had planned. They said:

Yes, 'sometimes' when she wants to compromise us about the assessment and how to do the learning activities outdoors.

Yes, 'seldom' when my teacher gives us the learning tasks to do in a small group. We must control our group to plan and manage everything to reach the group goal. I like to work in a small group. I enjoy working in a small group.

When the researcher asked the students about the extent to which they can be involved in helping their teacher control the learning environment, for example, helping the teacher to decide which activities are best for them, how much time they spend on some learning activities, or which activities they want to do, the students answered:

'Sometimes', when I do my science project.

'Sometimes', when she lets us to select how to present our reports.

'Not often', only about the weight of scores in each assessment task.

Furthermore, the teacher also provided opportunities for her sudents to negotiate with one another. During their work in small groups, the students seemed to be quite active. They gave their ideas to and shared them with their peers. While this work was going on, the teacher moved around the class to help her students. She always

smiled, answered students' questions and encouraged the students to develop their own solutions to the problems, and to report on the results of the experiments. When students were asked about the cooperation with their friends in this class, they made the following comments.

R: Please think about your favourite lesson in this class. Did you have chances to interact with other students in the class, or would you rather learn on your own?

I enjoy studying in this class because I usually have to do the learning activities in a small group. With these activities I feel happy to interact with my friends. I do not want to learn on my own. In group work, we help each other to learn to finish the assignment.

I preferred the lessons with small group learning activities. In this class, I always have the chance to interact with my friends through various kinds of activities such as group discussions, writing mind mapping, group reporting or presentation. I usually have good emotions when I work with my friends.

R: In this class, does your teacher provide you with opportunities to explain and justify to other students the newly developing ideas?

Yes, often specially in group investigation activities.

Yes, in my class, my teacher always provides opportunities for me and my friends to work cooperatively in small groups to do the learning tasks. She also often asks students who sit near each other to answer some questions or create some ideas in writing.

R: Please think about the degree of your cooperation with your friends in your lessons.

A lot of time in small group activities.

'Often' with lab activities.

'Sometimes', when we discuss problems, such as the social pollution.

'Frequently'. Every period we have time to discuss or work with our friends. I often work in pairs or in a small group to do the learning task.

It was observed that the science content was related to students' experiences. For example, the teacher asked her students to give some names of economic plants and animals of Thailand and discuss how these organisms can be used to give high value to the country. The following quotes indicate students' opinions on their science lessons related to personal relevance to their life.

R: In this class, do you think that it is important for your teachers to relate your classroom studies to outside world?

Yes, I think so. I am sure that if she can't give the examples of what is happening in real life, it means that she does not have a good understanding about what she is teaching. However, in my class, my teacher is excellent at this. She almost always explains the lesson content related to our experiences.

R: In this class, does your teacher relate science lesson contents with your everyday experiences?

Yes, my teacher always brings us to learn in the real situations. For example, the Botanical Garden and National Zoo.

Yes, my teacher always provides us with direct experiences such as letting us see various plants and animal in their real settings or at least some photos of them.

Yes, the science lessons in my textbook are very good because they help us to understand science concepts by using examples from our experiences.

As for the scale of Critical Voice to improve teaching and learning, the teacher permitted her students to comment on her teaching behaviour or complain about anything that prevented them from learning. She said to her students; " *If you have any problems in learning in this course, please let me know. Don't be afraid to tell me of your difficulties. Learning activities in this class can be flexible to be suitable for you"*. It can be said that all the students in this class had the opportunity to comment. The following quotes indicate their opinions on their science classroom environment:

R: Does your teacher encourage you to ask questions in class?

Yes, she is very friendly to us. She wants all of us to have a good understanding. She lets us ask any questions we want.

Yes, 'very often'. I love her very much.

Yes. She says that students should ask any questions that will enhance our good understanding.

However, students' comments were only about the assessment as reported earlier in this section, they did not criticise any thing else about their teacher. Some students commented that it was impolite for students to criticise their teacher:

I think the younger should pay respect to the older. I feel it is unsuitable for students to say bad things about the teacher.

It is impossible for me to show her my difficulties in learning because she may feel unhappy to teach me. I love her and do not want to make her sad.

In conclusion, it was observed that the learning environment in this class was in keeping with a constructivist perspective. The lesson content was related to students' experiences. They commented that their teacher was excellent in explaining the content by using the examples that were relevant to their experiences. She used the inquiry approach to teach through problem solving. Students also had the opportunities to comment on the learning activities and assessment tasks, but their comments were only about the assessment. They did not make critical comments about their teacher. Some students commented that it was impolite for students to criticise the teacher. Students indicated that they could share control with their teacher about the assessment, how to do the learning activities, and controlling their learning in small groups and project activities. In this class, the teacher provided in her classroom a learning environment that promoted student negotiation through small group learning. Students commented that they enjoyed their classroom learning and felt happy in interacting with their classmates.

5.2.3 Qualitative Data from Class 3

The third class visited, in a middle seize secondary school, contained 35 students learning physics. From talking about the background of these students, the teacher described that although the students in this class were in the science stream, their minor-selection areas were not mathematics, but were vocation. So there were only a few of them who were smart with science, but others were not. Besides, the economic and social status of these students were not quite high. Almost all of them came from low and middle class agricultural family. The lesson was about the step-up and the step-down of transformers. The desks were arranged in straight rows, with students sitting behind one another. The classroom environment in this class appeared similar to that in Class 1 with inactive learning behaviours. The teacher used most of the time in telling students about physics content and writing on the blackboard. She also wrote diagrams on the blackboard to enhance student understanding. She encouraged students to keep quiet and take notes. She said:

> *Today I am very happy because our class was quieter than before. I wanted you to listen carefully. This topic was very important because the test of the previous entrance examination involved this topic. If you pay*

more attention to our lesson, I am sure that you can pass the entrance examination.

She wrote this test of multiple choice type and told students to work in pairs to solve it. She should have explained to the students that this lesson was useful to student life, but she never did. Besides, she did not use students' prior knowledge which was relevant to student learning. The teacher's style of teaching was traditional with a teacher-centred approach. It was observable that students in this class paid more respect to their teacher. Although they did not understand what they were studying, they did nothing to express these feelings to their teacher. The researcher also observed that several students did not understand what she was explaining. Some students used a barely audible voice to tell these problems to their peers, two students read a sports magazine while another six closed their eyes to sleep. It was noteworthy that the teacher used almost all the time for teaching; therefore students had no opportunity to comment on their teacher about her teaching and did not help their teacher to decide about their learning activities. However, during one half hour of the lesson of two hours, the teacher asked her students to work in pairs and complete an exercise from the textbook. While doing this, the students looked happier than they did previously. Working in pairs, students had a short time to talk and share their ideas. When the teacher told her students to do some homework from the textbook, the students' eyes seemed unhappy but they said nothing. Five minutes before the end of the lesson, the teacher said: "*Don't forget to do your homework and submit it to me tomorrow. Do you have any questions?"* However, she did not allow time for students to ask a question. The students said nothing, while almost everybody stood up, chatted with each other, spoke with a very loud voice and tried to move quickly to another classroom to attend the next lesson. During this movement, the teacher just walked away.

During the interviews, students were asked to comment on their classroom environment. The following quotes are examples of student comments:

R: Does your teacher encourage you to ask questions in class?

Yes, 'not frequently', because she usually gives us only a lecture and writes on the board for us to copy. However, before the end of each part of the study she often asks whether we have any questions? We often reply 'no' or keep silent because we must hurry to move to learn in other classroom.

No, 'never'. She often asks us many questions to check our understanding, but she never lets us ask her any questions.

Yes, when she finishes teaching, she lets us ask any questions about what we do not understand. However, you know, we have so shorts a time to do so because we must hurry to move to other room for learning another subject.

R: In this class, have you ever complained with your teacher (or just complain personally with your friends) about her teaching performance?

No, 'never'. I am afraid that if I do so I may make her angry and this may impact on my grade of this subject. However, I often comment about her behaviour to my friends.

You know, my teacher 'never' provides me with the opportunities to express my comments on her teaching. However, when I have some difficulties in learning, I do not often tell her that I cannot catch up with what she is teaching. For example, when she explains or writes quickly on the board, I ask her to go slower. In response, she smiles and accepts my request.

Oh. I cannot do that. I am afraid of her. If I do so, I think that she will feel sorry or she may be angry at me.

Yes, but 'not frequently'. I feel that it is not polite for students to comment about the teacher. I think a lot of my friends have the same feeling like me.

R: In this class, does your teacher relate science lesson contents with you everyday experiences?

Yes, 'often'. My teacher always gives us the problems to solve. These problems are always about the situations in my life, such as about electric instruments and water power.

Yes, 'almost always'. The exercises in my text are mostly related to my experiences. My teacher always asks us to do the exercises in the book. They usually are about our everyday experiences.

R: Does your teacher reflect the perspectives from modern philosophy of science in your lessons?

Yes, but 'not frequently'. She sometimes asks us about our reasons for making decisions when doing the exercise.

Yes, sometimes, she asks us about how to solve the problems related to science concepts.

'Often'. In doing the exercise, she always asks students to express the reasons for any solutions.

'Frequently'. I have to answer questions in writing with good explanations for the causes and effects of many situations.

Yes, 'often', particularly when she uses the present science text. The content in my science text is very reasonable and the exercises in this book provide me the opportunities for the investigation.

R: In this class, does your teacher invite you to share with her control of the learning environment?

Yes, 'sometimes' when we want to postpone our quiz or assignments.

Yes, when I felt that my teacher's criteria for some assessments were not suitable. We asked her to explain why we got low scores in spite of the best things we have done.

R: In this class, to what extent can you be involved in helping your teacher control the learning environment? For example, help the teacher to decide which activities are best for you, how much time you spend on some learning activities, or which activities you want to do.

I never do it.

'Sometimes', when we work in small groups, we must control our groups to finish the assignment.

'Often', when I do the project assignment. We must help each other to plan, do, assess and present our project.

R: In this class, does your teacher provide you with the opportunities to explain and justify to other students the newly developing ideas?

Yes, she does. She asks us to do group discussions in order to solve the problems in the exercises.

Yes, sometimes, when my teacher tells us to work in a small group to do the exercises.

R: Please think about the degree of your cooperation with your friends in your lessons.

'Often', when we work in small groups to solve the problems of the learning tasks, my teacher always tells us to work cooperatively to reach the goal.

'Not often'. I usually have no good ideas for my group, so it is better to keep quiet.

'Not frequently'.

'Sometimes' when we fall asleep, she writes the questions on the board and tells us to work in a small group to answer these questions.

In summarising the learning environment in Class 3 in regard to the Personal Relevance dimension, classroom observations indicated that the teacher did not explain to the students how the lesson was useful to student life and did not make use of students' prior knowledge which had relevance to their learning. However, interview data indicated that the teacher was able to relate the lesson content to students' prior knowledge by using the exercises in the textbook. From the observations, there were no inquiry situations to enhance students' understanding, but students commented that the content in their science textbook was very reasonable and provided them with the opportunities for the investigation. In this class, students did not use their critical voice to express to their teacher their problems in learning. They paid great respect to their teacher, so they felt that they should not comment on the teacher's performance. Students commented on some ways to share control with their teacher in controlling themselves in small group and project learning activities. Moreover, students also said that they had only limited opportunities to explain, discuss and share their ideas with their friends.

5.3 RESULTS AND INTERPRETATION FROM MIXED METHODS

This section describes the Thai students' perceptions of their actual and preferred learning environments from a constructivist perspective. In this section, the differences and similarities between the quantitative data (see section 5.1 and Table 5.2) of the survey and the qualitative data (see section 5.2) of observations and

interviews are examined. The following subsections describe the Thai students' perceptions of their learning environments related to the five dimensions of the constructivist learning environments.

5.3.1 Personal Relevance

The survey data in this scale indicated that students perceived that the connections between their science classroom environments and their everyday experiences, were *sometimes* provided in their classrooms. Interview data with students confirmed this result in two ways. First, science textbook-dependent teaching performance in Thailand might be one of the reasons why Thai students had more favourable perceptions about their science lessons. Almost all science teachers used textbooks provided by the Institute of Promotion of Teaching Science and Technology. This institute had the mission to enhance teachers' abilities in teaching science, mathematics and technology. Second, the impact of the university entrance examinations on practice could influence students' perceptions on this scale. Thai upper-secondary school lessons are mainly driven by university entrance examinations and recent examinations have dealt with items related to everyday contexts. During observations, the researcher noted that teachers in the three classes often used examples from everyday contexts in their teaching. For example, one teacher remarked, *'You know, the examples in this lesson were dealt with in the entrance examination last year. Also make sure you understand the connection the concept we've learned today has with these everyday examples. Do you understand these concepts?*' Despite the university entrance examinations including items that are related to everyday life and science teachers' recognition of the need to make science more meaningful to students, the results of the university entrance examinations still appears to rule over what and how teachers teach in the upper secondary schools. Teachers still stress content in their lessons to ensure that students attain a high score in this examination, and often this means that they do not make lessons personally relevant to the student.

5.3.2 Uncertainty

On the scale of Uncertainty, students showed their perceptions at the same level as Personal Relevance. They expressed that they *'sometimes'* learnt about the uncertainty of scientific concepts. Observations and interviews with students indicated that this result was related to two factors: the first one was about the teaching performance of each teacher and the second one was about textbooks. It would appear that students' perceptions on this scale depend on the individual teacher's style of teaching. Some teachers had excellent abilities to discuss uncertainty of scientific concepts with their classes while others did not want to do so. The teachers preferred to use the content in the textbooks. So, if such materials are not in the textbooks, then the teachers will not utilize constructivist teaching approach.

5.3.3 Critical Voice

The Critical Voice scale of the CLES measures the degree to which students are able to question the teacher's pedagogical plans and methods and voice their concerns about impediments to their learning. The quantitative data collected using the CLES (see Table 5.2) indicated that science students in Thailand were *seldom* able to criticise the way in which they were taught. Interviews with students revealed that students in Thailand appear to have a high degree of respect for their teachers. During the interviews with students, it was found that the teacher's knowledge was never questioned and the teaching methods or the lesson content were rarely complained about.

Interview data also indicated that students were most reluctant to criticise their teacher about the way in which they are taught. The students' reluctance to criticize their teachers could be an indication of the Thai way of thinking. In the Thai culture, the younger should pay great respect to their seniors. It follows that Thai students are expected to respect their teachers as elders. Therefore, they tend to obey their teachers. From the students' interviews it could be said that students preferred to express their critical voice to question or speak to their peers about problems after

the lesson. These students indicated that they would not publicly express a critical voice about their teachers.

5.3.4 Shared Control

The Shared Control scale of the CLES measures the extent to which students are invited to share control with the teacher over the design and management of the learning activities, the determination and application of assessment criteria, and the articulation of their own learning goals. The questionnaire data indicated that Thai students generally had a less positive view of the Shared Control scale than other scales (see Figure 5.1).

Observation data were highly consistent with the students' recorded perceptions. During a class visit, it was observed that students tried to do their learning tasks in small groups given by the teachers. During these activities which occupied most of the lesson time, students shared control with other students in their group (i.e., designing the concept map and answering the questions).

Because of the high expectations for good results in the examinations for upper secondary schools in Thailand, teachers are pressured to teach what is relevant to the strands in the curriculum in terms of content as indicated in the textbooks. Teachers try to manage their classes in such a way to help their students pass the examinations, to enable them to enter into a university or a higher education institute. To push students to reach good results from tests, teachers are expected by the community to teach in the traditional style and use the traditional lecture method, mind-on activities, and 'chalk-and-talk methods'. Because of this style of teaching, all learning activities are planned and managed by teachers. Therefore, students' participation in sharing control will be done in terms of doing something that is asked by teachers. The two general conclusions drawn from the comments of the Thai students who were interviewed was that: first, the teacher is the expert one who is more able to make decisions focused on teaching, planning and assessing than are the students and, second, students had never exhibited the type of freedom expressed in the Shared Control scale of the CLES. In many cases, these students interpreted

this freedom as a form of participation in the class such as working in small groups or doing science projects.

5.3.5 Student Negotiation

The Student Negotiation scale measures the extent to which opportunities exist for students to explain and justify to other students their newly developing ideas and to reflect on the viability of their own and other students' ideas.

During observations, it could be seen that there were various episodes illustrating students' responses to the CLES. More attention was paid on scale of Student Negotiation, for which students were asked to indicate how often they have opportunities to discuss, explain and talk about their learning with other students. It was evident that, in most lessons, most students discussed their work with other students in their group and, occasionally, with students from other groups, especially during times when groups were cross-checking data with other groups. Students seemed to be explaining their ideas to their group, to share their ideas, and decide which ideas were the best.

One reason to explain why Thai students had a high degree of opportunity to share their ideas with their peers is that today, cooperative learning is one of most well-known teaching strategies among the Thai teaching population and there are large number of students in classes. With these reasons, it is very hard for teachers to interact with students individually and they try to encourage cooperative learning in their classes. By using this kind of teaching strategy, students are provided with opportunities for negotiating their ideas.

Although teachers use cooperative learning techniques to encourage student negotiation, the average mean of this scale corresponded to s*ometimes*. Observations and interviews with students generally reflected this result. Some teachers had effective skills in providing learning situations that encouraged students to negotiate with one another, while some who had students working in groups without effective learning tasks were not successful in encouraging students to negotiate their ideas with their peers. There are still a number of teachers who lack skills in designing

cooperative learning activities. They tend to use standard group work learning activities with the misconception that these are cooperative activities.

In conclusion, there were only three aspects of constructivism observable in Thai secondary school science classes. These aspects appeared to be related to the scales of Personal Relevance, Uncertainty, and Student Negotiation. Therefore, this result suggests that upper-secondary school science classes in Thailand emphasise the uncertainty of science or inquiry-centred learning, relevance with everyday life, and opportunities for student negotiation to happen approximately *sometimes* as perceived by students. But the other two aspects of constructivism assessed by the scales of of Critical Voice and Shared Control were at the level of *seldom* which means that students seldom complained to their teachers about their teaching performance. In addition, students are also seldom involved in helping their teachers control the learning environment. The quantitative data were congruent with qualitative data which indicated that cultural and social context could have influenced students' responses to the CLES.

5.4 FEEDBACK TO TEACHERS IN THE FIRST PHASE

Whereas Figure 5.1 in section 5.1 depicts average student actual and preferred classroom environments for the whole sample of 17 science classes of seven teachers, Table 5.3 provides the information of each individual teacher's students' actual and preferred classroom environments. The shapes of the profiles of each teacher's students' perception of the classroom environments are similar (see Appendix J). This means that students' perceptions of their science classroom environments of each class are almost the same.

The mean scores of the CLES (see Table 5.3) were reported to seven teachers in graphical format (see Appendix J) to arouse their interest in using the CLES to improve their own classroom environments so that they were willing to be selected for case studies in the next phase of the study. These charts included comparisons of student actual and preferred environment. Most teachers were surprised by the information collected. Even though changes in classroom environment were not assessed in this phase of the study, some teachers indicated a personal desire to

improve areas of their classroom environments. Although the questionnaire results were strictly confidential, several teachers reported informal sharing of data and results for their classes with other teachers in the sample.

Table 5.3
Average Item Means of Each Teacher for Each Scale of Students' Perceptions of Actual and Preferred Forms of the CLES (N=606)

Teacher	Test	Personal Relevance	Uncertainty	Critical Voice	Shared Control	Student Negotiation
A	Actual	3.03	3.52	2.48	2.38	3.32
	Preferred	3.93	3.96	3.84	3.69	3.95
B	Actual	3.00	3.39	2.3	2.00	3.41
	Preferred	4.18	4.03	3.64	3.74	4.06
C	Actual	3.20	3.28	2.23	2.05	3.16
	Preferred	4.02	4.08	3.57	3.62	4.02
D	Actual	2.62	3.15	1.87	1.73	2.76
	Preferred	3.91	4.01	3.40	3.45	3.79
E	Actual	2.83	3.21	2.05	1.81	2.81
	Preferred	4.01	4.2	3.70	3.51	3.96
F	Actual	2.86	3.29	2.40	2.42	3.17
	Preferred	3.86	4.03	3.47	3.57	4.04
G	Actual	2.72	3.09	2.13	1.88	2.38
	Preferred	3.73	3.93	3.37	3.34	3.70

5.5 SUMMARY

The information described in this chapter presents a typical upper secondary school science classroom environment in Thailand related to constructivism. Quantitative data from the CLES were combined with qualitative information from interviews and classroom observations to provide a description of average students' perceptions of the actual and the preferred classroom environment for the 17 science classes of upper secondary schools in Nakornsawan Province, Thailand in this study.

The average science classroom learning environments in Thailand in this study had relatively high levels of student perceived Uncertainty, Student Negotiation, and Personal Relevance, but the level of Shared Control and Critical Voice were consistently lower.

When students' actual and preferred perceptions were compared, a pattern similar to that found in previous research (Fisher & Fraser, 1983c) emerged. On all five scales, students preferred a more favourable classroom environment (in terms of greater Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student negotiation) than what they perceived as being actually present. There was a statistically significant difference between the students' actual and preferred environments on all the five scales. This suggests that students would prefer to have more opportunities to be given personal relevance, to know the uncertainty nature of science, to express their critical voice, to have a shared control in the class, and to negotiate meaning with other students than was perceived to be present in the science classroom.

In addition, feedback was provided to the teachers in the sample in that all of them were provided with the results of the differences between average item means of their students' perceptions of the Actual and Preferred Form of the CLES in the form of graphical format.

In the next Chapter, the effectiveness of constructivist teaching on improving science classroom environments is described. This includes the description to answer the third and fourth research questions: Are teachers able to make use of learners' responses to the CLES to improve their own classroom learning environments?; and Does constructivist teaching improve students' attitudes towards science learning activities and self-efficacy?

CHAPTER 6

EFFECTIVENESS OF CONSTRUCTIVIST TEACHING ON IMPROVING LEARNING ENVIRONMENTS

Whereas Chapters 4 and 5 focused on the assessment and description of the constructivist classroom environments in Thailand, this chapter reports the third phase of the study that assesses and describes the effectiveness of constructivist teaching on improving learning environments, i.e., whether teachers are able to use constructivist teaching through an action research process in order to improve their classroom environments. The results of this investigation can be used to answer the third and the fourth research questions: Are teachers able to make use of learners' responses to the CLES to improve their own classroom learning environments? and Does constructivist teaching improve students' attitudes towards science learning activities and self-efficacy?

This chapter first describes the selection of three case-study teachers from the original sample and their attempts to use constructivist teaching to improve their own classroom learning environments. Each of these three teachers selected a class whose learning environment she desired to change. The theoretical underpinning of this phase of the study resulted from two paradigms. Firstly, the teachers followed the methodology to improve classroom environments used in previous studies (Fraser & Deer, 1983; Fraser & Fisher, 1986; Fraser, Seddon, & Eagleson, 1982; Sinclair & Fraser, 2001; Yarrow & Millwater, 1995). Secondly, the concept of constructivist teaching created by Brooks and Brooks (1999), and Taylor, Fraser, and White (1994) was used. As the pretest, each student in the sample responded to the actual and preferred versions of the CLES and to the eight-item 'Attitudes to Science Learning

Activities' and 'Self-Efficacy' scales which was based on the Test of Science Related Attitudes (TOSRA) (Fraser, 1981b) and a scale developed by Jinks and Morgan (1999). Based only on the results of the CLES, the teachers developed their own action plans in an attempt to change their classroom environments.

This chapter next describes the methodology in which the three case-study teachers used both the quantitative and qualitative data obtained from their students. Each teacher's initial classroom environment and students' attitude pretest results, improvement plan, interventions in the class between assessments, and the final posttest results are then discussed. The total sample was comprised of all the students from the three classes and their teachers. This phase of the study was conducted during the second semester of the academic year 2002 (from the last week of October 2002 to the end of February 2003).

6.1 CASE STUDY SAMPLE

From the database of seven teachers and their 17 classes described in Chapter 5, three teachers were selected to continue in the third phase of the research. This selection was based on the teachers' readiness to implement constructivist teaching in their classrooms, their strongly-expressed intention to improve their own classroom learning environments, the feasibility of the researcher to visit their classrooms, and the permission of the principals to let the researcher conduct the study in their schools.

The three teachers were told why the researcher thought that they were unique and (that they) desired to continue the study in the following academic term. All three teachers allowed the researcher full access to their classes for this phase of the study. A brief biography of each teacher is included in the case studies.

Two of these three teachers taught in Nakornsawan School while the other taught in Ladyaowittayakhom School. The first which was the largest and most well-known secondary school in the province was situated in the heart of Nakornsawan Province while the second was situated 40 kilometres from the central part of this province.

Students in the case-study sample from the class of Teacher A were regarded as middle academic standard in science. Teacher B's case-study class contained the most able students of the school in science. The students in Teacher D's case-study class, although being science students of grade 11, were regarded by Teacher D as not good at science.

6.2 THEORETICAL UNDERPINNINGS

The Constructivist Learning Environment Survey was developed to enable teachers to measure the extent to which they adopt constructivist notions in their classes and assist teachers to reshape their teaching practice (Taylor, Fraser, & Fisher, 1997). Consequently, in this phase of the study, the CLES was selected to investigate whether teachers were able to make use of the learners' responses to the CLES to improve their own classroom environments. The value of the research described in this thesis is that it demonstrates the effectiveness of constructivist teaching on improving learning environments.

Each of the three teachers chose one of her classes that she believed needed a better constructivist classroom environment. The pretest of students' perceived actual and preferred constructivist classroom environments and students' attitudes towards learning activities and students' self-efficacy were not conducted until four weeks after the beginning of this semester. This was to allow time for a consistent classroom environment to develop.

However, before any of the above occurred, a two-hour seminar was conducted with the three case-study teachers to provide information on the background of the classroom environment study, particularly about the CLES questionnaire and its use in stimulating self-reflection and improvement.

6.2.1 Method for Using Constructivist Teaching for Improving Classroom Environments

The basic method in this phase of the study for using constructivist teaching to improve the constructivist classroom environment in each class was adapted from

previous research (Fraser & Fisher, 1986; Sinclair & Fraser, 2001; Yarrow, Millwater, & Fraser, 1997) and involved:

1. assessing the students' perceived and preferred classroom environments;
2. providing the results to the teacher and assisting the teacher in making action plans to improve her own classroom environment;
3. collecting qualitative data from students about the class, activities and the teacher;
4. holding weekly individual meetings with the teacher concerning class occurrences and specific techniques that could be used in an attempt to change the actual environment; and
5. re-assessing the students' actual environments.

6.2.2 Constructivist Teaching

For the purposes of this phase of investigation, constructivism followed the definition of Brooks and Brooks (1999), as well as the constructivist model proposed by Taylor, Fraser, and White (1994).

As defined by Brooks and Brooks (1999), a social-constructivist classroom is one in which students are viewed as partners in the learning process. Learning is a filter by which each student creates personal meaning through peer negotiation of the sensory experiences that are provided. The teacher's role in this type of classroom changes from someone who practically provides information on a certain topic to someone who orchestrates the environment and provides opportunities for students to create meaning through active and relevant experiences. In a constructivist classroom, student questions and input are highly valued and encouraged, as opposed to a more traditional classroom where the existing curriculum (often a science textbook) dictates student learning. Table 6.1 compares traditional classrooms with constructivist classrooms.

Taylor, Fraser, and White (1994) emphasized the social constructivist perspective. They noted that this constructivist perspective included both prior knowledge and interpersonal negotiation of meaning as the fundamental components in creating

opportunities for conceptual understanding. From this constructivist perspective, the role of the teacher drastically transforms from the traditional objectivist role of 'giver of knowledge of the established curriculum' to 'mediator of students' encountered with their social and physical worlds' (Taylor, Fraser, & White, 1994, p. 3). The social constructivist teacher facilitates student interpretations and reconstructions of individual knowledge and provides opportunities for students to engage in critical dialogue regarding the viability and implications of their ideas on socially constructed knowledge and values in the classroom and broader community.

Table 6.1

Traditional and Constructivist Classroom Environments

Traditional Classrooms	**Constructivist Classrooms**
Curriculum is presented part to whole, with emphasis on basic skills.	Curriculum is presented whole to part with emphasis on basic skills.
Strict adherence to fixed curriculum is highly valued.	Pursuit of student questions is highly valued.
Students are viewed as "blank slates" on to which information is sketched by the teacher.	Curricular activities rely heavily on primary sources of data and manipulative materials.
Teachers generally behave in a didactic manner, disseminating information to students.	Teachers generally behave in an interactive manner, mediating the environment for students.
Teachers seek the correct answer to validate student learning.	Teachers seek the students' point of view in order to understand students'
Assessment of student learning is viewed as separate from teaching and occurs almost entirely through testing.	Assessment of student learning is interwoven with teaching and occurs through teacher observations of students at work and through student exhibitions and portfolios.

(adapted from Brooks & Brook, 1999. p. 17)

6.3 ASSESSMENT INSTRUMENTS

There are two assessment instruments in this phase of study: the CLES questionnaire and the Attitude Questionnaire (as described in Chapters 2 and 3). The students completed the 25-items Thai version of the CLES, in both its Actual and Preferred Forms. The CLES scales are Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation.

The Attitude Questionnaire in this study is composed of two scales: one is the Attitude to Science Learning Activities and the other is the Self-Efficacy Scale. Each scale has eight items. The first scale measures student attitudes to important aspects of the classroom environment, including their anticipation of the activities, their sense of worthwhileness of the activities, and the impact of the activities on student interest, enjoyment and understanding. The second scale assesses students' sense of their own ability in learning science.

6.4 ADMINISTRATION OF INSTRUMENTS

The researcher administered the Actual Form of the CLES, the attitude questionnaire, and the Preferred Form of the CLES to each participating teacher's class. Because these three selected teachers participated in the study during the prior semester, the returning grades 10 and 11 students were familiar with the questionnaire. In order to ensure confidentiality for the students, the teachers left the rooms, thus allowing the researcher to administer the questionnaire, monitor its completion and secure its enclosure in a sealed envelop. The researcher explained the purpose of the questionnaire, read the instructions and answered any individual questions that the students asked. The remaining time of the class period was spent by the researcher observing interactions between each teacher and her class, and asking students informal questions while they were working. Students were open and frank with their comments, including, *"May I tell you about my bored class (he laughs) by telephone?" "Do you want to know the names of my friends who always produce bad environments in my class?"*

Scale scores from the Students' Actual Form and Students' Preferred Form of the CLES questionnaire were tabulated and reported to the teachers in a graphical format. These charts included student actual and preferred environments through a constructivist perspective.

In an attempt to use constructivist teaching to improve aspects of a classroom environment during the next ten weeks of the study, each teacher selected an area (or more than one) of specific concern, based on the differences between the scale means of the students' actual and preferred scores and designed an improvement plan of action with the researcher. The researcher visited the classes once a week during the next ten weeks prior to the posttest in order to observe the classes and interview the students. The researcher interviewed several different students during each visit. At the end of the ten weeks, all students completed the students' actual version of the CLES as a posttest. Results were analyzed by the researcher who presented them to the teacher privately. The teacher and researcher discussed the results and possible explanations.

6.5 QUALITATIVE DATA FROM STUDENTS

Qualitative data from students came from using student interviews in all three case-study classes. Because the students included their names on the questionnaires, the researcher was able to ask students during interviews to elaborate their answers. Additional opinions from the students were collected during the entire ten weeks of this part of the study. This information was gathered from individual students at their desks, or in the form of group interviews. These data provided important insights into the students' perceptions of their class environments. More detail of students' perceptions of their classroom environments can be found in sections 6.6.3.2, 6.7.3.2 and 6.8.3.2.

6.6 CASE STUDY OF TEACHER A

Teacher A was female with 16 years of teaching experience in science. She was 40 years old and said that she loved and wanted to improve her teaching to be more effective in encouraging students' learning and that she wanted to practise more

about how to teach using a constructivist approach. She felt that her greatest teaching strength was her strong willingness to improve her teaching and students' learning. She was studying in a graduate course of Curriculum and Instruction and intended to write her thesis related to constructivist teaching. She taught both tenth and eleventh grade science classes of physics. Almost all her students said that she had very good sense of humour. She had a teaching load of 18 hours, plus three hours of additional teacher tasks, per week.

Teacher A's physics class of grade 11 in this study consisted of 21 male and 23 female students. This physics course focused on electricity and magnetism for four hours per week for a total of 18 weeks. In this course, students were expected to have enough understanding, skills and attitudes to explain the phenomenon and solve problems related to electricity and magnetism.

6.6.1 Pretest Results for Teacher A's Class

Table 6.2 shows the pretest actual and preferred classroom environment scores of Teacher A's class. The average preferred pretest scores were higher than actual average scores in all five components of the CLES.

Table 6.2
Differences between Pretest Scores on Actual and Preferred Forms of the CLES for Teacher A's Students in the Sample (n=44)

Scales	Mean		Difference	Standard Deviation	
	Preferred (P)	Actual (A)	(P-A)	Preferred (P)	Actual (A)
Personal Relevance	4.13	3.16	0.97	0.51	0.67
Uncertainty	4.07	3.63	0.44	0.61	0.77
Critical Voice	3.38	2.13	1.25	0.71	0.77
Shared Control	3.41	2.31	1.10	0.68	0.75
Student Negotiation	3.75	3.44	0.31	0.64	0.80

The differences between the students' pretest actual and preferred scale scores were 1.25 for Critical Voice and 1.10 for Shared Control, but were lower for the Personal Relevance, Uncertainty and Student Negotiation scales (0.97, 0.44 and 0.31, respectively).

6.6.2 Improvement Plans of Teacher A

Based on the results of the pretests (see Table 6.2 and Figure 6.1), Teacher A decided to improve students' perceptions of two dimensions of her classroom environments: critical voice and shared control.

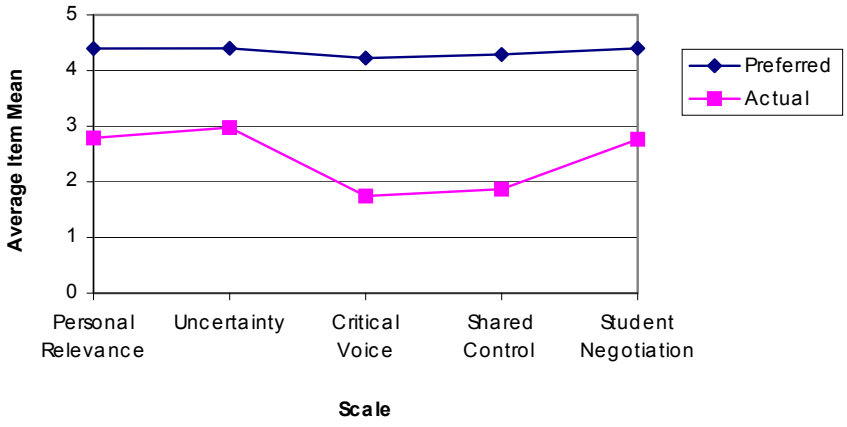

Figure 6.1. Differences between pretest scores on Actual and Preferred Forms of the CLES for Teacher A's students in the sample (*n* =44).

Focusing on the pretest results, Teacher A thought that her style of teaching, with an emphasis on direct teaching, was the cause of the results, particularly for critical voice. So she decided to change this style of teaching by using new ways of speaking during conversations with her students. During the conversations with her students, she planned to question them both individually and in the group. She believed that this type of conversation would make students more willing to express their ideas about learning activities that were confusing or about anything that prevented them from answering or discussing. This discursive technique involved three ways of speaking: 1) guided discussions, 2) student-generated inquiry discussions, and 3) peer collaborations. She also believed that student critical voice could occur when

she set up discourse structures that explicitly elicited student questions, engaged students in conversations about familiar contexts in which they had made many observations over a long period of time, created comfortable discursive environments in which students could try to understand one another's thinking, and established small groups where students were collaborating with one another. Typically, she planned to elicit students' suggestions about her teaching by using two kinds of questioning techniques. The first one was asking questions that develop conceptual understanding. These included questions to help students clarify their meanings, explore various points of view in a neutral and respectful manner, and monitor the discussion and their own thinking. The second one was practising quietness through long wait times, attentive silence, and reticence.

To improve students' perceptions of critical voice and shared control, she used group investigation techniques and effective learning assessment tasks. She asked all of her students to work cooperatively to make one effective product. In this case, students in class planned and managed to produce an electrical instrument that would prevent someone from being kidnapped by using a message from calling-by-phone. By using this technique, students needed to control themselves and others in order to produce the product.

Regarding the assessment tasks, she included students responding orally, writing essays, performing series of manipulations, and selecting from a list of alternative possibilities. These assessments included some tasks that needed to be performed independently and others that required student cooperation within a working group. She said; *"With this kind of the assessment, students will have more opportunities to develop as autonomous learners who feel that they are able to share control about their learning with the teacher."* She believed that this could be achieved partly by providing opportunities for students to exercise a degree of control over their learning that extended beyond the traditional practice of working 'independently' in class on sets of prescribed problems.

Teacher A said that she intended to provide her students with science experiences that were enjoyable, comprehensible and useful.

In summary, Teacher A decided to make plans to improve her classroom environment by using these four constructivist teaching techniques:

1. Using new ways of speaking during conversation with her students.
2. Using group investigations for students to produce a class product on the theme of electricity and magnetism.
3. Providing students with effective learning assessment tasks.
4. Providing students with experience of science as an enjoyable, comprehensible and useful activity.

6.6.3 Results and Interpretations of Teacher A's Interventions

6.6.3.1 Observations of Interventions by Teacher A

When the time came for the classroom observations, students in Teacher A's class had become familiar with the researcher. When the researcher came in to their class before Teacher A, everybody smiled and showed their respect and one student shouted to the researcher to show how proud he was of receiving the first prize for having the cleanest classroom. Teacher A used the jigsaw technique (Johnson, Johnson, & Smith, 1998) to empower students to express Critical Voice and Shared Control. She told her students that in this class this technique would be used often. After that she asked students to read the details of this technique in their worksheets.

Every student within each jigsaw group received one specific topic or task to do. Later, members from different jigsaw groups, who studied the same topic, joined together in what were named the expert groups. Within each expert group, the students worked cooperatively on the learning tasks. These learning tasks required students to learn the topic in depth, read the content, and exchange ideas, to solve problems, while posing questions to their expert peers. Later, the students decided, planned, and prepared materials for teaching their peers. This peer teaching took place when they returned to their original jigsaw group.

After describing how to calculate the value of electric voltage, electric current and electrical resistance, Teacher A asked the students of each home group, (about seven members), to solve one of six problems. In home groups, each student had responsibility to: 1) make a decision about which choice of given problem was

correct; 2) draw an electric circuit related to the given problem; and 3) write an explanation to support the answer. After that each student from the home groups went to the expert group to share what was done. Group discussion in each expert group was used to find the final answer to the specific task. Sharing the answer with the home group followed and helped every student better understand how to reach an answer for each of the given problems. During the activity, Teacher A moved around the class to help her students.

Once students realised how to learn in this activity, they actively did all the learning tasks. In small groups, students expressed their ideas, listened to others and helped each other to solve the problems given by Teacher A. Almost all students smiled, laughed and concentrated on summarizing their own ideas or those of their peers. Some groups raised their hands to request help when they needed it. When Teacher A noticed these, she smiled and went quickly to help the students.

During the researcher's second visit, Teacher A told her students a story about one of her students who could not get a job and earn a living because he could not set the multimeter when he was tested. While listening to this story, all students showed an expression of interest and attentiveness on their faces. One student said:

> *I know why you told us this story. You want all of us to be interested in what you will teach, don't you?*

Although Teacher A did not expect to improve personal relevance, she did it by relating the importance of understanding about how to use a multimeter to the opportunities to get a job and earn a living. This made the students interested in the topic of their learning and in learning how science can be part of their out-of-school life.

During the third observation, Teacher A taught by using a task based on the group investigation teaching model. From the discussion with Teacher A during the period of designing the improvement plan for her class, Teacher A said:

I think that a class project task through a Group Investigation method will enable my students to cooperatively plan ways and means of organizing and managing themselves and their inquiry efforts to reach academic science objectives.

In this instance, the researcher observed that students in this class showed their initiative with their ideas and responsibility for their academic work, as individuals, as members of study groups, and as members of an entire class. In implementing group investigation in the class, Teacher A asked her students to provide the names of products related to science concepts about electricity and magnetism that they wanted to construct. She spent the time posing questions to arouse students' interest and curiosity in the targeted area of concern. Students then engaged in guided tasks to suggest some possible kinds of instruments or methods to support the class product. Working together in small groups, students shared their ideas and made a decision to make a product and present it to the class. In this case, the students of Teacher A made a decision to construct an electrical instrument that would prevent someone from listening to a telephone communication between two people.

From the observations of group investigation activities, students became active within a team conducting disciplined inquiry toward finding solutions and showed the important learning behaviours related to the five dimensions of the CLES. These behaviours were: 1) asking questions about things that interested them; 2) planning together the objectives, content, and strategies of their interest group inquiry; 3) organizing and managing how they would go about doing the research; 4) interpreting the information and forming conclusions in light of their personal experiences and prior knowledge of the initial problem they selected; 5) interacting with their peers in a constant exchanging of information and ideas; and 6) operating and practising social skills in a social community that was representative of the world outside the classroom. During group investigation activities, students as group members cooperated in organizing themselves as research teams, in planning their inquiry, in carrying out and monitoring their plans, and in pooling their efforts to develop a final product. Their plans involved a division of work among members so that the research activities combined independent study as well as work in pairs and small groups. When they had completed their research, group members integrated

and summarized their findings and decided how to present the essence of their work to their classmates. Teacher A encouraged students to pool their groups' findings to generate plausible solutions and construct an original class product.

The following are quotes from the transcript of field notes made during the observations to illustrate the classroom environment through a constructivist perspective:

To express their critical voice and to complain about the activity that was confusing them and prevented them from learning, one student asked:

> *Why do we have to write an explanation to support the answers? It is very difficult to do. We don't want to explain. Writing to explain something is difficult, isn't it?*

To express their sense of shared control with the teacher about their learning, a confident female student said to the teacher:

> *Please give us more time to do this activity. We can't finish it in time.*

Again, based on shared control, the students helped Teacher A to decide what activities were best for them. Some students suggested to Teacher A that they preferred to go with one or two of their friends to show, express ideas, or answer questions more than to do an activity alone. A student said to Teacher A:

> *Previously, I did not dare to do something alone in front of the class, I felt shy and that my friend might think I was ridiculous. However, if I have the chance to do something with my friends I think the situation will be better.*

When this student stopped speaking, another in this group said:

> *I think the same. Is it possible for you to let us do it like this? It will help me feel better?*

Teacher A often demonstrated good humour. For example, when she asked her students about the exam results, a student said that she failed. She then gave feedback to the student in the following way:

> *You have the good luck of experiencing not passing before you become university students. It is a necessary experience of being a university student.*

When she asked a female student to answer a question, and some male students stood up to answer, she said:

> *You are male or female. I think you are not sure you are male or female.*

Teacher A also often gave positive feedback about unclear answers from the students to encourage them to continue their learning:

> *Somsak, because of your ability to answer my question today, I think your group had high scores because of you.*

> *Today I feel happier than before, all of you now have better social skills to help your group reach group goals.*

The students looked happy in their science lessons. Almost all the students smiled and laughed. Some students moved to share their ideas with their friends. One shy female student said to the researcher:

> *Although physics is very difficult for me, and for almost all students in this class, we feel happy and only a little serious.*

Furthermore, Teacher A designed activities that allowed students to have a critical voice about her teaching. She asked students to write very short answers (within one minute) to three questions. She wrote these three questions on the black board:

1. *How do you feel about my teaching today? 2. What difficulties of learning did you see during my period of teaching today? 3. What do you want me to do and not do in the next period of study?*

She then told the researcher:

> *By using this technique, my students will be happy and feel free to express their ideas about my teaching and their problems in learning.*

6.6.3.2 Interviews of Students about Teacher A's Interventions

During one visit, some students were asked about how often they spoke out directly to Teacher A about her teaching and the difficulties they faced, these students said:

> *Although my teacher sincerely tells us to happily criticise her teaching, I and almost all of my friends wouldn't dare to speak out directly to her because we feel that she is excellent in teaching and she will be sad if she knows that her teaching is not perfect.*

> *In this class, my teacher wants all of us to be able to pass the entrance to the university, she lets us say anything that she can do, but we appreciate her style of teaching.*

It is noteworthy that more than half of the students preferred to critisise their teacher's teaching behaviour by writing them on a half-sheet paper ('one minute paper' technique). Four groups of students said that they felt safer and happier not to speak directly to their teacher about such behaviour, but rather write to her.

The following were their comment about using the above technique:

> *By this way, my teacher cannot know the name of the student who sent her the feedback, but she could understand what student wanted her to do.*

About three to five minutes before the end of the lesson, I usually write to explain to her about what I do not understand or any problems or difficulties I had about my learning. She always discusses these problems in the next lesson.

My friends and I love to give our feedback about our teacher's teaching behaviour to her in writing. Almost all students love this activity. However, we are afraid that sometimes she may be sad or get angry with us.

The following were the responses of some students when the researcher asked them about the extent of shared control in their class. The researcher asked the students whether their teacher invited them to share with her the control of the learning environment.

Yes, often. She often gets us to solve problem exercises. In doing this, we can share with her the time to finish this work, how to check the right answers, or sometimes how to present the answers.

Yes, almost always. In my class, Teacher A wants all of us to be able to pass the entrance examination. So, she always provides us with various kinds of exercises, in order to help us have a good understanding about the science concepts of the study. It is necessary for us to work cooperatively in small groups to solve the problems and present them with good explanations. We have many opportunities to work hard and manage our learning. We must control ourselves. My teacher does not give us direct answers. She wants us to solve problems by ourselves.

Quite often, especially in group investigation activities. During our group project, we have responsibilities to plan, do, assess and evaluate our work. Our teacher only encourages us to work and gives some necessary ideas for us to manage our research. This means that we share our control with my teacher, doesn't it?

Almost always. Before the end of each lesson, I feel that I have the responsibility to write about what I should or would like to participate with my teacher to improve my learning. For example, some topics that should be decreased or increased, assessment activities or interested learning activities that we would like her to provide. One of our suggested learning activities is a fieldtrip and exhibition. My friends and I love to study outside the school. We wanted to go to a natural setting to see the real world. We also prefer to manage our learning exhibition. We want our teacher to use the exhibition as our assignment and give high scores to us. We do not like assessment by testing. We write to explain these needs to her. Luckily for us, she accepted all these ideas. Consequently, we were happy in our science class.

6.6.3.3 Posttest Results for Teacher A

Figure 6.2 and Table 6.3 show that improvement occurred in the students' perceived environments between pretest and posttest on all dimensions of the CLES ($p<.01$ and $p<.001$). For the Critical Voice and Shared Control scales, on which changes were attempted, the change was positive, 0.68 and 0.76, on the scale means (see Table 6.3). The scales, which were not targeted by the teacher for improvement namely, Personal Relevance, Uncertainty and Student Negotiation also showed improvement of 0.63, 0.35 and 0.34, respectively.

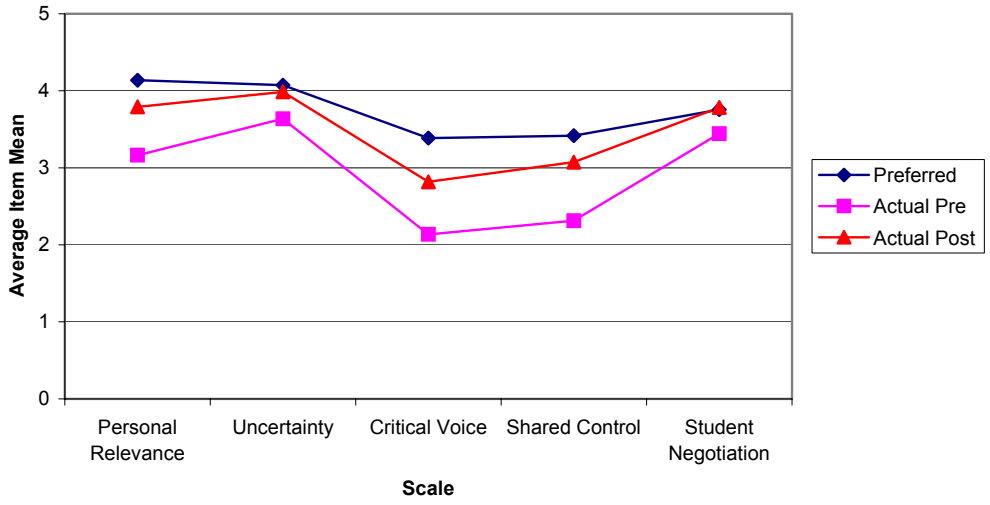

Figure 6.2. Preferred, actual pretest and actual posttest scores of Teacher A's students (n =44).

Table 6.3

Actual Pretest and Posttest Scale Means and Standard Deviations of Teacher A's Students (n=44)

Scale	Mean		Difference	Standard deviation		t
	Pretest (Pre)	Posttest (Post)	Post-Pre	Pretest (Pre)	Posttest (Post)	
Personal Relevance	3.16	3.79	0.63	0.67	0.36	6.058***
Uncertainty	3.63	3.98	0.35	0.77	0.45	2.999**
Critical Voice	2.13	2.81	0.68	0.77	0.80	4.597***
Shared Control	2.31	3.07	0.76	0.75	0.82	5.364***
Student Negotiation	3.44	3.78	0.34	0.80	0.66	3.373**

**p<.01, ***p<.001

In summary, the observation and interview data generally supported the questionnaire results of the improvement of the mean scores of the CLES on the dimensions of Critical Voice and Shared Control. In doing all of the activities described earlier, students expressed critical voice and negotiation with one another. Some students commented about the learning activities that they liked or disliked. They voiced their opinions to their peers and talked to other students about how to solve the problems. Some students asked their friends to explain their ideas. Almost all students listened carefully to the ideas of their peers. A short answer at the end of the lesson proved to be effective instrument for students to give feedback and share with their teacher the control of their learning environments. The good humour of Teacher A resulted in her students having fun and enjoying the lesson. Furthermore, such humour motivated students to be interested in learning. In addition, because the content of the lesson was relevant to the students' lives, students enjoyed their lessons and were interested in their learning activities. Thus, the improvement suggested that Teacher A was able to make use of her students' responses to the CLES in order to improve her classroom environment. Teacher A was pleased with her results and plans to continue to implement constructivist teaching in her classrooms.

6.7 CASE STUDY OF TEACHER B

Teacher B was a 47-year old female with 21 years of science teaching experience in biology. She held a Master of Science Education degree and was selected by the Ministry of Education as a 'Master Teacher of Science'. Last year she was trained in implementing constructivist teaching in the classroom. Now she is teaching biology to grade ten science classes and general science to grade nine. She said that she would love to participate in this research and was willing to use a more constructivist teaching approach in her classes. She felt that her greatest teaching strength is her good relationship with her students and her ability to create various kinds of instructional media to improve students' concepts of biology. Her teaching load per week was 21 hours with an added extra three hours for school teacher tasks.

In this study, Teacher B taught a grade 10 biology class which consisted of 39 students of both genders. These students were those classified as high achievers in

science learning in their school. This biology course focused on ecology, and lasted for two hours per week over 18 weeks. In this course, students were expected to have enough understanding, skills and attitudes about relationships between organisms and environments to be able to solve problems related to ecology.

6.7.1 Pretest Results for Teacher B's Class

Table 6.4 shows the pretest actual and preferred classroom environment scores of Teacher B's students. The average preferred pretest scores were higher than the actual average scores on all five scales of the CLES. The difference between the pretest actual and preferred scale scores were respectively, 1.37, 1.22, 0.90, 0.66 and 0.48 for Critical Voice, Shared Control, Personal Relevance, Uncertainty and Student Negotiation. Greater differences between the actual and preferred mean scores occurred on the Critical Voice and Shared Control scales.

Table 6.4
Differences between Pretest Scores on Actual and Preferred Forms of the CLES for Teacher B's Students in the Sample (n=39)

Scales	Mean		Difference (P-A)	Standard Deviation	
	Preferred (P)	Actual (A)		Preferred (P)	Actual (A)
Personal Relevance	4.39	3.49	0.90	0.41	0.42
Uncertainty	4.39	3.73	0.66	0.45	0.50
Critical Voice	3.44	2.07	1.37	0.56	0.49
Shared Control	3.53	2.31	1.22	0.75	0.59
Student Negotiation	4.20	3.72	0.48	0.50	0.42

6.7.2 Improvement Plans of Teacher B

After considering the results of the pretest (see Table 6.4 and Figure 6.3), Teacher B decided to attempt to improve the constructivist nature of her classroom environments in the areas of critical voice and shared control.

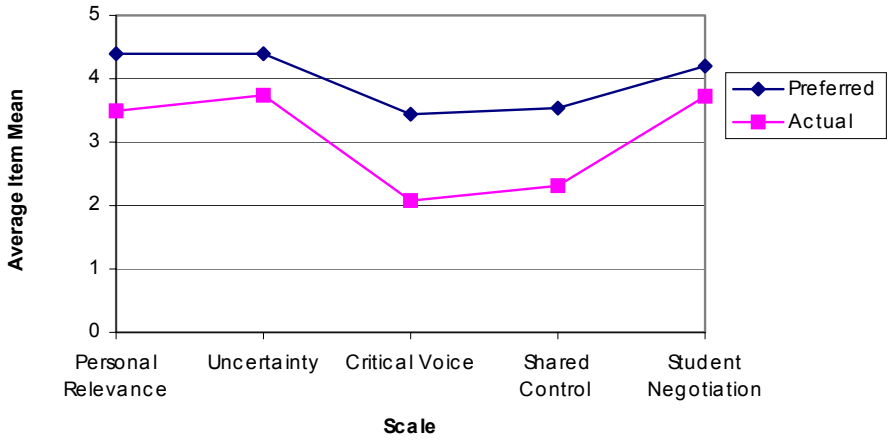

Figure 6.3. Differences between pretest scores on Actual and Preferred Forms of the CLES for Teacher B's students in the sample (*n* =39).

During a conversation with the researcher, Teacher B said:

> *I believe that active learning activities could enhance my students' perceptions of their classroom environments. Significantly, to improve my students' perceptions of Critical Voice and Shared Control, I plan to make my students understand clearly at the beginning of each lesson what the expected learning outcomes are, the learning tasks they must do, learning activities, assessment and time available. Also, I intend to encourage my students to give any comments and share control of my teaching.*

First, she planned to change her role to be a more constructivist teacher who encourages her students to be more active in their learning. By doing this, she believed that her students would try harder to reach their expected learning outcomes. She said to the researcher:

In my class, I will tell my students to express their ideas on my teaching, if they believe that my teaching behaviors or lesson plans are not relevant to their learning, they could give me some suggestions.

Her new role was to be that of a teacher using laboratory activities whose purposes ranged from the verification of the principles of relationships to engagement in inductive activities where students identified relationships from data which they had gathered. She believed that critical voice and shared control would be enhanced when laboratory activities incorporated metacognitive experiences and focused on the manipulation of ideas instead of just materials. Also, the practical lessons should have hands-on and mind-on activities incorporating discussions for constructing explanatory models, analogies, diagrams, graphs, and simulations. She would emphasise the importance of critical voice as students engaged in pre-laboratory and post-laboratory discussions and participated fully in activities in which the teacher mediated the development of their understandings. In relation to hands-on activities, Teacher B said:

It's phenomenal…this is the way science should be taught … this is good teaching … a good way for students to learn … this is the way I should teach secondary school student science.

Second, this teacher wanted to focus on cooperative learning activities. She planned to use this learning technique to improve students' perceptions of critical voice and shared control. Jigsaw was one of the techniques in which the teacher planned to have the students work in small groups. These groups were called jigsaw groups as described earlier in relation to Teacher A in section 6.6.3.1.

Teacher B also decided to change her approach to questioning and class discussion. She planned to include class discussions in which she engaged students in questioning and answering both individually and cooperatively. Importantly, she would accept varied responses and use them in some ways. Thus, these answers would not be a cause for fear or ridicule for students. She also planned to ask students to pose questions about real-life problems while engaging in a variety of learning activities, such as reading the press or scientific articles, analyzing tables

and graphs, and creating posters and advertisements related to the problem. Teacher B believed that if students were asked to answer or discuss some problems, they might see some difficulties about the ways they were learning. This situation would encourage students to give her some feedback about any of her unsuitable teaching behaviours, or try to share control with her on their learning, such as the time made available for the learning activities.

In summary, Teacher B decided to plan to improve her students' perceptions on the scales of critical voice and shared control in her class. She made a particular attempt to engage students more in four types of child-centered learning activities as follows:

1. a science laboratory cooperative learning activity approach for the whole semester,
2. some kinds of cooperative learning activities,
3. class discussions, and
4. questioning.

6.7.3 Results and Interpretations of Teacher B's Intervention

6.7.3.1 Observations of Intervention by Teacher B

The two areas that Teacher B wanted to improve were critical voice and shared control. During class visits when the topic was the *Unit of Plant Division,* Teacher B implemented in her class effective cooperative learning activities in seven learning centres. These learning centres were outside the classroom but in one area of the school. This area, full of many plants of various divisions, was provided for teaching and learning about the plant kingdom and ecology. Each of the seven learning centres consisted of effective quantitative and qualitative learning materials related to the topic of plant divisions. These materials included worksheets for individual students, a science text, a set of colorful pictures, journals, lenses, questions to answer in a written format, and actual plants to observe. Four microscopes were also supplied to support the students' learning.

During the visit, Teacher B said to the researcher:

If I tell my students clearly about the learning tasks, they will be able to see what will happen in each lesson. Therefore, I will explain to them about the expected learning outcomes, learning activities, assessment and time available on each lesson and give them opportunities to question me about the design and management of the expected learning outcomes, the learning activities and the assessment criteria.

In this lesson, students were very interested in their learning such as reading, observing the material very carefully and asking the teacher about what they suspected. They actively helped their groups to finish the learning tasks in each centre by having group discussions and sharing roles in the group. Although a lot of critical voices between students about solving problems in each group were audible, there was only one student whose critical voice was about his teacher's practice. This student suggested that his actual learning centre was too warm with the sun, therefore it would be better to move this learning centre to another area.

A quote of a male student's critical voice about a better situation to learn is as follows:

Ajarn, now the sun is too warm, may I move my learning centre to another more convenient area?

Other evidence that indicated the dimension of shared control was an episode in which one student expressed responsibility for his learning, and a sense of his ability to share control with his teacher. This episode indicated that it was time for students in each group to move to another centre but the teacher did not indicate that they should do this. So he said to the teacher:

Ajarn, this is the time for all of us to move to other centres.

It was apparent during the observation of two hours of this unit that Teacher B was excellent in the following three dimensions:

1. providing effective cooperative learning group size and group tasks on suitable amount of time: students were divided into seven

heterogeneous groups to work cooperatively to reach their group learning goal with various kinds of activities such as observing, drawing, peer discussion and writing analyses together;

2. having good understanding about what she planned to teach: she could answer all questions asked by students; and
3. using skills to play roles of facilitator and manager: to provide learning source, material, and learning activities; and to solve the problems during student learning.

During the second observation, Teacher B's lesson was about the animal kingdom. She used an out-off class science laboratory technique. This lesson was on Saturday from seven o'clock in the morning until two o'clock in the afternoon. Her students in the small cooperative learning groups investigated a natural area of fresh-water swamp using provided questions and various science instruments. The students were asked to read the laboratory directions and complete the answers on the answer sheets. These answers required the students to use scientific skills in order to answer. Students in each group were asked to present a selected topic related to the topic of the lesson for the next classroom session.

It was observed on the school bus that they used to get to this lesson that many students sang songs together with their faces full of happiness. Furthermore, during their investigation to solve the learning problems, it seemed that students were not afraid to ask their teacher about their learning difficulties. They also maintained eye contact with their teacher. After coming back to school, the students suggested many ideas on how to assess and evaluate the learning activities and outcomes. They suggested that on the next occasion of a field study, they could help the teacher's preparation, such as preparing the breakfast and lunch, printing necessary sheets and programs of learning activities. They also suggested that the time of the next field study should be provision for recreation activities. They also suggested that the output of the lab experiment should be scored and used for one of the evaluation of this course.

It can be said that in this lesson, students expressed their ideas about their teacher to improve their learning. Furthermore, students could share with the teacher aspects

about the control of the learning activities. Although Teacher B planned to use jigsaw activities, the researcher did not see these.

6.7.3.2 Interviews of Students about Teacher B's Interventions

The followings are some quotes from interviews of students about the extent to which they had opportunities to express their comments on the behaviour of Teacher B:

> R: In this class, does your teacher encourage you to express your ideas about her teaching or about any difficulties you may have in your learning?
>
> *Yes, she always does. However, you know, almost all students who have learned with Teacher B concluded that she paid great attention to pushing her students hard for them to be able to pass the entrance examination, and she has succeeded in doing so. So we think that she has already known about, and used, effective teaching with us, and we don't want to intervene or comment on her teaching.*
>
> *Yes, she does. In this class, the learning activities are interesting. We enjoy learning in lab experiments. We do not want to change her style of teaching.*
>
> *Yes, she often asks us to tell her about our difficulties in learning. I haven't given her any comment on her teaching. However, some of my friends ask her about the assessment assignments and the inadequate time to do these. I enjoy learning in her lessons.*
>
> *Yes, often. However, my friends and I feel free to do this when we have a fieldtrip study or are learning outside the classroom.*
>
> *Yes, often. Usually in this class I plan the subtopics of the lesson with her. She always asks other students whether these subtopics were interesting or useful. If we say O.K., she says O.K. too.*

When students were asked whether they dared to share control in this class with their teacher, they said that they rarely did so. Usually this would happen only in cases regarding assessment. For example:

> R: In this class, does your teacher invite you to share with her control of the learning environment?
>
> *Yes, often. We always try to compromise with my teacher about what and when to assess and what type of task the assessment should be. We also try to compromise with my teacher about the time for completing the assignments.*
>
> *Yes, we sometimes ask her about the criteria for getting high scores in each learning task and she always is O.K. if we have reasonable suggestions.*

The above evidence from observations and interviews indicated that from the overall style of teaching, the students were provided with a constructivist teaching situation that enhanced the students' ability to express a critical voice and share control. This allowed students in this class to make the most of their personal effort of learning during science lessons. Furthermore, Teacher B's belief in the new national science curriculum could be the main reason for her classroom practices. She said:

> *Although a large number of Thai science teachers have enough understanding on how to implement constructivist teaching in his/her classroom, sometimes it is very difficult to do. This problem results from the pressure of a lot of content and insufficient time for instruction, and the needs of parents wishing their children will be able to pass the entrance examination.*

6.7.3.3 Posttest Results for Teacher B

Table 6.5 and Figure 6.4 show that improvement occurred in the students' perceived environments between the pretest and posttest on the two dimensions (Critical Voice and Shared Control) on which changes were attempted. For the Critical Voice and

Shared Control scales, the change was 0.96 and 0.86 in the scale means (see Table 6.5). The scales, which were not targeted by the teacher for improvement namely, Personal Relevance, Uncertainty and Student Negotiation also showed improvements of 0.60, 0.23 and 0.94, respectively.

Table 6.5
Actual Pretest and Posttest Scale Means and Standard Deviations of Teacher B's Students (n=39)

Scale	Mean		Difference	Standard deviation		*t*
	Pretest (Pre)	Posttest (Post)	Post-Pre	Pretest (Pre)	Posttest (Post)	
Personal Relevance	3.49	4.09	0.60	0.42	0.50	5.350***
Uncertainty	3.73	3.96	0.23	0.50	0.42	2.210*
Critical Voice	2.13	3.09	0.96	0.77	0.66	8.304***
Shared Control	2.31	3.17	0.86	0.75	0.69	5.952***
Student Negotiation	3.44	4.38	0.94	0.80	0.53	6.226***

*p<.05, ***p<.001

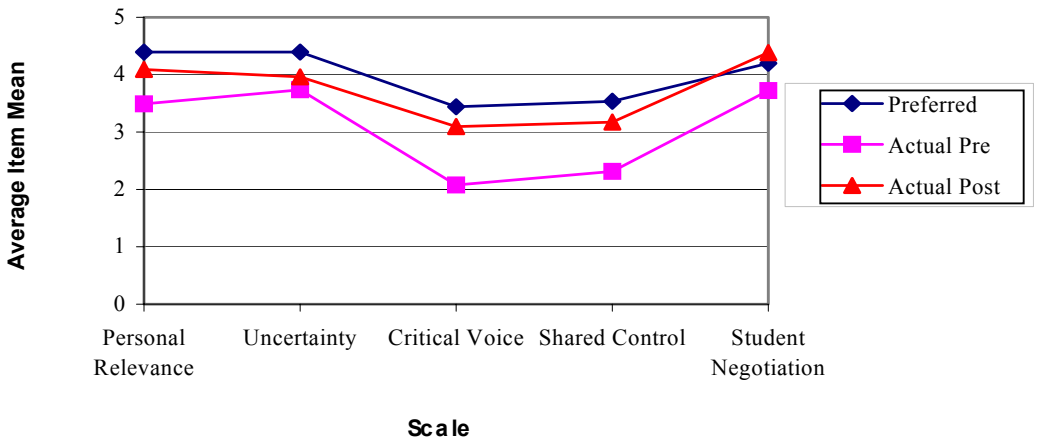

Figure 6.4. Preferred, actual pretest and actual posttest scores of Teacher B's students (n =39).

In summary, the quantitative data in Teacher B's class showed that there was an improvement in the students' perceived environment on all dimensions of the CLES. The classroom observation and interview data supported the questionnaire results. Thus, the improvement that occurred suggested that Teacher B succeeded in making use of her students' response to the CLES for improving her classroom environment.

6.8 CASE STUDY OF TEACHER D

Teacher D was a strong female teacher who had been teaching for 22 years. She was 46 years old and was very keen to develop her classroom learning environment. She believed that her greatest strength as a teacher was her ability to produce worksheets and other instructional materials that were attractive to students for learning science. She holds a Bachelor's degree in Science Education. She taught Grade 11 science and, during this study, she taught a biology course about the reproduction and growth of organisms. This course had a duration of 18 weeks with three hours per week.

Teacher D's class in this study consisted of 32 students. She said that although these students were science students, they were not good at learning science. She has a

heavy teaching load of 26 hours with three additional hours of school teacher tasks per week.

6.8.1 Pretest Results for Teacher D's Class

Table 6.6 and Figure 6.5 show Teacher D's students' pretest actual and preferred classroom environment scores. This figure shows that students' preferred scores are higher than their corresponding actual scores on all of the CLES scales. The differences between the students' actual and preferred scores (see Table 6.6) were quite large for Critical Voice (2.48) and Shared Control (2.42), but were smaller for the Student Negotiation (1.64), Personal Relevance (1.61) and Uncertainty (1.43) scales.

Table 6.6
Differences between Pretest Scores on Actual and Preferred Forms of the CLES for Teacher D's Students in the Sample (n=32)

Scales	Mean		Difference (P-A)	Standard Deviation	
	Preferred (P)	Actual (A)		Preferred (P)	Actual (A)
Personal Relevance	4.39	2.78	1.61	0.41	0.39
Uncertainty	4.40	2.97	1.43	0.38	0.52
Critical Voice	4.22	1.74	2.48	0.52	0.55
Shared Control	4.28	1.86	2.42	0.64	0.64
Student Negotiation	4.40	2.76	1.64	0.40	0.63

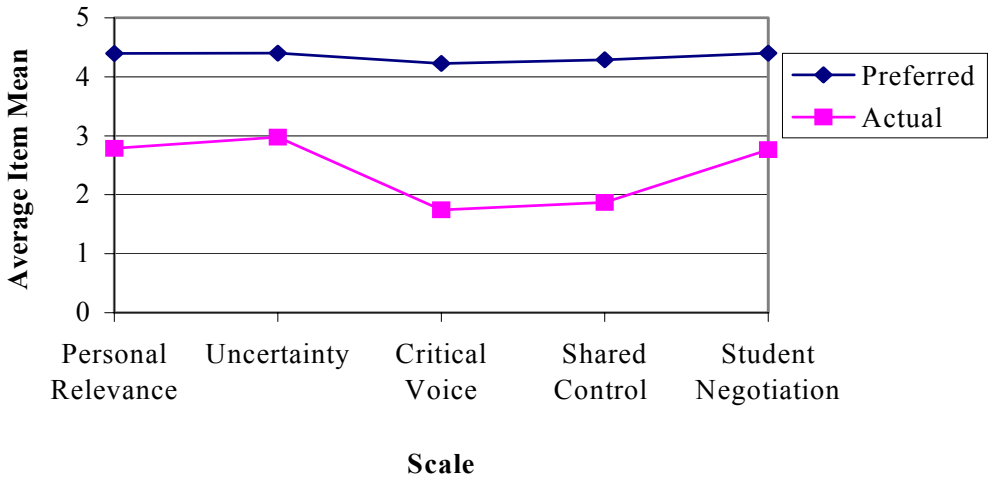

Figure 6.5. Differences between pretest scores on Actual and Preferred Forms of the CLES for Teacher D's students in the sample (*n* =32).

6.8.2 Improvement Plans of Teacher D

Although the researcher suggested to Teacher D that, in this semester, it was not necessary to change her learning environment in all dimensions related to the CLES, Teacher D wanted to do so. Her students' pretest scores prompted her to attempt to change the levels of scores in her class on all five CLES scales.

Teacher D believed that improvements to students' perceptions of their constructivist learning environment could be achieved far more easily in science by communicating with peers as members of academic teams. Communicating in and about science are critical factors in understanding, sharing, and expressing one's understanding of science as a way of thinking, as a field study, and as an attitude about inquiry. She said: *"I want to engage my students in activities to ensure that they not only do, write, and act science; but 'talk' science and 'talk scientifically' as well. Therefore, one readily available means by which this talking and communicating can occur in the classroom is through academic teams that function as cooperative learning teams."*

To improve the students' inquiry learning method in her class, Teacher D argued that if a teacher can provide learning situations that engaged students in talking and writing, this will promote active learning and students' inquiry skills. She said, *"The use of writing as an instrument for learning underlies the personal construction of knowledge, where as the use of talk for learning is consistent with social constructivist thought. Therefore, instructional strategies encompassing both should enhance learning more than another using only one of these two language modalities alone."* So, in this class, she planned to ask her students to explain scientific phenomena, either orally or in writing.

During a discussion, Teacher D told the researcher that her students always had passive learning behaviours. They feared and felt unhappy about answering her questions or sharing their ideas with her. She thought that this had resulted from her teaching and the students' low level of self-efficacy. Therefore, she wanted to make the students more active in learning and hoped that active learning would lead students to have a critical voice, share control with their peers and negotiate among themselves. So, to solve this problem, the researcher suggested that she should integrate the assessment in nearly every activity and explained to her that through this strategy, students would have a wide range of opportunities to express their knowledge and understanding through writing tasks and oral questioning. Furthermore, this strategy would have a significant impact on increasing the students' critical voice about the teacher's teaching. If students could not solve the problems, their negotiation of ideas with their peers could help. Besides, the assessment activities would encourage students to share control with their teacher to enhance their scores. Teacher D accepted this idea.

The researcher also explained and discussed with Teacher D other strategies that could be used to improve the mean scores of Critical Voice and Shared Control. This was directly teaching students how to have a critical voice and share control. Furthermore, to encourage students to be actively involved in the learning activities, Teacher D planned to provide her students with positive feedback.

Teacher D asserted that to improve students' perceptions on the Personal Relevance dimension, she would try to use students' prior knowledge in her explanations or

discussion with her students and provide various examples related to science concepts from everyday life.

In summary, Teacher D decided that the most effective ways to close the gap between the students' actual and preferred scores were to use the following five strategies:

1. engage students in cooperative learning activities;
2. use talking and writing learning activities;
3. provide students with positive feedback;
4. directly teach students to express critical voice and share control; and
5. use assessment embedded in learning activities.

6.8.3 Results and Interpretations of Teacher D's Interventions

6.8.3.1 Observations of Interventions by Teacher D

During the first visit, it was observed that students were in small groups for the learning activities and were completing an instructional unit about plant reproduction by learning the parts of plants such as flowers, leaves, and stems. They then began a new unit on human reproduction which involved the jigsaw technique. In the introduction to this lesson, Teacher D used a traditional whole-class discussion activity about plant reproduction to refresh the students' prior knowledge and linked this to the new topic of human reproduction. There was no response from the students who kept very quiet. The only sound was the teacher's questions and the teacher's own answers. There were no critical voices or student negotiation between students and students, or between students and the teacher.

However, during the second visit, the situation of this passive classroom environment observed in the first visit had changed. The situation was much more active and close to a constructiivist learning environment with Teacher D using the jigsaw technique. Teacher D used the jigsaw groups in the following way. First, each student in the expert groups individually wrote a mind map about the sub-topic provided by the teacher. Then each member presented this map to their peers in the group, after which they discussed a possible new and more suitable map. Together, they drew a

new map and discussed ways of explaining this map to their home group. In the home group, students checked the understanding of each other in preparation for an individual high score, which would lead to a high score for the whole group. The worksheets for students of this lesson were very interesting and attractive with art works diagrams and pictures. It was apparent that students in jigsaw groups had to have face-to-face interactions with their peers. Three groups of students asked Teacher D to extend the time for working in their expert groups. In addition, students had opportunities to talk with other students about how to complete their group work and to explain their ideas. Almost all the students listened carefully to the ideas of others. Teacher D excitedly phoned the researcher to tell her that with cooperative learning, one of her students who preferred to keep quiet was able to explain the consensus of his group in front of the class.

One day, Teacher D was so surprised about the changes in her students' behaviour, that she phoned the researcher again to describe her students' active learning in more detail. Ideas related to the active participation of students — to speak out directly to the teacher and share negotiation with their peers in the class — were described by Teacher D:

> *I have seen that my students participate actively in their teams … I have observed that the students with low grade averages have participated in their teams. I sincerely thought that this would continue as before … I never believed that the students with low academic achievement, after reading their academic material, would ask me questions on concepts that they did not understand. Usually, those who ask questions are those with a high grade average.*

The next statement by Teacher D was concerned with the effectiveness of constructivist teaching strategies in improving her science classroom environment:

> *These constructivist teaching strategies, in some sense, have encourage me to deal more closely with the students. I have asked them about their anxieties, their questions about the academic material … These strategies have allowed to me to have an approach that is closer to the*

students. I believe this will allow me to improve students' perceptions of their classroom environments through the constructivist perspective.

In addition to using the jigsaw technique to improve students' perceptions of their classroom environments, Teacher D also used ongoing embedded assessment in the learning tasks. These tasks were: every activity had an integrated assessment component; students had a wide range of opportunities to express their knowledge and understanding through writing tasks and oral questioning; and individual students responded to and benefited from the different assessment techniques in various ways. For example, Teacher D used groups of two with talking and writing activities to increase opportunities for student negotiation. She asked her students to share ideas together while writing the answers, drawing concept maps, and constructing various kinds of mind maps to express their understanding.

To improve students' perceptions of Critical Voice or the feeling of being free to question teacher practice, Teacher D used an assessment technique called 'One-Minute Paper' or 'Half-Sheet Response'. Teacher D explained to the researcher that this technique was a quick and simple way to obtain feedback from her students about her own teaching behaviours. She asked her students to write answers to these five questions on a half-sheet paper.

1. *How was the pace of the class?*
2. *Were the topics presented sufficiently?*
3. *Were there any confusing parts in the learning activities of this lesson?*
4. *Were there any important factors that prevented you from learning in this lesson? What were they?*
5. *What important questions remain unanswered?*

The observations indicated that, when using this technique, Teacher D stopped her teaching two or three minutes before the end of each lesson and asked each student to respond to five questions on the half-sheets of paper and hand them in to her. When asked about the results of the process, Teacher D said that this technique made her students feel free and happy to express their comments about her teaching practice.

Furthermore, she told the researcher that her students asked her many questions about her teaching. She said:

> *My students asked me many questions for example:*
>
> *Why didn't you stop some loud chat among some groups of students?*
> *This interrupted my learning.*
>
> *Could I ask you to explain……again next period?*
>
> *Today you taught so fast that I could not get in to the lesson.*

To make the assessment tasks more useful, Teacher D gathered information that exposed students' ideas and reasoning while they were working on the learning or assessment tasks. In practice, she did this as part of her normal teaching by observing and listening to students who were engaged in a learning task, talking to them, asking probing questions, involving students in whole-class discussions following the work on a particular task, and examining their written and graphic work that were the products of the task.

One piece of evidence that can be used to describe Teacher D's attempts to improve students' potential to be critical was that during a visit to her class, she invited students to be critical of the usefulness of writing the concept map at the end of each lesson. Almost all of the students did not value this activity and most rejected it initially because they were not able to do it individually. They wanted to cooperatively construct a concept map in a small group and wanted more time to it. Consequently, Teacher D decided to have students working in small group activities within a more suitable time which compromised with her students in creating the concept maps.

Another method that Teacher D used to increase her students' opportunities for negotiation, was to use group work which combined guidelines with positive feedback. The students enjoyed this type of learning activity.

When Teacher D asked her students whether they preferred these types of activities, almost all the students shouted out that they loved it. One shy male student said:

> *I like group work; I can hear different ideas about the topic of study from my friends, I can ask my friends to explain their ideas.*

A female student said:

> *When I give wrong or unclear answers, I feel better when you pay your respect to my actions.*

In this case, Teacher D smiled and said:

> *O.K. this was an interesting idea……if you try to express your ideas, you will help your friends find a more suitable answer.*

Changes in classroom learning environment above were manifested by Teacher D as follows:

> *In almost all lessons, I always ask my students in the combined talk and writing group to discuss the problems in groups prior to individually writing their explanations. I observed that the level of negotiation among students was increased.*

Teacher D used about two hours for directly teaching students how to express a critical voice and share control with her about the learning environment. She explained to her students that they could express these two behaviours by using both verbal and nonverbal strategies. First, she wrote some sentences that illustrated how students could speak to her about their needs or suggestions about her teaching behaviour and their learning environment. Then, to practise this strategy, she asked students, in each of the small groups of four, to create four new sentences and write them on the black-board. After that she demonstrated how to use non-verbal techniques, such as using their faces, hands and manners. Finally, she asked students to work cooperately to demonstrate how they could express these two kinds of

activities. She also discussed this with students and gave feedback to them. It was observed that students could use a critical voice and share control.

Further observations during the unit of 'Male and Female Reproduction System' indicated that students frequently became involved in negotiation with their peers during the lesson.

6.8.3.2 Interviews of Students about Teacher D's Interventions

From the actual preferred comparisons test, Teacher D intended to improve her classroom environments on all five scales of the CLES. Consequently, the researcher tried to interview her and her students about the degree of constructivism in her classroom environment. The following were some comments by students on the teacher's ideas about the science classroom environments.

During one interview, the researcher asked:

> To what extended, do you relate the context of this lesson content with everyday experiences?

A student then responded:

> *I get a better understanding of the world outside the school, I know more about the evolution of organisms.*

To probe students' thoughts about uncertainty in the science learning activities, the researcher asked:

> Does Teacher D ask you to solve some problems or investigate some concepts using inquiry strategies?
>
> *Yes, often, because my teacher often asks us to do the exercise in the provided text. These exercises generally are designed for us to investigate the problems using inquiry skills. It is very difficult to do but I enjoy the activities.*

Yes, often. But I did not want to do it. It required various and many skills to finish it. I was not good at learning science.

Yes, almost always. In many exercises I cannot do it by myself, however, some of my friends help me. I am very poor at learning science.

The conversation with Teacher D revealed that her students were able to criticise the way in which she taught. She said:

My students criticise my teaching by writing a very short comment on my teaching and propose some ideas that were impediments to their learning. These included suggestions, such as: using clearer question; giving enough time to do each learning task; explaining more slowly; using questions to check students' understanding; using various kinds of instructional instruments; and using multiple choice items for learning assessments.

During observations, the researcher observed that Teacher D also asked students to work in small groups to prepare concept maps and use them as material that the group could use to explain the concept in front of the class. This meant that Teacher D had created conditions for open discourse in her classroom. Students perceived that they shared control of the classroom environment with their teacher, particularly in relation to assessing the success of their own learning. In this situation, students generally responded positively to opportunities for self-determination, and as the course progressed, they engaged with increasing enthusiasm in interactive and self-reflective activities. It is evident that this openness in the classroom contributed to the development of their responsibilities when in the small groups that were on concept maps for explaining to the rest of the class. The following extract, from an interview about students' responses to the CLES, illustrates this evidence. The interviewer asked:

Do you help your teacher decide how well your learning is going?

The student then responded:

> *Yes, almost always…because we just have a good relationship in our class, so …we are able to tell our teacher if we are understanding things and, you know, how progress was with our decisions.*

During an interview about the students' response to the CLES, it became apparent that some students, who had very positive learning experiences during the course, felt very uncomfortable with the idea of expressing themselves in a way that might be interpreted as being critical of the teacher, especially when they did not believe that criticism was warranted. The interviewer asked:

> In this class, do you express your comments to your teacher about her teaching or your difficulties in learning?

One student responded:

> *I marked 'seldom'…because I think that it seemed to be not suitable to say…In this class, the learning activities were relevant to the topic of the study, so she didn't go off on something else.*

By contrast, some other students were willing to offer critical comments on her innovative teaching strategies. For example, the following extract is from an interview using the same question about doing the concept map in classroom.

One student said:

> *I marked 'sometimes'…I said to my teacher that it is too difficult for us to do the concept map. It took a long period of time to finish it. It was not necessary to use a lot of time to do such an activity.*

The next statement shows the increase of students' perceptions of sharing control with their teacher:

When both of us have responsibilities to help each other to do any group work of answering and writing, it is necessary for us to talk together about how to solve the problems. I have to explain my ideas to my buddy and other students. Sometimes other students listen to me carefully to get ideas.

We liked doing the concept map in a group on the magnetic board. This type of activity made us happy and we had fun. We can laugh, talk with one another, and help each other to solve the problem.

When asked about her opinion of how often she expressed her ideas to her group, a shy student said:

I need to pay more attention to do so and I can do that. My friends in my group tried to work out whether I understood the topic of learning or not. I must speak out to show my understanding. They won't let me act silly because they want good grades in the group scores.

When talking with others, the students were excited and told the researcher about how brave some of their friends could be in trying to explain the results of the learning tasks in front of the teacher and their classmates. This further supports the view that students were trying to express their ideas to others.

The student interview data also supported the assertion that students frequently got involved in negotiation with their peers in their science lesson, as one student said:

I can talk about problems with other students who are sitting near myself; sometimes we are required to make one academic paper in a group.

6.8.3.3 Posttest Results for Teacher D

Table 6.7 and Figure 6.6 shows that between the pretest and posttest, improvement occurred in the perceived environments in the science class of Teacher D on all scales of the CLES. For Personal Relevance, Uncertainty, Critical Voice, Shared

Control and the Student Negotiation scales, the changes were 0.77, 0.91, 0.94, 0.97 and 1.07, respectively (see Table 6.7). The posttest scores of Teacher D's students suggest that her attempts in making use of her students' responses to the CLES to improve her classroom learning environments were successful. Information about the classroom environment gathered from observations and student interviews supported the quantitative data. However, in comparison to the classes visited with the other two case-study teachers, the students in this class expressed fewer comments about how their class was taught. Teacher D was pleased with her results and planned to continue to use constructivist teaching in her classrooms.

Table 6.7
Actual Pretest and Posttest Scale Means and Standard Deviations for Teacher D's Students (n=32)

Scale	Mean		Difference	Standard deviation		*t*
	Pretest (Pre)	Posttest (Post)	Post-Pre	Pretest (Pre)	Posttest (Post)	
Personal Relevance	2.78	3.55	0.77	0.39	0.48	6.564***
Uncertainty	2.97	3.88	0.91	0.52	0.57	6.455***
Critical Voice	1.74	2.68	0.94	0.55	0.61	5.939***
Shared Control	1.86	2.83	0.97	0.64	0.79	4.104***
Student Negotiation	2.76	3.83	1.07	0.63	0.47	7.803**

**$p<.01$, ***$p<.001$

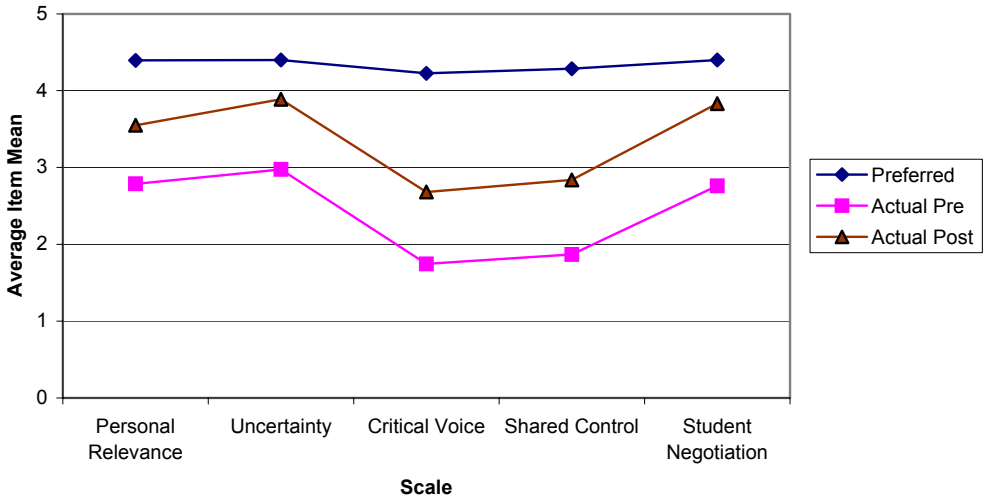

Figure 6.6. Preferred, actual pretest and actual posttest scores of Teacher D's students (n =32).

6.9 SUMMARY OF IMPLEMENTING CONSTRUCTIVIST TEACHING IN ORDER TO IMPROVE CLASSROOM LEARNING ENVIRONMENTS

In summary, the results from the quantitative data (see Table 6.8, 6.9) and qualitative data (student interviews, classroom observations, and incidental conversations with teachers) indicated that in the three classrooms of the case-study teachers, students' perceptions of their science classroom environments increased on all dimensions of the CLES scales. The qualitative data confirmed the quantitative results. Therefore, it can be interpreted that all the case-study teachers were able to make use of their learners' responses to the CLES to improve their own classroom learning environments. The action research method used in this study, in order to improve the classroom learning environments, proved to be effective and could be implemented in science classrooms.

Table 6.8
Students' Actual Pretest and Posttest Scale Means and Standard Deviations for Three Teachers

Teacher	Scale	Scale Mean		Standard Deviation	*t*
Teacher A	**Personal Relevance**	Pretest	3.16	0.67	6.058***
		Posttest	3.79	0.36	
	Uncertainty	Pretest	3.63	0.77	2.999**
		Posttest	3.98	0.45	
	Critical Voice	Pretest	2.13	0.77	4.597***
		Posttest	2.81	0.80	
	Shared Control	Pretest	2.31	0.75	5.364***
		Posttest	3.07	0.82	
	Student Negotiation	Pretest	3.44	0.80	3.373**
		Posttest	3.78	0.66	
Teacher B	**Personal Relevance**	Pretest	3.49	0.42	5.350***
		Posttest	4.09	0.50	
	Uncertainty	Pretest	3.73	0.50	2.210*
		Posttest	3.96	0.42	
	Critical Voice	Pretest	2.13	0.77	8.304***
		Posttest	3.09	0.66	
	Shared Control	Pretest	2.31	0.75	5.952***
		Posttest	3.17	0.69	
	Student Negotiation	Pretest	3.44	0.80	6.226***
		Posttest	4.38	0.53	
Teacher D	**Personal Relevance**	Pretest	2.78	0.39	6.564***
		Posttest	3.55	0.48	
	Uncertainty	Pretest	2.97	0.52	6.455***
		Posttest	3.88	0.57	
	Critical Voice	Pretest	1.74	0.55	5.939***
		Posttest	2.68	0.61	
	Shared Control	Pretest	1.86	0.64	4.104***
		Posttest	2.83	0.79	
	Student Negotiation	Pretest	2.76	0.63	7.803**
		Posttest	3.83	0.47	

*$p<.05$, **$p<.01$, ***$p<.001$

Table 6.9

Difference between Pretest and Posttest Scale Means for Three Teachers

Scale	Difference between Posttest and Pretest		
	Teacher A	Teacher B	Teacher D
Personal Relevance	0.63	0.60	0.77
Uncertainty	0.35	0.23	0.91
Critical Voice	0.68	0.96	0.94
Shared Control	0.76	0.86	0.97
Student Negotiation	0.34	0.94	1.07

6.10 STUDENTS' ATTITUDES TOWARDS SCIENCE LEARNING ACTIVITIES AND SELF- EFFICACY

This section describes changes in students' attitudes after learning science with constructivist teaching. The descriptions are divided into four subsections. The first three subsections are about students' attitudes in each of the three teachers' classes. The final section contains a summary of the effectiveness of the constructivist teaching approach in improving students' attitudes. In each class, quantitative data of students' perception on two attitudinal scales and qualitative data of classroom observations and student interviews are provided. This was investigated in order to determine whether students' attitudes towards science learning activities and their self-efficacy changed after learning with constructivist teaching.

6.10.1 Students' Attitudes for Teacher A's Class

6.10.1.1 Qualitative Approach

During observations to investigate students'perceptions toward their science learning activities and self-efficacy, the researcher observed that Teacher A was enthusiastic in her teaching. She always gave a big smile to her students, spoke with a strong and pleasant voice, explained very clearly about science concepts and how the science content of the lessons was very useful for students. She used discovery methods in which she was a guide to solve the problems in the science text and in the various problems taken from past entrance examinations. Students actively and attentively

worked in small groups to discuss and solve the problems in the learning tasks. She also encouraged her students to ask any questions about the lessons. She frequently said; *"Any questions? Raise your hands to let me know when you have a question."* While students explained their answers or how to solve some specific problem, Teacher A kept silent and listened to them with her smiling face. This encouraged students to try to explain. It was interesting that she used non-scientific language to explain important principles. Furthermore, she also related students' science content to the real life of students, such as how to calculate the cost of using electricity. It was noteworthy that she always told her students how important each topic in this course was for the university entrance examinations. She gave students the collection of past entrance examination papers and asked them to do them as homework. Furthermore, it appeared that students in this class always laughed loudly. This may be the influence of Teacher A because she always laughed like this during her teaching. It seemed that the classroom learning environment of Teacher A was fun with good humour demonstrated by the teacher.

The following are some examples of transcripts from the interviews in Teacher A's class:

When the researcher asked the students:

Do you enjoy this class?

Students responded:

> *Yes, I enjoy interacting with my classmates. In this class, my teacher often asks me to work and discuss in a small groups. I do not enjoy working alone. I can talk pretty loudly in normal classes and sometimes she yells or tells us off a little bit but she doesn't give really bad punishments or anything.*
>
> *Yes, all students enjoy talking and working on the project. I enjoy working with other students. In project learning activities, we have more opportunities to plan and manage our work. Learning activities in our project are very interesting. We have chances to study from many*

sources and we share these sources to the class. These were interesting activities.

I enjoy this class. I'm someone who likes a fair bit of freedom in class. I like to try things my way or try different methods of doing thing, like projects and things like that. As well as having the leadership that she's got she lets me, like…do things my own way sometimes or go at my own pace without having the pressure of doing everything the way she wants me to do it.

Her good humor motivates us to learn and express our ideas about her practice.

A conversation with Teacher A's students helped the researcher to understand why the learning activities in this class were interesting.

My teacher makes us interested in her exercise because I know that if I do this exercise, this will make it easier for me to pass the entrance examination.

She's interested in the subject. She's enthusiastic. She wants us all to enjoy science and to be able to pass the entrance to the university. Her enthusiasm for the subject has made me more open to it and in the process of course I've become much more interested and enthusiastic as well.

Yes, my teacher always relates classroom studies to the outside world. For example, she always uses the current news and applies it to her physics class; asking students about the progress of the community project about the electric energy factory and discussion about dangerous accidents resulting from inadequate understanding about electric circuits.

I feel it is easier than before for me to get a better score in this subject because my teacher explains everything so clearly, in terms that I could understand…She didn't talk in scientists' talk. She used normal language. Even though we did go into the concepts-more scientific concepts-she'd mention the scientific terms but then she'd explain those in the language that I understood.

She was quite willing to answer all our questions no matter how far fetched they were, and everybody appreciated that because it encouraged us to keep asking and wanting to know more. Her willingness to spend five to ten minutes every lesson answering anything and everything I think encouraged a lot of us to keep asking, keep inquiring. Which is what she wanted us to do, I assume.

The following interview transcripts indicated that some students had positive perceptions on their self-efficacy in this class:

Yes definitely. It's definitely changed. I'm looking forward to learning with her next semester and I have a bit more confidence in learning physics…This class was lots of fun…If my teacher did the same thing again next year I'm sure that it would change students' minds again in learning physics. My teacher has helped me gain those experiences that I needed to boost my confidence, and to me that is what happened. It was all about my confidence.

She's got a tremendous clarity of presentation which helps incredibly… and that was simply because it was explained in such a clear way. And it wasn't technical. It was correct, but it wasn't technical. I often have higher scores. Sometimes I think that I am an intelligent student in learning science.

So I think that I have more confidence to explain some science concepts in this class to my friends. This is because of my clear understanding resulting from the effective explanations of my teacher.

6.10.1.2 Quantitative Approach

Table 6.10 and Figure 6.7 show Teacher A's students' pretest and posttest mean scores of the attitude questionnaire. In describing the level of students' perceptions about their science learning activities and self-efficacy, there is a change in students' attitudes towards their learning activities from *sometimes* to *often* in Teacher A's class with mean score of 3.48 to 3.88. However, for the scale of Self-Efficacy, although the level has increased significantly with mean score of 2.11 to 2.38, it still remains low and less than three.

Table 6.10
Changes of Attitudes of Teacher A's Students towards Science Learning Activities and Self-Efficacy after Learning with Constructivist Teaching (n=44)

Teacher	Scale	Mean		Difference	Standard Deviation		*t*
		Pre	Post	(Post-Pre)	Pre	Post	
Teacher A	Learning Activities	3.48	3.88	0.40	0.61	0.48	4.791***
	Self-Efficacy	2.12	2.38	0.26	0.67	0.57	2.899**

**p<.01, ***p<.001

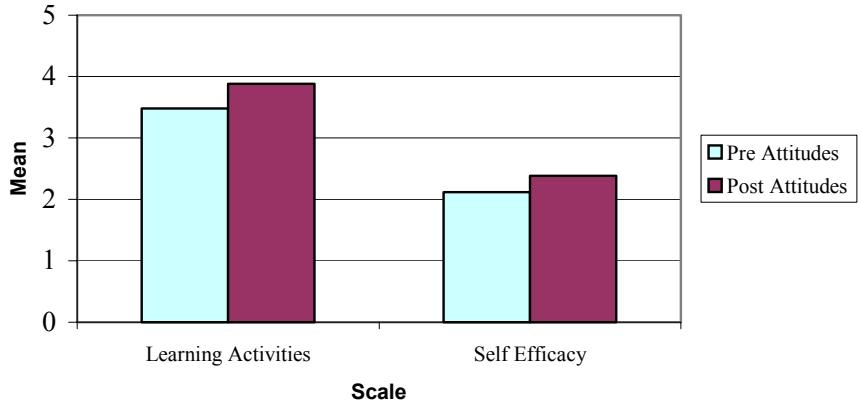

Figure 6.7. Changes in attitudes of Teacher A's students towards science learning activities and self-efficacy after learning with constructivist teaching (n=44).

6.10.2 Students' Attitudes for Teacher B's Class

6.10.2.1 Qualitative Approach

During the visits to Teacher B's class, it appeared that this class was comfortable with hands-on and cooperative learning in small groups (see section 6.7.3.1). Everything for learning in the laboratory was ready for the students at the beginning of the period. Before starting the learning tasks, students were told about the expected learning outcomes and learning activities of the lesson. The learning tasks in small groups were well sequenced, understandable and interesting (as described in section 6.7.3.1). During the learning tasks, students enjoyed sharing their ideas with the group, discussing the specific problems and working out how to construct the concept maps. It was noteworthy that, in order to get high scores, students were happy to urge on their group members to answer the questions that were selected by the teacher by attentively listening to the problems. They were also willing to answer that question if their friend could not answer it. Although the learning environment was competitive, all students were happy. Their faces were full of smiles. Some laughed in a loud way. They also clapped their hands to applaud when a group was able to answer a question. It was observed that Teacher B was an enthusiastic, helpful and encouraging teacher who could make science fun and difficult concepts easier to learn. She explained the lessons clearly by using real objects or other visual aids and making it easy for students to understand. She also used an academic game for answering questions which made students active in learning. Students in Teacher B's class enjoyed themselves at the learning centres in the science laboratory and on field trips. Teacher B also related science content such as plants and animals to those in the students' communities and many areas in Thailand. This made the lesson more interesting and easier for the students to learn.

During interviews, evidence from the students' responses showed that the students had positive attitudes towards their learning activities as illustrated in the following comments:

> *In other subjects, I just don't do the hands-on activities. May be other subject makes it harder to do that. But in this class it always seems to be*

hands-on and it really engages me. I always seem to be interested in what I'm doing.

Yes, I enjoyed learning in the small group activities. Difficult problems can be solved by group. We feel happy when we accomplish our learning tasks.

Sure, I feel very happy in this class. My teacher always provides us with various kind of learning activities to do, such as observing, drawing, create a mind map, making a presentation in front of the class.

I love my teacher and I think that my teacher is very expert in this subject. I enjoy myself very much in this subject. I am very happy to learn in group activities and lab. It is very understandable when my teacher gives us opportunities to study in the lab both or out of class on a field study. I like to talk and discuss with my peers and my teacher.

Some students commented that one of the teaching strategies that had a positive influence on their attitudes was when at the beginning of each lesson, their teacher presented an overview that accurately described the purpose and structure of the session. Students said:

She would tell us what we would be doing that day so I could plan it in my head as well.

My learning activities in this class are not confusing because I know that I am learning in a class that is well-structured. My teacher told us at the beginning what it is that I'm going to be looking at, and at the end this is what I will have hoped to have achieved…and it goes on. It flows through logically.

To determine the students' perceptions about their academic self-efficacy, the students were asked whether they thought science was easy. Some of their comments were:

Oh, no, I have to work hard to pass this subject. The quiz or the formative assessments are very difficult.

Absolutely no, I have to do many lab activities, read many texts and be attentive to listen to the lecture. However, I enjoy this class and feel that I can pass the assessment of this course.

No, I always ask my friend to help me. In this subject, there are a lot of concepts to understand and remember. I must use some part of my weekend for a tute.

Yes, 'sometimes' if we do lab activities or learning with hand-on activities.

Sure, (he speaks with a loud voice). *If I think it is difficult, I will not make decisions to learn science in the major stream. In this class, it is easy for me to get a good grade* (all students looked at him and laugh).

Absolutely, formerly I would have said that I would not have felt at all confident about learning science. Now I feel, I can easily do it. That's great, and I have become much more interested in learning this subject. I think I can pass the university entrance.

I'm quite confident with the area of biology. I had a high score in this subject and I want to be a doctor.

6.10.2.2 Quantitative Approach

In the class of Teacher B, as shown by Table 6.11 and Figure 6.8, the level of students' attitudes increased on the mean scores in both scales and was statistically significant ($p<.001$). The mean score of Attitude to Science Learning Activities scale changed from 3.73 to 4.30 where as the Self-Efficacy mean changed from 2.56 to 3.08.

Table 6.11
Changes of Attitudes of TeacherB's Students' towards Science Learning Activities and Self- Efficacy after Learning with Constructivist Teaching (*n*=39)

Teacher	Scale	Mean		Difference	Standard Deviation		*t*
		Pre	Post	(Post-Pre)	Pre	Post	
Teacher B	Learning Activities	3.73	4.30	0.57	0.38	0.46	5.839***
	Self-Efficacy	2.56	3.08	0.52	0.52	0.52	5.584***

***p<.001

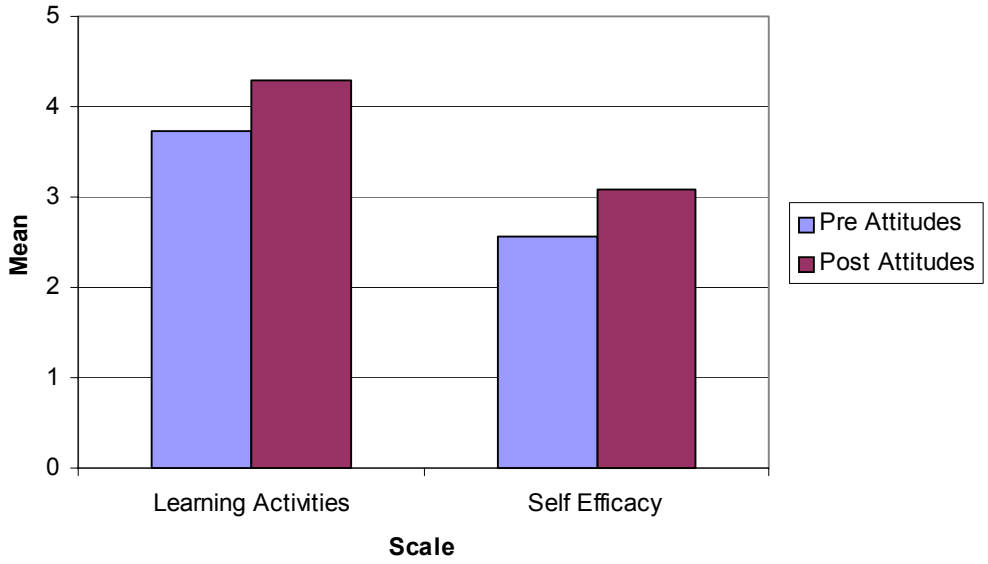

Figure 6.8. Changes in attitudes of Teacher B's students towards science learning activities and self-efficacy after learning with constructivist teaching (*n* =39).

6.10.3 Students' Attitudes for Teacher D's Class

6.10.3.1 Qualitative Approach

The speaking activities and the creation of concept maps on magnetic boards made Teacher D's class more enjoyable. Students looked cheerful when doing these

activities. Furthermore, during cooperative learning tasks, each member of the group was necessary in order to ensure that each student achieved the group goal. These kinds of learning activities provide opportunities for more interaction between students and teachers and between students and their peers which result in the promotion of positive social interactions and thus create a constructivist and positive learning environment. It was noteworthy that some students said that they had better psychological health when they worked in small heterogeneous group. Teacher D, like the other two teachers, always gave positive feedback to students and encouraged them to learn. For example, she indicated clearly to students the positive areas in their assignments or presentations. It was interesting to see that three of the students who previously did not share their ideas with their friends could do this four weeks after the intervention in this course. In the interviews, they said that they felt more confident in explaining their ideas in small groups. It appeared that Teacher D used various kinds of individual and group assessments during each lesson. For example, she often asked students to answer short questions in written form, present assignments to the class, report laboratory investigations and construct concept maps. These assessment activities seemed to make students more involved in their learning because it was necessary for them to be responsible for their individual work and their particular role in the small group activities. Also, she showed the students their scores as soon as possible and this prompt feedback encouraged students to improve their learning.

Comparatively, among the three case-study classrooms, students in Teacher D's class generally had the lowest achievement. Consequently, when Teacher D's students were interviewed about their perceptions of their academic efficacy, almost all of them perceived that they were not good at this subject and that it was difficult for them to get a good grade. The following examples support this assertion. The researcher asked the whole class whether it was easy to get good grades in this subject. When the students heard this question, almost all of them made comments like:

> *No, never. You know learning biology needs a lot of brain for keeping the content in my memory. Hard work!*

No, I am not an intelligent student. Particularly, I do not pay much attention to reading and doing my homework.

Yes, seldom if my teacher explained the concept slowly.

At the beginning of this course, I didn't feel like I was very good at this subject. However, now I feel better because my teacher provided us with many kinds of learning activities, such as group presentation, creating concept maps and playing games.

The researcher then probed further and asked whether they felt that their friends would always ask him/her for help. The researcher asked them to indicate this with a show of hands. However, nobody responded. One student shouted the names *Preda, Yanee*, but both of these students denied that this had occurred.

In the interviews, students in Teacher D's class indicated that they had a negative attitude towards their academic self-efficacy. However, they had positive attitudes towards their learning activities in this class.

The following responses support this interpretation in response to the researcher's question on whether they felt that the learning activities of the class were interesting.

Yes, often, my teacher always provides me with small group activities. I like working in a group. Besides, when I gave the wrong answer, she always smiled and gave me the time to rethink.

Yes, always. I preferred talking activities and presenting the learning task to other students.

At the beginning of this class, I disliked the learning activities because I always fell asleep. I was bored listening to my teacher's voice. She talked too much. However, my feelings changed more when my teacher encouraged me to learn and when she was more accessible to students with questions. Furthermore, we had to do various kinds of learning

activities, such as group discussion, presentation, reporting and written answers. These make me interested in science.

Some students commented that they enjoyed their learning activities of experiment and hands-on activities in small group as follows:

We did so many experiments and hands-on activities in small groups. Each group had chances to explain the investigation results to other groups. It was interesting for me to change my ideas in my group. I enjoyed it.

I think the thing I enjoyed about this class was the investigation and discovery…and the encouragement of being able to talk about the experiments. Because often after we'd done an experiment she'd ask, "What did your group find out? Oh! That's interesting. Why do you think that happened?" That was an important part, because often each group would do an experiment and change it slightly and then we'd all discuss what happened. That was valuable.

The researcher also asked a follow-up question on whether they found the learning activities of the class confusing. The students responded as follows:

Yes, we were seldom confused by my teacher giving us unclear directions.

No, never because if I didn't understand anything, I can ask her to explain it again.

I show my confusion on my face and I know she can tell when everybody is confused. Her great thing was, "Give me some questions'. She was always receptive to questions and I felt that it was important too. I could ask the stupid questions and I wouldn't feel stupid. Things were clairified for me.

6.10.3.2 Quantitative Approach

As indicated in Table 6.12 and Figure 6.9, there are changes in students' attitudes in both scales of Attitude to Science Learning Activities and Self-Efficacy in Teacher D's class. The level of students' attitudes towards science learning activities changes from *sometimes* to *often* with mean scores of 3.10 to 3.66, whereas students' attitudes towards self-efficacy changed from *seldom* to *sometimes* with mean scores of 2.04 to 2.83.

Table 6.12
Changes of Attitudes of TeacherD's Students' towards Science Learning Activities and Self- Efficacy after Learning with Constructivist Teaching (n=32)

Teacher	Scale	Mean		Difference	Standard Deviation		*t*
		Pre	Post	(Post-Pre)	Pre	Post	
Teacher D	Learning Activities	3.10	3.66	0.56	0.45	0.42	5.195***
	Self-Efficacy	2.04	2.83	0.79	0.64	0.47	6.083***

***p<.001

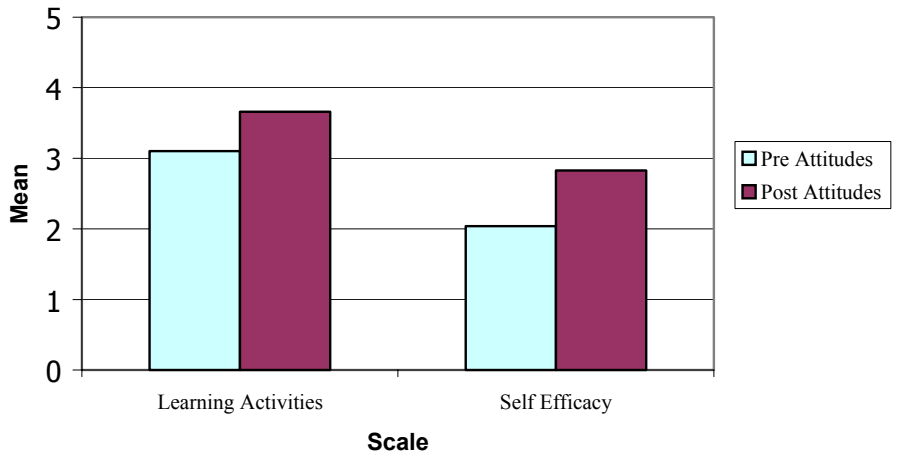

Figure 6.9. Changes in attitudes of Teacher D's students towards science learning activities and self-efficacy after learning with constructivist teaching (n =32).

6.10.4 Summary of Effectiveness of Constructivist Teaching on Improving Students' Attitudes

In summary, the statistical data in Table 6.13 and Figures 6.7, 6.8 and 6.9 indicate that constructivist teaching does improve students' attitudes towards science learning activities and self-efficacy. This table and these figures show improvements in students' attitudes towards science learning activities and their self-efficacy in the three classrooms of the three case-study teachers after learning with constructivist teaching. There were significant differences ($p<.01$) between pretest and posttest mean scores in each class for both scales. The posttest scores of the three teachers' classes are all higher than the pretest scores in all scales. For the scale Attitude to Science Learning Activities, the greatest difference between pretest and posttest of mean scores was in Teacher B's class with a mean score difference of 0.57, slightly lower in Teacher D's class (0.56) and lowest in Teacher A's class (0.40). For the scale of Self-Efficacy, in all three classes, the statistical data show that the greatest difference between pretest and posttest scores was in the class of Teacher D (0.79), lower in class of Teacher B (0.52) and lowest for the class of Teacher C (0.26).

It is noteworthy that the level of students' attitudes before and after learning with constructivist teaching had changed from *Sometimes* to *Often* on the 'Attitude to Science Learning Activities' scale in classes of Teachers A and D, but the same in level of *Often* was maintained in Teacher B's class. Also, in 'Self-Efficacy' scale, there was a change from *Seldom* to *Sometimes* in only Teacher D's class, but relatively the same in level of *Seldom* and *Sometimes* in the classes of Teachers A and B.

Table 6.13
Changes in Students' Attitudes towards Science Learning Activities and Self-Efficacy after Learning with Constructivist Teaching

Teacher	Scale	Mean		Difference	Standard Deviation		*t*
		Pre	Post	(Post-Pre)	Pre	Post	
Teacher A	Learning Activities	3.48	3.88	0.40	0.61	0.48	4.791***
	Self-Efficacy	2.12	2.38	0.26	0.67	0.57	2.899**
Teacher B	Learning Activities	3.73	4.30	0.57	0.38	0.46	5.839***
	Self-Efficacy	2.56	3.08	0.52	0.52	0.52	5.584***
Teacher D	Learning Activities	3.10	3.66	0.56	0.45	0.42	5.195***
	Self-Efficacy	2.04	2.83	0.79	0.64	0.47	6.083***

**$p<.01$, ***$p<.001$

The qualitative data from classroom observations and interviews with students supported the quantitative data in all three case-study classes. From the researcher's observations, students seemed to be interested in and enjoyed their learning through active learning activities such as discovery activities, hands-on activities, small group discussion, concept mapping, observation, laboratory experimentation, problem solving and cooperative learning. Furthermore, they had various kinds of learning activities to do, such as writing, speaking or producing some products. It was apparent that each of the case-study teachers usually provided for positive interactions situations among students and between students and themselves.

The transcripts of student interviews indicated that students in all three classes enjoyed themselves and were interested in their learning activities. They said that these positive attitudes were influenced by the teacher's enthusiasm, positive feedback, good humour and confidence, variety of teaching strategies, clarity of explanations, clear structure for each lesson, hands-on activities, encouragement of

students' questions, various kinds of assessment tasks embedded during each learning activity, and the cooperative learning activities.

However, on the dimension of Self-Efficacy, most students in the three case-study classes said that they felt that they did not have a high ability in learning science because it was not easy to get good marks in science. There was only one student in Teacher B's class who said that she felt that she was good at science and that it was easy to get good grades in her class. It seemed that students were not happy to directly express their feelings about their own abilities.

From the classroom observations and students' interviews, it can be interpreted that there are various factors that have a positive influence upon students' attitudes. These factors are two main characteristics of constructivist teaching approaches: personal attributes of the teacher and teaching strategies. Therefore, the qualitative and quantitative data from the case-study classes support the assertion that constructivist teaching can improve students' attitudes towards science learning activities and self-efficacy.

6.11 SUMMARY

This chapter has reported the results from the case studies of the three teachers who participated in the second phase of the study in an attempt to use constructivist teaching approach to improve their classroom environments. The case-study teachers used a model for improving classroom environments (Fraser & Fisher, 1986; Sinclair & Fraser, 2001; Yarrow, Millwater, & Fraser, 1997). First, each teacher selected one class in which they wanted to improve some aspects of the classroom environments. These students completed as pretests the Actual and Preferred Forms of the Constructivst Learning Environment Survey (CLES) as well as the pretest form of the Attitude Questionnaire. The survey results were used to determine whether the teachers were able to make use of learners' responses to the CLES to improve their own classroom learning environments and whether constructivist teaching improved students' attitudes towards science learning activities and self-efficacy. Secondly, based on the survey results provided by the researcher, the case-study teachers developed their own action plans to improve their classroom environments. Lastly, at

the end of a ten-week intervention period, the students completed the Actual Form of the CLES and the Attitude Questionnaire as posttests.

For all three case studies, some changes in classroom environment dimensions occurred during the ten weeks of intervention. Statistical analysis ($p<.05$, $p<.01$, $p<.001$) showed that improvement occurred in the students' perceived environments between pretest and posttest on the dimensions in which changes were attempted. Furthermore, the scales which were not targeted by the teachers for improvement also showed an increase in mean scores. Students' attitudes were measured using two scales namely, the Attitude to Science Learning Activities and a Self-Efficacy scale. The research question in this study was to investigate whether students' attitudes towards learning activities and their self-efficacy changed after learning from the constructivist teaching approach. The statistical data ($p<.01$, $p<.001$) from the change from pretest and posttest mean scores indicated that constructivist teaching could improve students' attitudes towards science learning activities and self-efficacy.

The qualitative data, derived from the interviews and observations shed additional light on the improvement perceived by the students and provided plausible explanations as to why the observed improvement occurred. As each case study was unique in its interventions and results, the finding suggests that by implementing constructivist teaching in each of the teachers' classes, changes can be made if so desired by the individual teacher.

In conclusion, the results in this phase of the study led to the assertion that teachers are able to make use of learners' responses to the CLES to improve their own classroom environments and that constructivist teaching has positive effects on improving students' attitudes towards science learning activities and self-efficacy.

The following chapter brings together the four parts of this study to conclude the thesis. First there is an overview of the major findings of this study. The second and the third parts discuss the limitations and the implications of this study. The last part contains suggestions for further research to promote the implementation of constructivist teaching to improve learning environments in Thai secondary school science classrooms.

CHAPTER 7

CONCLUSION

This chapter provides a conclusion for this thesis. First, an overview of the study is provided and the major findings are summarized; second, the limitations to this study and the methods taken to compensate for these data are discussed; and third, the practical implications for this study are described. Finally, suggestions for further research and a final comment are made.

7.1 OVERVIEW AND MAJOR FINDINGS OF THIS STUDY

The study consisted of three phases. First, the CLES was validated for future use in the assessment of secondary school science classrooms in Thailand. Second, a description of Thai students' perceptions of their actual and preferred learning environments from a constructivist perspective was provided based on a large sample of upper secondary school science students in Thailand. Third, three teachers from these classes were selected to serve as case studies to explore how they attempted to assess, plan and improve their classroom environments. Highlights of each of these three phases are presented in sections 7.1.1, 7.1.2, and 7.1.3.

7.1.1 Phase One of the Study

This phase of the study involved the validation of the instrument, the Constructivist Learning Environment Survey (CLES), for assessing upper secondary school science students' perceptions of their actual and preferred learning environments from a constructivist perspective. Separate Actual and Preferred Forms of the CLES contain five scales covering aspects of a constructivist learning environment. The scales are

Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation.

The sample in this phase consisted of seven invited secondary school science teachers and their 17 classes of 606 students. This sample was selected from the population of Thai students from an upper secondary school district, in Nakornsawan Province, Thailand.

The English version of the CLES and the Attitude Questionnaire were translated into Thai, using a method involving translation and back-translation. The researcher translated these questionnaires into the Thai language. They were then back-translated into English by a person not involved in the original translation. Minor modifications were made to the items following the pilot study in order to ensure that the Thai students understood the meaning of each of the items.

Factor analysis led to the confirmation of the five-factor structure of the Actual and Preferred Forms of the CLES using the individual student as the unit of analysis. Cronbach alpha coefficients affirmed the internal consistency of the scales of the CLES. Another desirable characteristic of questionnaires like the CLES is that students within the same class perceive it similarly while students in different classes should perceive a different environment. The eta^2 statistic (the variance accounted for by class membership) ranged from 0.15 to 0.23 for different scales indicating that the Thai version of the CLES is able to differentiate between classrooms. The results of these analysise led to the validation of the Thai version of the CLES.

7.1.2 Phase Two of the Study

In this phase of the study, typical Thai secondary school science classroom learning environments were described based on quantitative and qualitative data. Quantitative information was collected using the CLES students' Actual and Preferred Forms and provided data for statistical analyses and graphical representations of the responses on the scales. Qualitative data were gathered by the researcher through classroom observations and interviews with randomly selected students. The qualitative methods were particularly useful in clarifying the reasons for the observed

differences in students' scores on the perceptions of actual and preferred classroom environments. The differences in average scores (Actual Form and Preferred Form) on each scale of the CLES (Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation) were also described. The results suggested that the average classroom in this study had relatively high levels of student perceived Uncertainty (3.28), Student Negotiation (3.01), and Personal Relevance (2.90), but the levels of Shared Control (2.01) and Critical Voice (2.20) were consistently lower. When students' actual and preferred perceptions were compared, the pattern that emerged was similar to that in previous research (Fisher & Fraser, 1983b). There were statistically significant differences between the students' actual and preferred environments on all five scales ($p<.001$). On all five scales, students preferred a more favourable classroom environment than what they perceived as being actually present.

7.1.3 Phase Three of the Study

The third phase of the study assessed the effectiveness of constructivist teaching through the involvement of teachers in action research techniques. This process was based on Fraser's (1986) suggested model of improving students' perceptions of their science classroom environments by aligning the actual perceptions more closely with the preferred. Three teachers selected from the original sample served as case studies and they participated during the academic semester in an attempt to improve their science classroom environments. The teacher action research model (Fraser, 1986) involved the assessment of the students' actual and preferred classroom environments using the CLES and feedback of these results to the teachers enabling them to reflect and discuss ways of improving their environments. The researcher also provided assistance when the teachers so desired. Also, two scales of the Attitude Questionnaire were used to assess student attitudes towards their science learning activities and self-efficacy. The attitude scores were used as posttest outcome variables. At the end of 16 weeks, the students' perceptions were reassessed using the Actual Form of the CLES as a posttest.

For all three case studies, some changes occurred on those scales that the teachers had selected to improve. This supported the original proposal that constructivist

teaching can improve students' perceptions of their classroom environments. In addition, this also supports the hypothesis that classroom environments can be improved by teachers who received support and training as suggested by researchers such as Fraser and Fisher (1986), Fraser (1981a, 1986), and Woods and Fraser (1995).

Furthermore, the statistical data of pretest and posttest mean scores indicated that in all three case studies, constructivist teaching could improve students' attitudes towards their science learning activities and academic self-efficacy. It was noteworthy that the level of students' attitudes before and after learning with constructivist teaching had changed from *Sometime*s to *Often* on the Attitude to Science Learning Activities scale in the classes of Teachers A and D, but remained at the same in level of *Often* in Teacher B's class. On the Self-efficacy scale, there was a change from *Seldom* to *Sometimes* in only Teacher D's class, but remained at the same level of *Seldom* and *Sometimes* in the classes of Teachers A and B.

In conclusion, this study has shown that constructivist teaching is effective in improving students' perceptions of their classroom environments. The major findings of this study can be summarized as follows:

1. The Constructivist Learning Environment Survey (CLES) is a valid and reliable questionnaire for use in Thailand.
2. The average classroom in this study had relatively high levels of student perceived Uncertainty, Student Negotiation, and Personal Relevance, but the levels of Shared Control and Critical Voice were consistently lower. In addition, on all five scales, students preferred a more favourable learning environment than they actual are they perceived in their classrooms.
3. Teachers are able to make use of learners' responses to the CLES to improve their own classroom learning environments.
4. A constructivist teaching approach can improve students' attitudes towards science learning activities and self-efficacy.

7.2 LIMITATIONS OF THIS STUDY

There are four limitations in this study which could affect the generalisability of the results. The first is the assumption that the students in the sample provided truthful and accurate information on the CLES questionnaires and during interviews with the researcher. The possible inaccuracy of results could be a result of students and/or teachers purposely providing inaccurate responses. Another possibility is the unintentional inaccurate data caused by student comprehension of the meaning of some words in the questionnaire, such as 'the world' in item 1 (I learn about the world outside of school.) wrongly comprehended as 'mountain, sea or soil'. Another example is the students' misunderstanding of item 14. (It's OK for me to complain about anything that prevents me from learning.) They could think that this means that students can complain to their friends about anything that prevents them from learning. To compensate for these limitations, triangulation was used to verify data. Methodological triangulation was achieved by combining quantitative data from the students' Actual and Preferred CLES questionnaires, student and teacher interviews with the researcher, and classroom observations made by the researcher several times during the study.

The second limitation was the short period of time allowed for the study. Only two semesters were available for the collection of data (one semester for phases one and two, and one semester for phase three). The research results could be different when a short-term study is used compared with a long-term study. Using a longer period of research time such as one or more years may decrease the limitations caused by this problem.

Third, the results were limited to a particular sample in Thailand and therefore this affects the possibility of making strong generalisations. The sample consisted of only Nakornsawan area secondary school students. Therefore, care needs to be taken when generalizing from these results to a different location or to students of different ages.

A fourth limitation is that the scope of this study did not include students' cognitive outcomes as these were not available to the researcher. Therefore, no information is

available from this study to relate scores on the CLES scales with the achievement of students' cognitive outcomes.

Although the present study had limitations, each limitation was addressed in order to ensure that as accurate a picture as possible was provided.

7.3 IMPLICATIONS OF THIS STUDY

From the findings of the research presented in Chapters 4, 5 and 6, there are a number of implications concerning the use of constructivist teaching for improving learning environments in Thai classrooms.

In Chapter 4, the CLES was congruence to be valid and reliable for use in Thailand. This result was similar to the validation of the CLES not only in the USA and Australia (Dryden & Fraser, 1998; Taylor, Fraser, & Fisher, 1997) but also in the non-Western countries (Aldridge, Taylor, Fraser, & Chen, 2000; Idiris & Fraser, 1997; Lee & Fraser, 2001a; Soeharto, 1998; Wilks, 2000) as described in Chapter 2. Consequently, the CLES could be used by Thai science teachers and researchers to conduct further investigations leading to improvements in science classroom environments and consequently students' achievement in science. Moreover, it was found that the CLES took little class time to administer and could be quickly hand-scored. It is also possible to design and use a CLES score sheet which could be scored by a computer. The CLES is easily accessible, inexpensive, reliable, and easy to score and interpret making it of considerable value to classroom teachers.

It is noteworthy that students perceived that their science classes sometimes and seldom reflected constructivist aspects, with the average item mean ranging from 2.01 to 3.28 (a mean of 3 and 2 corresponds to *Sometimes* and *Seldom,* respectively). The mean scores of Personal Relevance, Uncertainty and Student Negotiation were close to 3.00, which suggests that the learning environment in science classrooms of Thailand emphasises relevance to everyday life, inquiry-centred learning, and student negotiation. In the case of Shared Control and Critical Voice students perceived that in their science lessons this seldom occurred. This suggests that Thai students perceived that their teachers are not sharing aspects of learning science with their

students and students do not often express their thoughts and criticisms about their learning and how it might be improved. They also suggested that social interactions have an effect on the classroom environment, but that this positive effect is not great enough to change traditional science classrooms into highly constructivist-oriented ones. The finding implies that Thailand needs more teacher-development programs, particularly those regarding teachers' readiness to implement a new science curriculum based on constructivist principles, for improving science learning environments.

The findings confirmed that teachers are able to make use of learners' responses to the CLES to improve their own classroom learning environments. Therefore, teachers who receive support and training can consider students' views about their classrooms and improve their classroom environments. Consequently, teachers can develop and apply their own plans to induce classroom environment changes based on their students' actual and preferred CLES results. The CLES results can remain confidential or teachers could compare their results with other teachers or educators in an attempt to receive professional opinions concerning ways of changing what they are doing. After a desirable time, the teachers can reassess their environments with the CLES and compare the information with that in the previous assessment to see if their applied methods do improve their classroom environment.

This study has provided significant findings for teachers, researchers, Rajabhat Institutes, and other organizations which deal with the development of science teaching and curriculum to increase students' understanding of concepts, ideas and directions, to make choices or decisions using constructivist teaching, and action research in the classroom. For example, to implement constructivist teaching in science classrooms, the following strategies were shown to be effective. First, creating a science classroom learning environment situation in which students can create personal meanings through peer negotiation of the sensory experiences. Second, indicating that student questions and input are encouraged and highly valued in the class. Third, allowing sufficient time for student learning: during constructivist teaching, each student and each group must be given the time each needs to learn the targeted information to the extent expected; without sufficient time, the academic benefits of constructivist learning will be limited. Fourth, using cooperative learning

to support constructivist teaching by fostering three important components in learning activities: face-to-face interaction, student social skills and individual accountability. In order for the students to express their opinions, it will be necessary for teacher to demonstrate and show them how to do this both verbally and non-verbally. Finally, it is important to give attention to efficiencies in assessment, and to alternative ways of assessment.

It is highly desirable to combine quantitative and qualitative methods in future research in Thailand, as was done in this study. Recently, increasing numbers of classroom environment studies are using both quantitative and qualitative methods in the same study (Fraser & Tobin, 1991; Tobin & Fraser, 1998). While quantitative methods involve predetermined classroom environment constructs, qualitative research makes assertions to highlight some salient aspects of classroom environment that emerge during the study (Tobin & Fraser, 1998). In this way, the highly complex nature of a study in which teaching and learning takes place is maintained and data are not lost. In addition, data from qualitative methods help to explicate trends and patterns that arise from quantitative methods.

7.4 SUGGESTED FURTHER RESEARCH

The CLES could be used for research in classrooms of elementary, and lower secondary schools. The present research study involved only science students in upper-secondary schools. This research could be replicated with different student populations at different grade levels, in different subjects, and in government and non-government schools. Information from these studies would provide a more comprehensive view of classroom environments and more generalizations could be made about Thai classroom environments. In addition, previous learning environment research has indicated differences in the perceptions of boys and girls in the same class and this also would be worth investigating.

There should be other types of classroom research involving constructivist teaching in the classrooms, including investigations of associations between student cognitive outcomes and the nature of constructivist classroom environments. Furthermore, it would be a fruitful line of research if versions of the CLES were made available for

assessing the differences between teachers' perceptions of their own classroom environments and differences between teachers' perceptions and those of their students. The evaluation of the success of educational innovations or programs also could involve the CLES scales as process criteria of effectiveness (e.g., Dryden & Fraser, 1996; Fraser, 1979; Maor & Fraser, 1996).

Longitudinal studies involving teachers who routinely use a constructivist teaching approach could also provide interesting data. The research topics could be about changes in teachers' beliefs, attitudes and teaching behaviours in implementing constructivist teaching in their classrooms.

Rajabhat teachers should conduct research on how they can help inservice teachers to implement a constructivist teaching approach in classrooms. An example of such a research questions is, What type of professional development programs might enable teachers to implement a constructivist teaching approach in their classrooms?

This study adapted a model for promoting improvement in classroom environments from prior research. School teachers can apply this model to improve their classroom environments systematically though teacher action research. Consequently, consideration should be given to discovering teachers' problems in implementing action research in their classrooms.

In this study, science students' outcomes were assessed in terms of students' attitudes on only two scales: Attitude to Science Learning Activities and Self-Efficacy. It would be a good idea to extend the study by broadening the students' attitudinal outcomes to include other attitude scales, such as Attitude toward Scientific Attitudes, and Career Interest in Science.

Various new questionnaires could be developed to assess psychosocial dimension of learning environments that would be easy for teachers to apply in their own classrooms. Culturally sensitive factors should be selected as important aspects in the questionnaire. This idea was originally suggested by Fisher and Waldrip (1999).

It would be beneficial to extend the use of the CLES to pre-service teacher education. Duschl and Waxman (1991) used a classroom environment instrument to assess student teachers' performance during their teaching practice. Findings from Duschl and Waxman's study informed student-teachers about their field experiences and were sources of information for their supervisors to use when counseling student-teachers about their teaching practice and teacher education as a whole. Similarly, such an idea could be introduced and research in Thailand.

7.5 FINAL COMMENT

Since the learning reform in Thailand related to the Thai National Education Act of B.E. 2542 (1999), this is the first study exploring the effectiveness of constructivist teaching approaches in improving science classroom learning environments. An unique feature of this study is that it was an attempt to understand and demonstrate how teachers used a constructivist teaching approach to improve their own classroom environments. The findings hold special interest for the science teachers of secondary schools where the study was conducted, because the study encouraged teachers to improve their psychosocial environment.

The experience of the researcher would indicate that a great deal of sensitivity must be shown to teachers in any schools when using the instrument. Clearly, if teachers want changes to occur, before the instrument is used, they must understand what are some of the expected outcomes, why students' accurate responses are required, what responsibility they will have, and what processes will be set up to interpret data and develop strategies for classroom improvement. Furthermore, once teachers decide to use this instrument or any other similar instrument, they must be committed to the process.

The best way of using the CLES in classrooms would appear to be:

- to identify which aspects of constructivist classroom learning environment could be improved and to adopt some innovation or strategies to achieve this.
- to develop CLES profiles to stimulate discussion and focus on areas of necessary concern among teachers.

It may be possible to successfully implement a constructivist teaching approach and use of the CLES in science classrooms if there is a more coordinated effort among Rajabhat Institutes, universities, school teachers, schools and the community. Rajabhat Institutes and universities should have the capability to train preservice and inservice science teachers to implement a constructivist teaching approach consistent with the CLES, the model for improving the classroom learning environment and students' learning outcomes. Also, with the teachers' own willingness and the support given by the school and community, it is hoped that science teachers will use a constructivist teaching approach and the CLES to improve their science classroom environment, students' academic and attitude outcomes.

REFERRENCES

Adler, S. (1991). The reflective practioner and the curriculum of teacher education. *Journal of Education for Teaching, 17*, 139-150.

Aldridge, J. M., & Fraser, B. J. (2000). A cross-cultural study of classroom learning environments in Australia and Taiwan. *Learning Environments Research, 3*, 101-134.

Aldridge, J. M., Fraser, B. J., & Fisher, D. L. (2003, January). *Investigating student outcomes in an outcomes-based, technology-rich learning environment.* Paper presented at the Science, Mathematics and Technology Education Conference, East London, South Africa.

Aldridge, J. M., Fraser, B. J., & Huang, T. C. I. (1999). Investigating classroom environments in Taiwan and Australia with multiple research methods. *Journal of Educational Research, 93*, 48-62.

Aldridge, J. M., Taylor, P. C., Fraser, B. J., & Chen, C. C. (2000). Constructivist learning environments in a cross-national study in Taiwan and Australia with multiple research methods. *The Journal of Educational Research, 93*, 48-62.

Allen, K., & Mitler, M. (1990). Teacher-researcher collaboration: Cooperative professional development. *Theory into Practice, 29*, 196-202.

Anderson, G., & Arsenault, N. (1998). *Fundamentals of educational research* (2 ed.). London, New York: Falmer Press.

Anderson, G. L., & Walberg, H. J. (1974). Learning environments. In H. J. Walberg (Ed.), *Evaluating educational performance: A sourcebook of methods, instruments and examples* (pp. 81-98). Berkeley: McCutchan.

Appleton, K., & Asoko, H. (1996). A case study of a teacher's progress toward using a constructivist view of learning to inform teaching in elementary science. *Science Education, 80*(2), 165-180.

Asghar, M., & Fraser, B. J. (1995). Classroom environment and attitudes to science in Brunei Darussalam. *Journal of Science and Mathematics Education in Southeast Asia, XVIII(2)*, 41-47.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist, 37*, 122-147.

Bandura, A. (1986). *Social foundations of thought and action*. Englewood Cliffs, New Jersey: Prentice-Hall.

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental Psychology, 25*, 729-735.

Beckett, T. M. (1999). *Development of conceptual understanding of statistics for concrete thinkers in a constructivist learning environment.* Unpublished Unpublished EdD, University of Lowell.

Bouffard-Bouchard, T. (1990). Influence of self-efficacy on performance in a cognitive task. *Journal of Social Psychology, 130*, 353-393.

Bouffard-Bouchard, T., Parent, S., & Larivee, S. (1991). Influence of self-efficacy on self-regulation and performance among jounior and senior high-school aged students. *International Journal of Behavior Development, 14*, 153-164.

Brooks, J., & Brooks, M. (1999). *The case for a constructivist classroom*. Alexandria,VA: ASCD.

Brophy, J., & Good, T. L. (1986). *Teacher behavior and student achievement* (3 ed.). New York: Macmillan.

Brown, S., & McIntyre, D. (1993). *Making sense of teaching.* Buckingham, England: Open University Press.

Bybee, R. (1997). *Achieving scientific literacy from purposes to practices*. Portsmouth, NH: Heinemann.

CETP. (1998). *Strategies for constructivist teaching*, from http://www.temple.edu/CETP/temple_teach/CM-struc.html

Chionh, Y. H., & Fraser, B. J. (1998, April). *Validation of the "What Is Happening In This Class" Questionnaire.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Diego, CA.

Cho, J. I., Yager, R. E., Park, D. Y., & Seo, H. A. (1997). Change in high school teachers' constructivist philosophies. *School Science and Mathematics, 97*, 400-405.

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education* (5 ed.). London, New York: Taylor & Francis, Inc.

Collins, J. L. (1982, March). *Self-efficacy and ability in achievement behaviour.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Connelly, F., & Clandinin, D. (1990). Stories of experiences and narrative inquiry. *Educational Researcher, 19*(4), 2-14.

Cook, T. D., & Reichardt, C. S. (1979). *Qualitative and quantitative methods in evaluation research*. In T. D. Cook & C. S. Reichardt (Eds.). New York: The Free Press.

Cronbach, L. J. (1970). *Essentials of psychological testing* (3 ed.). New York: Harper & Row.

Curriculum Development Centre: Ministry of Education. (1995). *Report of students' achievement in the primary and secondary levels*. Bangkok: Kuruspa Press.

Darling-Hammond, L. (1996). The quiet revolution: Rethinking teacher development. *Educational Leadership, 3*, 6-10.

Doman, J. P., Adams, J. E., & Ferguson, J. M. (2003). *A cross-national investigation of students' perceptions of mathematics classroom environment and academic efficacy in secondary schools*, from http://www.ex.ac.uk/cimt/ijmtl/dormanj.pdf

Dryden, M., & Fraser, B. J. (1996, April). *Evaluating urban systemic reform using classroom learning environment instruments.* Paper presented at the annual meeting of American Educational Research Association, New York.

Dryden, M., & Fraser, B. J. (1998, April). *Evaluating urban systemic reform using the Constructivist Learning Environment Survey.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, Ca.

Duit, R., & Confrey, J. (1996). Reorganizing the curriculum and teaching to improve learning in science and mathematics. In D. F. Treagust, R. Duit & B. J. Fraser (Eds.), *Improving teaching and learning in science and mathematics* (pp. 79 - 93). New York: Teachers College Press.

Dunkin, M. J., & Biddle, B. (1974). *The study of teaching*. New York: Holt, Reinehart and Winston.

Duschl, R. A., & Waxman, H. C. (1991). Influencing the learning environment of student teaching: Investgations with preservice teachers. In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 255-270). Oxford: Pergamon Press.

Education Sector: UNESCO. (2003). *Project INSITE*, 2000, from http://www.utexas.edu/education/LTC/zOLDfiles/research/index.html

Elliott, J. (1987). Teachers as researchers. In M. Dunkin (Ed.), *The international encyclopedia of teaching and teacher education* (pp. 162-164). Oxford: Pergamon Press.

Erickson, E. (1986). Qualitative methods in research. In M. Wittrock (Ed.), *Handbook of research on teaching* (pp. 119-161). New York: Macmillan.

Firestone, W. A. (1987). Meaning in method: The rhetoric of quantitative and qualitative research. *Educational Researcher, 16*(7), 16-21.

Fisher, D., Henderson, D., & Fraser, B. (1997). Laboratory environments & student outcomes in senior high school biology. *American Biology Teacher, 59*, 214-219.

Fisher, D. L., Aldridge, J. M., Fraser, B. J., & Wood, D. (2003). *Development, validation and use of a questionnaire to assess students' perceptions of outcomes-focused, technology-rich learning environments*. Retrieved 23/04, 2003, from http://www.aare.edu.au/01pap/fis01028.htm

Fisher, D. L., & Fraser, B. J. (1981). Validity and use of My Class Inventory. *Science Education, 65*, 145-156.

Fisher, D. L., & Fraser, B. J. (1983a). Validity and use of classroom environment scale. *Educational Evaluation and Policy Analysis, 5*, 261--271.

Fisher, D. L., & Fraser, B. J. (1983b). A comparison of actual and preferred classroom environment as perceived by science teachers and students. *Journal of Research in Science Teaching, 20*, 55--61.

Fisher, D. L., & Fraser, B. J. (1991). School climate and teacher professional development. *South Pacific Journal of Teacher Education, 19*, 17-32.

Fisher, D. L., Goh, S. C., Wong, A. F. L., & Rickards, T. W. (1997). Perceptions of interpersonal teacher behaviour in secondary science classrooms in Singapore and Australia. *Journal of Applied Research in Education, 2*(2-13).

Fisher, D. L., & Waldrip, B. G. (1999). Cultural factors of science classroom learning environments, teacher-student interactions and student outcomes. *Research in Science and Technological Education, 17*, 83-96.

Fisher, D. L., & Waldrip, B. G. (2002). Measuring culturally sensitive factors of classroom learning environments with the CLEQ. In S. C. Goh & M. S. Khine (Eds.), *Studies in educational learning environments*. Singapore: World Scientific Publishing.

Fraser, B. J. (1979). Evaluation of a science-based curriculum. In H. J. Walberg (Ed.), *Educational environments and effects: Evaluation, policy and productivity* (pp. 218-234). Berkely, CA: McCutchan.

Fraser, B. J. (1981a). Using environmental assessments to make better classrooms. *Journal of Curriculum Studies, 13*, 131-144.

Fraser, B. J. (1981b). *Test of science-related attitudes (TOSRA)*. Melbourne: Australian Council for Educational Research.

Fraser, B. J. (1982). Differences between student and teacher perceptions of actual and preferred classroom learning environment. *Educational Evaluation and Policy Analysis, 4*, 511-519.

Fraser, B. J. (1986). *Classroom environment*. London: Croom Helm.

Fraser, B. J. (Ed.). (1988). *The study of learning environments* (Vol. 3). Perth, Australia: Curtin University of Technology.

Fraser, B. J. (1989a). *Assessing and improving classroom environment*. Perth,Western Australia: Curtin University of Technology.

Fraser, B. J. (1989b). Twenty years of classroom climate work: Progress and prospect. *Journal of Curriculum Studies, 21*, 307-327.

Fraser, B. J. (1994). Research on classroom and school climate. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 493-451). New York: Macmillan.

Fraser, B. J. (1997). NARST's expansion, internationalization and cross-nationalization(1996 Annual Meeting Presidential Address). *NARST News, 40(1)*, 3-4.

Fraser, B. J. (1998a). Classroom environment instruments: Development, validity and applications. *Learning Environment Research, 1*, 7-33.

Fraser, B. J. (1998b). Science learning environments: Assessments, effects, and determinants. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education* (pp. 1-61). Dordrecht, The Netherlands: Kluwer.

Fraser, B. J. (1999). 'Grain sizes' in learning environment research: Combining qualitative and quantitative methods. In H. Waxman & H. J. Walberg (Eds.), *New directions for teaching practice and research* (pp. 285-296). Berkeley, CA: McCutchan.

Fraser, B. J. (2002). Learning environments research: Yesterday, today and tomorrow. In S. C. Goh & M. S. Khine (Eds.), *Studies in educational learning environments* (pp. 1-25). Singapore: World Scientific Publishing.

Fraser, B. J., Anderson, G. J., & Walberg, H. J. (1982). *Assessment of learning environments: Manual for Learning Environment Inventory (LEI) and My Class Inventory (MCI) (third version)*. Perth, Australia: Western Australian Institute of Technology.

Fraser, B. J., & Butts, W. L. (1982). Relationship between perceived levels of classroom individualisation and science-related attitudes. *Journal of Research in Science Teaching, 19*, 143-154.

Fraser, B. J., & Chionh, Y. H. (2000, April). *Classroom environment, self-esteem, achievement, and attitudes in geography and mathematics in Singapore.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, L.A.

Fraser, B. J., & Deer, C. E. (1983). Improving classrooms through use of information about learning environments. *Curriculum Perspectives, 3(2)*, 41-46.

Fraser, B. J., & Fisher, D. L. (1982). Predicting students' outcomes from their perceptions of classroom psychosocial environments. *American Educational Research Journal, 19*, 498-518.

Fraser, B. J., & Fisher, D. L. (1983a). Student achievement as a function of person-environment fit: A regression surface analysis. *British Journal of Educational Psychology, 53*, 89-99.

Fraser, B. J., & Fisher, D. L. (1983b). Use of actual and preferred CES in person-environment fit research. *Journal of Educational Psychology, 75*, 303-311.

Fraser, B. J., & Fisher, D. L. (1983c). Development and validation of short forms of some instruments for measuring student perceptions of actual and preferred classroom learning environment. *Science Education, 67*, 115-131.

Fraser, B. J., & Fisher, D. L. (1986). Using short forms of classroom climate instruments to assess and improve classroom psychosocial environment. *Journal of Research in Science Teaching, 5*, 387-413.

Fraser, B. J., & Fisher, D. L. (1994). Assessing and researching the classroom environment. In D. L. Fisher (Ed.), *The study of learning environments* (Vol. 8, pp. 23-38). Perth, Australia: Curtin University of Technology.

Fraser, B. J., Fisher, D. L., & McRobbie, C. J. (1996, April). *Development, validation, and use of personal and class forms of a new classroom environment instrument.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Fraser, B. J., Gidding, G. J., & McRobbie, C. J. (1995). Science laboratory classroom environments at schools and universities: A cross-national study. *Educational Research and Evaluation, 1*, 289-317.

Fraser, B. J., & Hoffman, H. (1995). *Combining qualitative and quantitative methods in a teacher-researcher study of determinants of classroom environment.* Paper presented at the annual meeting of the American Educational research Association, San Francisco.

Fraser, B. J., & McRobbie, C. J. (1995). *Science laboratory classrooms at schools and universities: A cross-national study.* Paper presented at the Educatioal Research and Evaluation: An international journal on theory and practice.

Fraser, B. J., Seddon, T., & Eagleson, J. (1982). Use of student perceptions in facilitating improvement in classroom environments. *Australian Journal of Teacher Education, 7*, 31-42.

Fraser, B. J., & Tobin, K. (1989). Student perceptions of psychosocial environments in classrooms of exemplary science teachers. *International Journal of Science Education, 11*, 14-34.

Fraser, B. J., & Tobin, K. (1991). Combining qualitative and quantitative methods in classroom environment research. In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 3-27). Oxford: Pegamon Press.

Fraser, B. J., & Treagust, D. F. (1986). Validity and use of an instrument for assessing classroom psychosocial environment in higher education. *Higher Education, 15*, 37-57.

Fraser, B. J., & Walberg, H. J. (1991). *Educational environments: Evaluation, antecedents and consequences*. London: Pergamon.

Fraser, B. J., Williamson, J. C., & Tobin, K. (1987). Use of classroom and school climate scales in evaluating alternative high schools. *Teaching and Teacher Education, 3*, 219-231.

Gallos, M., Treagust, D. F., & Berg, E. V. (2001, December). *A case study of course and faculty development in college chemistey in the Phillippines.* Paper presented at the annual conference of Australian Association of Research Education, Fremantle.

Gardner, P., & Gauld, C. (1990). Labwork and students' attitutes. In E. Hegarty-Hazel (Ed.), *The student laboratory and the science curriculum* (pp. 132-156). London: Routledge.

Geelan, D. R. (1997). Epistemological anarchy and the many forms of constructivism. *Science & Education, 6(1-2)*, 15-28.

Getzels, J. W., & Thelen, H. A. (1960). The classroom as a unique social system. In N. B. Henry (Ed.), *The dynamics of instructional design: Sociopsychological aspects of teaching and learning (Fifty-ninth Yearbook of the National Society for the Study of Education, Part 2)* (pp. 53-82). Chicago: University of Chicago Press.

Goh, S. C., & Fraser, B. J. (1998). Teacher interpersonal behavior and elementary students' outcomes in primary mathematics in Singapore. *Learning Environments Research, 1*, 199-229.

Goh, S. C., & Fraser, B. J. (2000). Teacher interpersonal behavior and elementary students' outcomes. *Journal of Research in Childhood Education, 14*, 216-231.

Groundwater-Smith, S. (1991). Practitioner research and practical knowledge: Their relationship to curriculum enquiry. *Curriculum Perspectives, 11*(4), 51-55.

Haertel, G. D., Walberg, H. J., & Haertel, E. H. (1981). Socio-psychological environments and learning: A quantitative synthesis. *British Educational Research Journal, 7*, 27-36.

Haladyna, T., Olsen, R., & Shaughnessy, J. (1982). Relations of student, teacher and learning environment variables to attitudes towards science. *Science Education, 66*, 671-687.

Haladyna, T. M., & Shaughnessy, J. M. (1982). *A manual for the inventory of affective aspects of schooling.* Monmouth, OR: Teaching Research.

Hand, B., Treagust, D. F., & Vance, K. (1997). Student perceptions of the social constructivist classroom. *Science Education, 81*, 561-575.

Hirata, S., & Sako, T. (1998). Perceptions of school environment among Japanese junior high school, non-attendant, and juvenile delinquent students. *Learning Environments Research, 1*, 321-331.

Hough, L. W., & Piper, M. K. (1982). The relationship between attitudes toward science and science achievement. *Journal of Research in Science Teaching, 19*, 33-38.

Howe, K. (1988). Against the quantitative-qualitative incompatibility thesis: Or dogmas die hard. *Educational Researcher, 17*(8), 10-16.

Hubeman, M. (1990). Linkage between researchers and practitioners. *American Educational Research Journal, 27*(2), 363-392.

Idiris, S., & Fraser, B. J. (1997). Psychosocial environment of agricultural science classrooms in Nigeria. *International Journal of Science Education, 19*, 79-91.

Jinks, J. L., & Morgan, V. L. (1996). *Students' sense of academic efficacy and achievement in science: A useful new direction for research regarding scientific literacy?*, from http//unr.edu/homepage/jcannon/jinksmor.html

Jinks, J. L., & Morgan, V. L. (1999). Children's perceived academic self-efficacy: An inventory scale. *Clearing House, 72*, 224-230.

Jinks, J. L., & Morgan, V. L. (2003). *Students' sense of academic efficacy and achievement in science: A useful new direction for research regarding scientific literacy?*, from http://unr.edu/homepage/jcannon/ejse/jinksmor.html

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). *Active learning: Cooperation in the college classroom* (4 ed.). Edina, MN: Interaction Book Company.

Kemmis, S., & McTaggart, R. (1988). *The action researcher planner*. Geelong, Victoria: Deakin University Press.

Khine, M. S. (2002). Study of learning environment for improving science education in Brunei. In S. C. Goh & J. B. Kahle (Eds.), *Studies in educational learning environments* (pp. 131-152). Singapore: World Scientific Publishing.

Khine, M. S., & Fisher, D. L. (2001, December). *Classroom environment and teachers' cultural background in secondary science classes in an Asian context.* Paper presented at the annual meeting of the Australian Association for Research in Education, Perth, Australia.

Khine, M. S., & Fisher, D. L. (2002, April). *Analysising interpersonal behaviour in science classrooms: Associations between students' perceptions and teachers' cultural background.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, New Oreans, L.A.

Khine, M. S., & Fisher, D. L. (2003). *Technology-rich learning environments*. New Jersey, London, Singapore, Hong Kong: World Scientific.

Khoo, H. S., & Fraser, B. J. (1997, April). *The learning environments associated with computer application courses for adults in Singapore.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Khoo, H. S., & Fraser, B. J. (1998, April). *Using classroom environment dimensions in the evaluating of adult computer courses.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Kim, H. B., Fisher, D. L., & Fraser, B. J. (1999). Assessment and investigation of constructivist science learning environments in Korea. *Research in Science and Technological Education, 17*, 239-249.

Kim, H. B., Fisher, D. L., & Fraser, B. J. (2000). Classroom environment and teacher interpersonal behaviour in secondary school classes in Korea. *Evaluation and Research in Education, 14*, 3-22.

Koballa, T. R. (1992). Peer coaching: Capitalizing on constructive criticism. *Science Teacher, 56*(6), 42-45.

Koury, K. A. (1994). *Comparing social learning condition and method of instruction in an inclusive school with fourth-grade students with and without mild disabilities.* Unpublished EdD, West Virginia University.

Lederman, N. G., & Niess, M. L. (1997). The nature of science: Naturally? *School Science and Mathematics, 97*(1), 1-2.

Lee, S. U., & Fraser, B. J. (2001a, December). *Assessment, description and effective of science classroom environment in Korea.* Paper presented at the annual conference of Australian Association of Research Education, Fremantle, Perth.

Lee, S. U., & Fraser, B. J. (2001b, April). *Science laboratory classroom environments in Korea.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Lee, S. U., & Fraser, B. J. (2002, April). *High school science classroom learning environments in Korea.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Lee, S. U., & Kim, H. B. (2002). Curriculum development and learning environment in Korea. In S. C. Goh & M. S. Khine (Eds.), *Studies in educational learning environments* (pp. 169-196). Singapore: World Scientific Publishing.

Lewin, K. (1936). *Principles of topological psychology*. New York: Ronald Press Co.

Mager, R. F. (1968). *Developing attitude toward learning*. Belmont, CA: Fearon Publishers.

Maor, D., & Fraser, B. J. (1996). Use of classroom environment perceptions in evaluating inquiry-based computer assisted learning. *International Journal of Science Education, 18*, 401-421.

Margianti, E. S., Fraser, B., & Aldridge, J. (2001, December). *Investigating the learning environment and students' outcomes in university level computing courses in Indonesia.* Paper presented at the annual conference of the Australian Association for Research in Education, Fremantle, Australia.

Marjoribanks, K. (1976). School attitudes, cognitive ability and academic achievement. *Journal of Educational Psychology, 68*, 653-660.

McCutcheon, G., & Jung, B. (1990). Alternative perspectives on action research. *Theory into Practice, 29(3)*, 144-151.

McNiff, J. (1993). *Teaching as learning: An action research approach*. London: Routledge.

McRobbie, C. J., Fisher, D. L., & Wong, A. F. L. (1998). Personal and class forms of classroom environment instruments. In B. J. Fraser & K. Tobin (Eds.), *International handbook of science education* (pp. 581-594). Dordrecht, The Netherlands: Kluwer Academic Publishers.

McRobbie, C. J., & Fraser, B. J. (1993, April). *A topology of science laboratory classroom environments.* Paper presented at the annual meeting of American Educational Research Association, Atlanta, GA.

Merriam, S. (1988). *Case study research in education: A qualitative approach*. San Francisco, CA: Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1984). *Qualitative data analysis: A sourcebook of new methods*. Bevery Hills, CA: Sage.

Ministry of Education. (2000). *Strand of science in basic education curriculum B. E. 2542*. Bangkok: Kuruspa Press.

Moos, R. H. (1974). *The social climate scales: An overview*. Palo Alto, CA: Consulting Psychologists Press.

Moos, R. H. (1979). *Evaluating educational environments: Procedures, measures, findings and policy implications*. San Francisco, CA: Jossey-Bass.

Moos, R. H., & Trickett, E. J. (1987). *Classroom environment scale manual* (2 ed.). Palo Alto, CA: Consulting Psychologists Press.

Munby, H., & Russell, T. (1992). Frames of reflection: An introduction. In T. Russell & H. Munby (Eds.), *Teachers and teaching: From classroom to reflection* (pp. 1-8). London: The Falmer Press.

Munro, P., & Elliot, J. (1989). Instructional growth through peer coaching. In P. Wolfe & P. Robbins (Eds.), *Opening doors: An introduction to peer coaching* (pp. 19-22). Alexandria, VA: Association for Supervision and Curriculum Development.

Murray, H. A. (1938). *Explorations in personality*. New York: Oxford University Press.

Nair, C. S., & Fisher, D. L. (2001). Transition from senior secondary to higher education: A learning environment perspective. *Research in Science Education, 30*, 435-450.

Nunnally, J. C. (1978). *Psychometic theory* (2nd ed.). New York: McGraw Hill.

Oberg, A., & Mc Cutcheon, G. (1990). Teacher as researcher. *Theory into Practice, 29*(3), 142-143.

Office of the National Education Commission: Office of Prime Minister Kingdom of Thailand. (1997). *Education in Thailand 1997*. Bangkok: Kuruspa Press.

Office of the National Education Commission: Office of Prime Minister Kingdom of Thailand. (1999). *Thai national education act of B.E. 2542*. Bangkok: Kuruspa Press.

Office of the National Education Commission: Office of Prime Minister Kingdom of Thailand. (2003). *Education in Thailand 2002/2003*. Bangkok: Kuruspa Press.

Oja, S. N., & Smulyan, L. (1989). *Collaborative action research: A developmental approach*. Philadelphia: The Falmer Press.

Pedhazur, E. J., & Schmelkin, L. P. (1991). *Measurement, design, and analysis: An integrated approach*. Hillsdale, NJ: Erlbaum.

Peterson, P. L., & Walberg, A. J. (1979). Research on teaching: Concepts, findings and implications. In P. L. Peterson & A. J. Walberg (Eds.). Berkeley, CA: McCutchan.

Poh, S. H. (1996). A study of biology laboratory learning environment in Brunei Darussalam. In M. Quigley, P. K. Veloo & W. K. Yoong (Eds.), *Assessment and evaluation in science and mathematics: Innovative approaches* (pp. 272-281). Brunei: Universiti Brunei Darussalam.

Pugach, M. C., & Johnson, L. J. (1995). Unlocking expertise among classroom teachers through structured dialogue: Extending research on peer collaboration. *Exceptional Children, 62*(2), 101-110.

Quek, C. L., Fraser, B. J., & Wong, A. F. L. (2001, December). *Determinants and effects of perceptions of chemistry classroom learning environments in secondary school gifted education classes in Singapore.* Paper presented at the annual conference of the Australian Association for Research in Education, Fremental, Australia.

Rentoul, A. J., & Fraser, B. J. (1979). Conceptualization of enquiry-based or open classroom learning environments. *Journal of Curriculum Studies, 11*, 233-245.

Riah, H., & Fraser, B. J. (1998, April). *Chemistry learning environment and its association with students' achievement in chemistry.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Schaler, J. A. (1995, November). *What you believe: The power of self-fulfilling prophecies.* Paper presented at the 1995 Conferrence for Treaty 6 First Nations of Alberta entitled 'Alternative Approaches to Addictions and Destructive Habits', Edmonton, Alberta.

Schön, D. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Schunk, D. H. (1981). Modeling and attributional effects on children's achievement: A self-efficacy analysis. *Journal of Educational Psychology, 73*, 93-105.

Schunk, D. H. (1982). Effects of effort attributional feedback on children's perceived self-efficacy and achievement. *Journal of Educational Psychology, 74*, 548-556.

Schunk, D. H. (1983). Ability versus effort attributional feedback: Differential effects on self-efficacy and achievement. *Journal of Educational Psychology, 75*, 848-856.

Schunk, D. H. (1989a). Self-efficacy and achievement behavior. *Educational Psychology Review, 1*, 173-208.

Schunk, D. H. (1989b). Self-efficacy and cognitive skill learning. In C. Ames & R. Ames (Eds.), *Research on motivation in education* (Vol. 3, pp. 13-44). San Diego, CA: Academic.

Scott, P. H., Dyson, T., & Gater, S. (1987). *A constructivist view of learning and teaching in Science*. Leeds, England: Children's Learning in Science Project, Centre for Studies in Science and Mathematics Education, University of Leeds.

Scott, R., & Fisher, D. L. (2001, December). *The impact of teachers' interpersonal behaviour on examination results in Brunei.* Paper presented at the annual conference of theAustralian Association for Research in Education, Fremantle, Australia.

Sebela, M. P., Fraser, B. J., & Aldrige, J. M. (2003). *Teacher action research and constructivist classroom environments in South Africa.* Paper presented at the Science, Mathematic and Technology Education, East London, South Africa.

She, H. C., & Fisher, D. L. (2000). The development of a questionnaire to describe science teacher communication behaviour in Taiwan and Australia. *Science Education, 84*, 706-726.

Showers, B. (1985). Teachers coaching teachers. *Educational Leadership, 42*(7), 43-48.

Showers, B., & Joyce, B. (1996). The evaluation of peer coaching. *Educational Leadership, 53*(6).

Shulman, L. S., & Tamir, P. (1972). Research on teaching in the natural sciences. In R. M. W. Travers (Ed.), *Second handbook of research on teaching* (pp. 1098-1148). Chicago, IL: Rand McNally.

Sinclair, B. B., & Fraser, B. J. (1998a, April). *Assessment and improvement of middle grade classroom environments.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Sinclair, B. B., & Fraser, B. J. (1998b, April). *The evaluation and improvement of middle grade classroom environments.* Paper presented at the annual meeting of the National Association of Research in Science Teaching, San Diego, CA.

Sinclair, B. B., & Fraser, B. J. (2001, April). *Assessing, describing and changing classroom environments in urban middle schools.* Paper presented at the annual meeting of the American Educational Research Association, Seattle.

Smith, D. L., & Fraser, B. J. (1980). Towards a confluence of quantitative and qualitative approaches in curriculum evaluation. *Journal of Curriculum Studies, 12*, 367-370.

Soeharto, S. (1998). *The effects of a constructivist learning environment on grade six student achievement and attitude toward mathematics in Indonesian primary schools*: Unpublished EdD, University of Houston.

Soerjaningsih, W., Fraser, B. J., & Aldrige, J. M. (2001a, April). *Achievement, satisfaction and learning environment among Indonesian computing students at the university level.* Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

Soerjaningsih, W., Fraser, B. J., & Aldrige, J. M. (2001b, December). *Learning environment, teacher-student interpersonal behaviour and achievement among university students in Indonesia.* Paper presented at the annual conference of the Australian Association for Research in Education, Fremental, Australia.

Sparks-Langer, G., & Colton, A. (1991). Synthesis of research on teachers' reflective teaching. *Educational Leadership, 48*(6), 37-44.

Stake, R. E. (1996). Case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 236-247). Thousand Oaks, CA: Sage.

Stake, R. E., & Easley, J. A. (1978). *Case studies in science education*. Urbana, IL: Center for Institutional Research and Curriculum Evaluation, University of Illinois.

Steffe, L. P., & Gale, J. (1995). *Constructivism in education*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Stenhouse, L. (1975). *An introduction to curriculum research and development*. London: Heineman Education Books.

Stepans, J., Dyche, S., & Beiswenger, R. (1988). The effect of two instructional models in bringing about a conceptual change in the understanding of science concepts by prospective elementary teachers. *Science Education, 72(2)*, 185-195.

Stern, G. G., Stein, M. J., & Bloom, B. S. (1956). *Methods in personality assessment.* Glencoe, IL: Free Press.

Tamir, P. (1987). Some factors which affect science achievement of high school seniors in Israel. *Research in Science and Technological Education, 5*, 69-92.

Taylor, P. C. (1991, April). *Development of an instrument for assessing constructivist learning environments.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Taylor, P. C., Dawson, V., & Fraser, B. J. (1995a, April). *A constructivist perspective on monitoring classroom learning environments under transformation.* Paper presented at the annual meeting of the American Educational Research Association, San Fransisco, CA.

Taylor, P. C., Dawson, V., & Fraser, B. J. (1995b, April). *Classroom learning environments under transformation: A constructivist perspective.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Taylor, P. C., & Fraser, B. J. (1998). *CLES2(25): Student Perceived; CLES2(25): Student Preferred (Unpublished Paper)*. Perth, Australia: SMEC, Curtin University of Technology.

Taylor, P. C., Fraser, B. J., & Fisher, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research, 27*, 293-302.

Taylor, P. C., Fraser, B. J., & White, L. R. (1994, April). *A classroom environment questionnaire for science educators interested in the constructivist reform of school science.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, Fontana, WI.

Teh, G., & Fraser, B. J. (1994). An evaluation of computer-assisted learning in terms of achievement, attitudes and classroom environment. *Evaluation and Research in Education, 8*, 147-161.

Teh, G., & Fraser, B. J. (1995). Associations between student outcomes and geography classroom environment. *International Research in Geographical and Environmental Education, 4*(1), 3-18.

Thorp, H., Burden, R. L., & Fraser, B. J. (1994). Assessing and improving classroom environments. *School Science Review, 75*, 107-113.

Tobin, K. (1987). The role of wait time in higher cognitive level learning. *Review of Educational Research, 57*, 69-95.

Tobin, K. (1998). Qualitative perceptions of learning environments on the World Wide Web. *Learning Environments Research, 1*, 139-162.

Tobin, K., & Fraser, B. J. (1998). Qualitative and quantitative landscapes of classroom learning environments. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education* (pp. 623-640). Dordrecht, The Netherlands: Kluwer.

Tobin, K., & Malone, J. (1989). Differential student participant in whole-class activities. *Australian Journal of Education, 33*, 320-331.

Tobin, K., & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In K. Tobin (Ed.), *The practice of constructivism in education* (pp. 3-21). New Jersy: Lawrence-Erlbaum, Hillsdale.

Tobin, K. E. (1993). *The practice of constructivism in science education*. Washington, DC: Association for the Advancement of Science (AAAS).

Treagust, D. F., Duit, R., & Fraser, B. J. (1996). Overview: Research on students' preinstructional conceptions: The driving force for improving teaching and learning in science and mathematics. In D. F. Treagust, R. Duit & B. J. Fraser (Eds.), *Improving teaching and learning in science and mathematics* (pp. 1-14). New York: Teachers College Press.

Vail, C. O., Tscanz, J. M., & Beviel, A. (1997). Dyads and data in peer coaching. *Teaching Exceptional Children, 30*(2), 11-12.

Walberg, H. J. (1976). Psychology of learning environments: Behavioral, structural, or perceptual? In L. Shulman (Ed.), *Review of Research in Education* (Vol. 4, pp. 142-148). Itasca, Illinois: F. E. Peacock Publishers, Inc.

Walberg, H. J. (1981). A phychological theory of educational productivity. In F. Farley & N. Gordon (Eds.), *Psychology and education: The state of the union*. Berkeley: McCutchan.

Walberg, H. J., & Anderson, G. J. (1968). Classroom climate and individual learning. *Journal of Educational Psychology, 59*, 414-419.

Waldrip, B. G., & Wong, A. F. L. (1996). Association of attitudes with science laboratory environments in Singapore and Papua New Guinea. *Journal of Science and Mathematics in South East Asia, 14*, 26-37.

Webb, E. J., Campbell, D. T., Schwartz, R. D., & Sechrest, L. (1965). *Unobtrusive measures*. Chicago: Rand McNally.

Weinburgh, M. H. (1995). Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970-1991. *Journal of Research in Science Teaching, 32(4)*, 387-398.

Wheatley, G. H. (1991). Constructivist perspectives on science and mathematics learning. *Science Education, 75*(1), 9-21.

Wilks, D. R. (2000). *An evaluation of classroom learning environments using critical constructivist perspectives as a referent for reform.* Unpublished EdD, Curtin University of Technology, Perth, Australia.

Wolfe, P., & Robbins, P. (1989). *Opening doors: An introduction to peer coaching.* Association for Supervision and Curriculum Development, Alexandria, VA.

Wong, A. F. L., & Fraser, B. J. (1996). Environment-attitude associations in the chemistry laboratory classrooms. *Research in Science and Technological Education, 64*, 29-40.

Wong, N. Y. (1993). Psychological environments in the Hong Kong mathematics classroom. *Journal of Mathematical Behavior, 12*, 303-309.

Wong, N. Y. (1996). Students' perceptions of the mathematics classroom in Hong Kong. *Hiroshima Journal of Mathematics Education, 4*, 89-107.

Woods, J., & Fraser, B. J. (1995, April). *Utilizing feedback data on students' perceptions of teaching styles and preferred learning style to enhance teaching effectiveness.* Paper presented at the annual meeting of the National Association of Research in Science Teaching, San Francisco, CA.

Woods, J., & Fraser, B. J. (1996). *Enhancing reflection by monitoring students' perceptions of teaching style and preferred learning style.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Wooten, V. (1999). *The effectiveness of a constructivist learning environment on learning in the high school science classroom.* Unpublished EdD, Curtin University of Technology, Perth, Australia.

Wubbels, T., & Brekelmans, M. (1997). A comparison of student perceptions of Dutch physics teachers' interpersonal behaviour and their educational opinions in 1984 and 1993. *Journal of Research in Science Education, 34*, 447-466.

Wubbels, T., & Levy, J. (1993). *Do you know what you look like?* In *Interpersonal relationships in education*. London: Falmer Press.

Yager, R. (1991). The constructivist learning model, towards real reform in science education. *The Science Teacher, 58*(6), 52-57.

Yager, R. E. (1995). Constructivism and the learning of science. In S. M. Glynn & R. Duit (Eds.), *Learning science in the schools: Research reforming practice* (pp. 35-58). Mahwah, NJ: Erlbaum.

Yarrow, A., & Millwater, J. (1995). SMILE: Student modifiation of learning environments: Establishing congruence between actual and preferred classroom learning environments. *Journal of Classroom Interaction, 30*(1), 11-15.

Yarrow, A., Millwater, J., & Fraser, B. J. (1997). Improving university and primary school classroom environments through preservice teachers' action research. *International Journal of Practical Experience in Professional Education, 1*(1), 68-93.

Yaxley, B. (1993). Critically reflective teachers in a devolving educational context: Implications of Schön's proposals for the teacher as a critically reflective practioner. *South Pacific Journal of Teacher Education, 21*(1), 23-32.

Yin, R. K. (1994). *Case study research*. Newbury Park, CA: Sage.

Zandvliet. (2002). Learning environments in technology-rich classrooms. In S. C. Goh & J. B. Kahle (Eds.), *Studies in educational learning environments* (pp. 49-72). Singapore: Worlld Scientific Publishing.

Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal, 29*, 663-676.

LIST OF APPENDICES

APPENDIX A

Student Preferred Form of the CLES in English Version

What I wish would happen in

my science classroom

(Student Preferred Form)

DIRECTIONS

1. **Purpose of the Questionnaire**
   This questionnaire asks you to describe important aspects of the science classroom which you are in right now. There are no right or wrong answers. This is not a test and your answers will not affect your assessment. Your opinion is what is wanted. Your answers will enable us to improve future science classes.

2. **How to Answer Each Question**
   On the next few pages you will find 25 sentences. For each sentence, circle only one number corresponding to your answer. For example:

	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that . . .					
1. I learned about the world outside of school.	5	4	3	2	1

- If you think this teacher *almost always* asks you questions, circle the 5.
- If you think this teacher *almost never* asks you questions, circle the 1.
- Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. **How to Change Your Answer**
   If you want to change your answer, cross it out and circle a new number, For example:

1. I learned about the world outside of school.	5	4	3	2	1

4. **Course Information**
   Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

a. Name:	b. School:
c. Grade/Year-level:	d. Sex: male /female (please circle one)

5. **Completing the Questionnaire**
   Now turn the page and please give an answer for every question.

Learning about the world	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that . . .					
1. I learned about the world outside of school.	5	4	3	2	1
2. My new learning would start with problems about the world outside of school.	5	4	3	2	1
3. I could learn how science can be part of my out-of-school life.	5	4	3	2	1
In this class I wish that. . .					
4. I would get a better understanding of the world outside of school.	5	4	3	2	1
5. I learned interesting things about the world outside of school.	5	4	3	2	1
Learning about science	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that. . . .					
6. I learned how science has changed over time.	5	4	3	2	1
7. I learned how science is influenced by people's values and opinions.	5	4	3	2	1
In this class I wish that. . . .					
8. I learned about the different sciences used by people in other cultures.	5	4	3	2	1
9. I learned that modern science is different from the science of long ago.	5	4	3	2	1
10. I learned that science involves inventing theories.	5	4	3	2	1
Learning to speak out	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that. . . .					
11. It was OK for me to ask the teacher "why do I have to learn this?"	5	4	3	2	1
12. It was OK for me to question the way I'm being taught.	5	4	3	2	1
13. It was OK for me to complain about activities that are confusing.	5	4	3	2	1
In this class I wish that. . .					
14. It was OK for me to complain about anything that prevents me from learning.	5	4	3	2	1
15. It was OK for me to express my opinion.	5	4	3	2	1

Learning to learn	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that . . .					
16. I could help the teacher to plan what I'm going to learn.	5	4	3	2	1
17. I could help the teacher to decide how well I am learning.	5	4	3	2	1
18. I could help the teacher to decide which activities are best for me.	5	4	3	2	1
In this class I wish that . .					
19. I could help the teacher to decide how much time I spend on activities.	5	4	3	2	1
20. I could help the teacher to decide which activities I do.	5	4	3	2	1
Learning to communicate	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that . . .					
21. I got the chance to talk to other students.	5	4	3	2	1
22. I could talk with other students about how to solve problems.	5	4	3	2	1
23. I had the chance to explain my ideas to other students.	5	4	3	2	1
In this class I wish that . . .					
24. I could ask other students to explain their ideas.	5	4	3	2	1
25. Other students could listen carefully to my ideas.	5	4	3	2	1
	Almost Always	Often	Some-times	Seldom	Almost Never

APPENDIX B

Student Actual Form of the CLES in English Version

What happens in my

science classroom

(Student Actual Form)

DIRECTIONS

1. **Purpose of the Questionnaire**
This questionnaire asks you to describe important aspects of the science classroom which you are in right now. There are no right or wrong answers. This is not a test and your answers will not affect your assessment. Your opinion is what is wanted. Your answers will enable us to improve future science classes.

2. **How to Answer Each Question**
On the next few pages you will find 25 sentences. For each sentence, circle only one number corresponding to your answer. For example:

	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
1. I learn about the world outside of school.	5	4	3	2	1

- If you think this teacher *almost always* asks you questions, circle the 5.
- If you think this teacher *almost never* asks you questions, circle the 1.
- Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. **How to Change Your Answer**
If you want to change your answer, cross it out and circle a new number, For example:

1. I learn about the world outside of school.	~~5~~	4	3	2	1

4. **Course Information**
Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

a. Name:	b. School:
c. Grade/Year-level:	d. Sex: male /female (please circle one)

5. **Completing the Questionnaire**
Now turn the page and please give an answer for every question.

Learning about the world	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
1. I learn about the world outside of school.	5	4	3	2	1
2. My new learning starts with problems about the world outside of school.	5	4	3	2	1
3. I learn how science can be part of my out-of-school life.	5	4	3	2	1
In this class . . .					
4. I get a better understanding of the world outside of school.	5	4	3	2	1
5. I learn interesting things about the world outside of school.	5	4	3	2	1
Learning about science	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
6. I learn that science has changed over time.	5	4	3	2	1
7. I learn that science is influenced by people's values and opinions.	5	4	3	2	1
In this class . . .					
8. I learn about the different sciences used by people in other cultures.	5	4	3	2	1
9. I learn that modern science is different from the science of long ago.	5	4	3	2	1
10. I learn that science involves inventing theories.	5	4	3	2	1
Learning to speak out	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
11. It's OK for me to ask the teacher "why do I have to learn this?"	5	4	3	2	1
12. It's OK for me to question the way I'm being taught.	5	4	3	2	1
13. It's OK for me to complain about activities that are confusing.	5	4	3	2	1
In this class . . .					
14. It's OK for me to complain about anything that prevents me from learning.	5	4	3	2	1
15. It's OK for me to express my opinion.	5	4	3	2	1

Learning to learn	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
16. I help the teacher to plan what I'm going to learn.	5	4	3	2	1
17. I help the teacher to decide how well I am learning.	5	4	3	2	1
18. I help the teacher to decide which activities are best for me.	5	4	3	2	1
In this class . . .					
19. I help the teacher to decide how much time I spend on activities.	5	4	3	2	1
20. I help the teacher to decide which activities I do.	5	4	3	2	1
Learning to communicate	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
21. I get the chance to talk to other students.	5	4	3	2	1
22. I talk with other students about how to solve problems.	5	4	3	2	1
23. I explain my ideas to other students.	5	4	3	2	1
In this class . . .					
24. I ask other students to explain their ideas.	5	4	3	2	1
25. Other students listen carefully to my ideas.	5	4	3	2	1
	Almost Always	Often	Some-times	Seldom	Almost Never

APPENDIX C

Student Preferred Form of the CLES in Thai Version

สิ่งที่ฉันต้องการให้เกิดขึ้น ในชั้นเรียนวิทยาศาสตร์ของฉัน (แบบวัดสภาพชั้นเรียนที่ต้องการ)

คำชี้แจง

1. **วัตถุประสงค์ของแบบสอบถาม**
   แบบสอบถามนี้
   ต้องการให้นักเรียนอธิบายลักษณะสำคัญของชั้นเรียนวิทยาศาสตร์ที่นักเรียนกำลังเรียนอยู่ในขณะนี้ไม่มีคำตอบใ
   ดถูกหรือผิด **ความคิดเห็น ของนักเรียนเป็นสิ่งสำคัญที่ผู้วิจัยต้องการ**
   คำตอบของนักเรียนจะช่วยให้ผู้วิจัยนำไปใช้ในการปรับปรุงห้องเรียนวิทยาศาสตร์ในอนาคต

2. **วิธีตอบคำถามแต่ละข้อ**
   ในหน้าถัดไปจะมีข้อความ 25 ข้อ ให้นักเรียนเลือกวงกลมล้อมรอบตัวเลข**เพียง 1 ตัว**ตามความคิดเห็น
   ของนักเรียนเช่น

	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่... 1 ฉันจะได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน .	5	4	3	2	1

- ถ้านักเรียนต้องการจะได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน**บ่อยมาก** ให้วงกลมล้อมเลข 5
- ถ้านักเรียนต้องการจะ ได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน**น้อยมาก**ให้วงกลมล้อมเลข 1
- นักเรียนสามารถเลือกวงกลม หมายเลข 2, 3 หรือ 4 ถ้าข้อความในข้อนั้น ๆ ตรงตามความเห็นขอ
  นักเรียน

3. **วิธีเปลี่ยนคำตอบ**
   ถ้านักเรียนต้องการเปลี่ยนคำตอบ **ให้ขีดเครื่องหมาย กากบาท (X)** และ วงกลมล้อมรอบตัวเลข
   ในข้อ**ใหม่**ที่ต้องการ เช่น

	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่... 1 ฉันจะได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน .	⑤	④	3	2	1

4. **ข้อมูลเกี่ยวกับรายวิชานี้**
   กรุณากรอกข้อมูลลงในตารางด้านล่างต่อไปนี้ตามความเป็นจริง

ก. ชื่อ:	ข. โรงเรียน:
ค. ชั้น:	ง. เพศ: ชาย / หญิง (เลือกวงกลมเพียง 1 ข้อ)

5. **การลงมือตอบแบบสอบถาม**
   ขอให้นักเรียนพลิกหน้าต่อไปและ กรุณาตอบ**ทุกข้อ**

การเรียนรู้เกี่ยวกับโลก	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
1. ฉันจะได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน	5	4	3	2	1
2. การเรียนรู้ของฉันจะเริ่มด้วยปัญหาต่าง ๆ เกี่ยวกับโลกภายนอกโรงเรียน	5	4	3	2	1
3. ฉันจะได้เรียนรู้ว่าวิทยาศาสตร์เป็นส่วนหนึ่งของชีวิตภายนอกโรงเรียนของฉันอย่างไร	5	4	3	2	1
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
4. ฉันจะเข้าใจเกี่ยวกับโลกภายนอกโรงเรียน	5	4	3	2	1
5. ฉันจะได้เรียนรู้สิ่งที่น่าสนใจเกี่ยวกับโลกภายนอกโรงเรียน	5	4	3	2	1
การเรียนรู้เกี่ยวกับวิชาวิทยาศาสตร์	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
6. ฉันจะได้เรียนรู้ว่าวิทยาศาสตร์มีการเปลี่ยนแปลงตลอดเวลา	5	4	3	2	1
7. ฉันจะได้เรียนรู้ว่าวิทยาศาสตร์ได้รับอิทธิพลจากค่านิยม และความคิดเห็นของคนเรา	5	4	3	2	1
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
8. ฉันจะได้เรียนรู้เกี่ยวกับวิทยาศาสตร์ต่าง ๆ ที่คนในสังคมอื่นใช้	5	4	3	2	1
9. ฉันจะได้เรียนรู้ว่าวิทยาศาสตร์สมัยใหม่แตกต่างจากวิทยาศาสตร์สมัยก่อน	5	4	3	2	1
10. ฉันจะได้เรียนรู้ว่าวิทยาศาสตร์เกี่ยวข้องกับการคิดค้นทฤษฎีต่าง ๆ	5	4	3	2	1
การเรียนรู้เกี่ยวกับการพูดแสดงความคิดเห็น	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
11. ฉันจะได้ถามอาจารย์ ว่า “ทำไมฉันต้องเรียนเรื่องนี้”	5	4	3	2	1
12. ฉันจะได้ถามอาจารย์ถึงวิธีการที่อาจารย์ใช้สอน	5	4	3	2	1
13. ฉันจะได้ร้องเรียนอาจารย์เกี่ยวกับกิจกรรมการเรียนที่สับสน	5	4	3	2	1
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
14. ฉันจะได้ร้องเรียนอาจารย์เกี่ยวกับสิ่งที่เป็นอุปสรรคในการเรียน	5	4	3	2	1
15. ฉันจะได้แสดงความคิดของตนเอง	5	4	3	2	1
การเรียนรู้วิธีการเรียน	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
16. ฉันจะได้ช่วยอาจารย์วางแผนสิ่งที่ฉันจะเรียน	5	4	3	2	1

. 17. ฉันจะได้ช่วยอาจารย์ตัดสินว่าขณะนี้ฉันเรียนรู้ดีเพียงใด	5	4	3	2	1
. 18. ฉันจะได้ช่วยอาจารย์ตัดสินใจเลือกกิจกรรมการเรียนที่ดีที่สุดสำหรับฉัน	5	4	3	2	1

	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆ ครั้ง	น้อยมาก
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
19. ฉันจะได้ช่วยอาจารย์ตัดสินใจว่าจะใช้เวลาในการทำกิจกรรมการเรียนนานเท่าใด	5	4	3	2	1
20. ฉันจะได้ช่วยอาจารย์ตัดสินใจว่ากิจกรรมใดที่ฉันควรทำ	5	4	3	2	1
การเรียนรู้การสื่อสาร	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆ ครั้ง	น้อยมาก
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
21. ฉันจะมีโอกาสคุยกับนักเรียนคนอื่นๆ	5	4	3	2	1
22. ฉันจะได้พูดคุยกับนักเรียนคนอื่นๆ เกี่ยวกับวิธีแก้ปัญหาต่างๆ	5	4	3	2	1
23. ฉันจะได้อธิบายความคิดของฉันแก่นักเรียนคนอื่นๆ	5	4	3	2	1
สิ่งที่ฉันต้องการในชั้นเรียนนี้ได้แก่...					
24. ฉันจะได้ขอให้นักเรียนคนอื่นๆ แสดงความคิดเห็น	5	4	3	2	1
25. นักเรียนคนอื่นๆ จะ ฟังความคิดเห็นของฉันอย่างตั้งใจ	5	4	3	2	1
	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆ ครั้ง	น้อยมาก

APPENDIX D

Student Actual Form of the CLES in Thai Version

สิ่งที่เกิดขึ้น **ในชั้นเรียนวิทยาศาสตร์ของฉัน** **(แบบวัดสภาพชั้นเรียนที่เป็นจริง)**

คำชี้แจง

1. วัตถุประสงค์ของแบบสอบถาม

แบบสอบถามนี้ ต้องการให้นักเรียนอธิบายลักษณะสำคัญของชั้นเรียนวิทยาศาสตร์ที่นักเรียนกำลังเรียนอยู่ในขณะนี้ ไม่มีคำตอบใดถูก หรือ ผิด

ความคิดเห็นของนักเรียนเป็นสิ่งสำคัญที่ผู้วิจัยต้องการ

คำตอบของนักเรียนจะช่วยให้ผู้วิจัยนำไปใช้ในการปรับปรุงห้องเรียนวิทยาศาสตร์ในอนาคต

2. วิธีตอบคำถามแต่ละข้อ

ในหน้าถัดไปจะมีข้อความ 25 ข้อ ให้นักเรียนเลือกวงกลมล้อมรอบตัวเลข **เพียง1 ตัว**ตามความคิดเห็นของนักเรียนเช่น

	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆ ครั้ง	น้อยมาก
ในชั้นเรียนนี้... 1 ฉันได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน .	5	4	3	2	1

- ถ้านักเรียนเห็นว่า ได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน **บ่อยมาก** ให้วงกลมล้อมเลข 5
- ถ้านักเรียนเห็นว่านักเรียนได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน **น้อยมาก** ให้วงกลมล้อมเลข 1
- นักเรียนสามารถเลือกวงกลม หมายเลข 2, 3 หรือ 4 ถ้าข้อความในข้อนั้น ๆ ตรงตามความเห็นของนักเรียน

3. วิธีเปลี่ยนคำตอบ

ถ้านักเรียนต้องการเปลี่ยนคำตอบ **ให้ขีดเครื่องหมาย กากบาท (X)** และ วงกลมล้อมรอบตัวเลขในข้อ ใหม่ที่ต้องการเช่น :

	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
ในชั้นเรียนนี้...					
1. ฉันได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน	(5)	④	3	2	1

4. ข้อมูลเกี่ยวกับรายวิชานี้

กรุณากรอกข้อมูลลงในตารางด้านล่างต่อไปนี้ตามความเป็นจริง

ก. ชื่อ:	ข. โรงเรียน:
ค. ชั้น:	ง. เพศ: ชาย / หญิง (เลือกวงกลมเพียง 1 ข้อ)

5. การลงมือตอบแบบสอบถาม

ขอให้นักเรียนพลิกหน้าต่อไป และ กรุณาตอบ**ทุกข้อ**

การเรียนรู้เกี่ยวกับโลก	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
ในชั้นเรียนนี้ ...					
1. ฉันได้เรียนรู้เกี่ยวกับโลกภายนอกโรงเรียน	5	4	3	2	1
2. การเรียนรู้ของฉันเริ่มด้วยปัญหาต่าง ๆเกี่ยวกับโลกภายนอกโรงเรียน	5	4	3	2	1
3. ฉันได้เรียนรู้ว่าวิทยาศาสตร์เป็นส่วนหนึ่งของชีวิตภายนอกโรงเรียนของฉันอย่างไร	5	4	3	2	1
ในชั้นเรียนนี้ ...					
4. ฉันเข้าใจเกี่ยวกับโลกภายนอกโรงเรียน	5	4	3	2	1
5. ฉันได้เรียนรู้สิ่งที่น่าสนใจเกี่ยวกับโลกนอกโรงเรียน	5	4	3	2	1
การเรียนรู้เกี่ยวกับวิชาวิทยาศาสตร์	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
ในชั้นเรียนนี้ ...					
6. ฉันได้เรียนรู้ว่าวิทยาศาสตร์มีการเปลี่ยนแปลงตลอดเวลา	5	4	3	2	1
7. ฉันได้เรียนรู้ว่าวิทยาศาสตร์ได้รับอิทธิพลจากค่านิยมและความคิดเห็นของคนเรา	5	4	3	2	1
ในชั้นเรียนนี้ ...					
8. ฉันได้เรียนรู้เกี่ยวกับวิทยาศาสตร์ต่าง ๆที่คนในสังคมอื่นใช้	5	4	3	2	1
9. ฉันได้เรียนรู้ว่าวิทยาศาสตร์สมัยใหม่แตกต่างจากวิทยาศาสตร์สมัยก่อน	5	4	3	2	1
10. ฉันได้เรียนรู้ว่าวิทยาศาสตร์เกี่ยวข้องกับการคิดค้นทฤษฎีต่าง ๆ	5	4	3	2	1
การเรียนรู้เกี่ยวกับการพูดแสดงความคิดเห็น	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
ในชั้นเรียนนี้ ...					
1. ฉันได้ถามอาจารย์ว่า “ทำไมฉันต้องเรียนเรื่องนี้”	5	4	3	2	1

1.					
12.	ฉันได้ถามอาจารย์ถึงวิธีการที่อาจารย์ใช้สอน	5	4	3	2	1
13.	ฉันได้ร้องเรียนอาจารย์เกี่ยวกับกิจกรรมการเรียน ที่สับสน	5	4	3	2	1
ในชั้นเรียนนี้ ...						
14.	ฉันได้ร้องเรียนอาจารย์เกี่ยวกับสิ่งที่เป็นอุปสรรคในการเรียน	5	4	3	2	1
15.	ฉันได้แสดงความคิดของตนเอง	5	4	3	2	1
การเรียนรู้วิธีการเรียน		บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
ในชั้นเรียนนี้ ...						
16.	ฉันได้ช่วยอาจารย์วางแผนสิ่งที่ฉันจะเรียน	5	4	3	2	1
17.	ฉันได้ช่วยอาจารย์ตัดสินว่าขณะนี้ฉันเรียนรู้ดีเพียงใด	5	4	3	2	1
18.	ฉันได้ช่วยอาจารย์ตัดสินใจเลือกกิจกรรมการเรียนที่ดี ที่สุดสำหรับฉัน	5	4	3	2	1

	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
ในชั้นเรียนนี้ ...					
19. ฉันได้ช่วยอาจารย์ตัดสินใจว่าจะใช้เวลาในการทำกิจกรรมการเรียนนานเท่าใด	5	4	3	2	1
20. ฉันได้ช่วยอาจารย์ตัดสินใจว่ากิจกรรมใดที่ฉันควรทำ	5	4	3	2	1
การเรียนรู้การสื่อสาร	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
ในชั้นเรียนนี้ ...					
21. ฉันมีโอกาสคุยกับนักเรียนคนอื่นๆ	5	4	3	2	1
22. ฉันได้พูดคุยกับนักเรียนคนอื่นๆเกี่ยวกับวิธีแก้ปัญหาต่าง ๆ	5	4	3	2	1
23. ฉันได้อธิบายความคิดของฉันแก่นักเรียนคนอื่นๆ	5	4	3	2	1

ในชั้นเรียนนี้ ...					
24. ฉันขอให้นักเรียนคนอื่นๆแสดงความคิดเห็น	5	4	3	2	1
25. นักเรียนคนอื่นๆฟังความคิดเห็นของฉันอย่างตั้งใจ	5	4	3	2	1
	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก

APPENDIX E

Back-translation of the CLES

What I wish would happen in

my science classroom

(Student Preferred Form)

DIRECTIONS

1. **Purpose of the Questionnaire**
   This questionnaire asks you to describe important aspects of the science classroom in which you are studying now. There are no right or wrong answers. Your opinion is what is wanted. Your answers will enable us to improve future science classes.

2. **How to Answer Each Question**

On the next pages you will find 25 sentences. Choose and circle only one number corresponding to your answer. For example:

	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that . . .					
1. I learned about the world outside school.	5	4	3	2	1

- If you think you would *almost always* learn about the world outside school, circle the 5.
- If you think you would *almost never* learn about the world outside school, circle the 1.
- Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. How to Change Your Answer

If you want to change your answer, cross it out and circle a new number, For example:

1. I learned about the world outside of school.	~~5~~	4	3	2	1

4. Course Information

Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

a. Name:	b. School:
c. Grade/Year-level:	d. Sex: male /female (please circle one)

5. Completing the Questionnaire

Now turn the page and please answer every question.

Learning about the world	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that . . .					
1. I learned about the world outside school.	5	4	3	2	1
2. My new learning would start with problems about the world outside school.	5	4	3	2	1
3. I learned how science can be part of my out-of-school life.	5	4	3	2	1
In this class I wish that. . . .					
4. I understood the world outside school.	5	4	3	2	1
5. I learned interesting things about the world outside school.	5	4	3	2	1
Learning about science	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that. . . .					
6. I learned how science changes all the time.	5	4	3	2	1
7. I learned how science is influenced by people's values and opinions.	5	4	3	2	1
In this class I wish that. . . .					
8. I learned about sciences used in other cultures.	5	4	3	2	1
9. I learned that modern science is different from science in the past.	5	4	3	2	1
10. I learned that science involves inventing theories.	5	4	3	2	1
Learning to speak for oneself	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that. . . .					
11. I asked the teacher, “Why do I have to learn this?”	5	4	3	2	1
12. I questioned the techniques the teacher used.	5	4	3	2	1
13. I complained to my teacher about activities that were confusing.	5	4	3	2	1
In this class I wish that. . . .					
14. I complained to my teacher about anything that prevented me from learning.	5	4	3	2	1
15. I expressed my opinion.	5	4	3	2	1

Learning how to learn	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that . . .					
16. I helped my teacher plan what I wanted to learn.	5	4	3	2	1
17. I helped my teacher decide how well I was learning.	5	4	3	2	1
18. I helped my teacher decide the best activities for me.	5	4	3	2	1
In this class I wish that …					
19. I helped my teacher decide how long I would spend on each learning activity.	5	4	3	2	1
20. I helped my teacher choose the activities I would do.	5	4	3	2	1
Learning to communicate	Almost Always	Often	Some-times	Seldom	Almost Never
In this class I wish that . . .					
21. I got the chance to talk to other students.	5	4	3	2	1
22. I discussed with other students about how to solve problems.	5	4	3	2	1
23. I had the chance to express my ideas to other students.	5	4	3	2	1
In this class I wish that . . .					
24. I asked other students to express their ideas.	5	4	3	2	1
25. Other students listened carefully to my ideas.	5	4	3	2	1
	Almost Always	Often	Some-times	Seldom	Almost Never

What happens in my

science classroom

(Student Actual Form)

DIRECTIONS

1. **Purpose of the Questionnaire**
This questionnaire asks you to describe important aspects of the science classroom in which you are studying now. There are no right or wrong answers. Your opinion is what is wanted. Your answers will enable us to improve future science classes.

2. **How to Answer Each Question**
On the next few pages you will find 25 sentences. Choose and circle only one number corresponding to your answer. For example:

	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
1. I learn about the world outside school.	5	4	3	2	1

- If you think you have *almost always* learned about the world outside school, circle the 5.
- If you think you have *almost never* learned about the world outside school, circle the 1.
- Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. **How to Change Your Answer**
If you want to change your answer, cross it out and circle a new number, For example:

1. I learn about the world outside school.	~~5~~	4	3	2	1

4. **Course Information**
Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

a. Name:	b. School:
c. Grade/Year-level:	d. Sex: male /female (please circle one)

5. **Completing the Questionnaire**
Now turn the page and please answer every question.

Learning about the world	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
1. I learn about the world outside school.	5	4	3	2	1
2. My new learning starts with problems about the world outside school.	5	4	3	2	1
3. I learn how science can be part of my out-of-school life.	5	4	3	2	1
In this class . . .					
4. I understand the world outside school.	5	4	3	2	1
5. I learn interesting things about the world outside school.	5	4	3	2	1
Learning about science	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
6. I learn that science changes all the time.	5	4	3	2	1
7. I learn that science is influenced by people's values and opinions.	5	4	3	2	1
In this class . . .					
8. I learn about sciences used in other cultures.	5	4	3	2	1
9. I learn that modern science is different from science in the past.	5	4	3	2	1
10. I learn that science involves inventing theories.	5	4	3	2	1
Learning to speak for oneself	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
11. I can ask my teacher, "Why do I have to learn this?"	5	4	3	2	1
12. I can question the teaching techniques of my teacher.	5	4	3	2	1
13. I can complain to my teacher about activities that are confusing.	5	4	3	2	1
In this class . . .					
14. I can complain to my teacher about anything that prevents me from learning.	5	4	3	2	1
15. I can express my opinion.	5	4	3	2	1

Learning how to learn	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
16. I help my teacher plan what I want to learn.	5	4	3	2	1
17. I help my teacher decide how well I am learning .	5	4	3	2	1
18. I help my teacher decide the best activities for me.	5	4	3	2	1
In this class . . .					
19. I help my teacher decide how long I spend on each learning activity.	5	4	3	2	1
20. I help my teacher decide which activities I will do.	5	4	3	2	1
Learning to communicate	Almost Always	Often	Some-times	Seldom	Almost Never
In this class . . .					
21. I get the chance to talk to other students.	5	4	3	2	1
22. I discuss with other students about how to solve problems.	5	4	3	2	1
23. I express my ideas to other students.	5	4	3	2	1
In this class . . .					
24. I ask other students to express their ideas.	5	4	3	2	1
25. Other students listen carefully to my ideas.	5	4	3	2	1
	Almost Always	Often	Some-times	Seldom	Almost Never

APPENDIX F

Student Attitude Questionnaire in English Version

Attitude to Science Learning Activities	Almost Always	Often	Some-times	Seldom	Almost Never
1. I look forward to the learning activities in this subject.	5	4	3	2	1
2. The learning activities are among the most interesting at this school.	5	4	3	2	1
3. I dislike learning activities in this subject	5	4	3	2	1
4. I feel confused about learning activities.	5	4	3	2	1
5. I enjoy learning activities in this subject.	5	4	3	2	1
6. Learning activities in this subject are a waste of time.	5	4	3	2	1
7. These learning activities make me interested in this subject.	5	4	3	2	1
8. I feel tense about learning activities.	5	4	3	2	1
Self-Efficacy	Almost Always	Often	Some-times	Seldom	Almost Never
9. I find it easy to get good grades in this subject.	5	4	3	2	1
10. I am good at this subject.	5	4	3	2	1
11. My friends ask me for help in this subject.	5	4	3	2	1
12. I find this subject easy.	5	4	3	2	1
13. I outdo most of my classmates in this subject.	5	4	3	2	1
14. I have to work hard to pass this subject.	5	4	3	2	1
15. I am an intelligent student.	5	4	3	2	1
16. I help my friends with their homework in this subject.	5	4	3	2	1
	Almost Always	Often	Some-times	Seldom	Almost Never

APPENDIX G

Student Attitude Questionnaire in Thai Version

แบบวัดเจตคติของนักเรียน

เจตคติต่อกิจกรรมการเรียนวิชาวิทยาศาสตร์	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
1. ฉันรอคอยที่จะได้ทำกิจกรรมการเรียนวิชานี้	5	4	3	2	1
2. กิจกรรมการเรียนวิชานี้ในโรงเรียนเป็นสิ่งที่น่าสนใจ	5	4	3	2	1
3. ฉันไม่ชอบกิจกรรมการเรียนวิชานี้	5	4	3	2	1
4. กิจกรรมการเรียนวิชานี้ทำให้ฉันสับสน	5	4	3	2	1
5. ฉันสนุกกับกิจกรรมการเรียนวิชานี้	5	4	3	2	1
6. เป็นการเสียเวลาเปล่าในการทำกิจกรรมการเรียน	5	4	3	2	1
7. กิจกรรมการเรียนทำให้ฉันสนใจวิชานี้	5	4	3	2	1
8. ฉันเคร่งเครียดในการทำกิจกรรมการเรียน	5	4	3	2	1
ประสิทธิภาพของตนเอง	บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก
9. ฉันรู้สึกว่าง่ายที่จะได้ผลการเรียนระดับดีในวิชานี้	5	4	3	2	1
10. ฉันเรียนเก่งในวิชานี้	5	4	3	2	1
11. ในการเรียนวิชานี้เพื่อนๆขอให้ฉันช่วยเหลือ	5	4	3	2	1
12. ฉันรู้สึกว่าวิชานี้ง่าย	5	4	3	2	1
13. ฉันเรียนวิชานี้ได้ดีกว่าเพื่อน ๆ ในชั้น	5	4	3	2	1
14. ฉันต้องเรียนอย่างหนักจึงจะผ่านวิชานี้	5	4	3	2	1

15.	ฉันเป็นนักเรียนที่ฉลาด	5	4	3	2	1
16.	ฉันช่วยเหลือเพื่อนๆทำการบ้านในวิชานี้	5	4	3	2	1
		บ่อยมาก	บ่อยครั้ง	บางครั้ง	นานๆครั้ง	น้อยมาก

APPENDIX H

Back-translation of Student Attitude Questionnaire

Attitude to Science Learning Activities		Very Often	Often	Some-times	Rarely	Almost Never
1.	I look forward to the learning activities in this subject.	5	4	3	2	1
2.	The learning activities in this subject are interesting.	5	4	3	2	1
3.	I dislike learning activities in this Subject.	5	4	3	2	1
4.	I learning activities confuse me.	5	4	3	2	1
5.	I enjoy the learning activities in this subject.	5	4	3	2	1
6.	It 's a waste of time doing the leaning activities in this subject.	5	4	3	2	1
7.	The learning activities in this subject make me interested.	5	4	3	2	1
8.	I get very tensed about learning activities.	5	4	3	2	1
Self-Efficacy		Very Often	Often	Some-times	Rarely	Almost Never
9.	I find it is easy to get good grades in this subject.	5	4	3	2	1
10.	I am good at this subject.	5	4	3	2	1
11.	My friends ask me for help in this subject.	5	4	3	2	1
12.	I find that this subject is easy.	5	4	3	2	1

13.	I can do better than my classmates in this subject.	5	4	3	2	1
14.	I have to work hard to pass the exam in this subject.	5	4	3	2	1
15.	I am an intelligent student.	5	4	3	2	1
16.	I help my friends with their homework.	5	4	3	2	1

APPENDIX I

Student Interview Protocol

1. Please think about your favourite lessons in this class. Is that lesson interesting to you? Describe these lessons briefly. Do you have chance to interact with other students in class, or would you rather study and learn on your own? Please think about the degree of your cooperation with your friends in your lessons.

2. During the lesson of this class, can you ask your teacher anything whenever you want to? Have you ever complained to your teacher (or just complained personally with your friend) about his/her teaching performance? Please give me some examples. In this class, to what extent do you have the opportunity to express your comments about your teacher in your lessons?

3. Do you think that it is important for teachers to relate your classroom studies to the outside world? Is the content of your science lesson in this class helpful to your life? If any, to what extent does your teacher relate science lesson content with your everyday experiences? Please give me some examples.

4. During the lesson, have you talked with your teacher about the expected learning outcomes and the learning activities and assessment which he/she plans? Please show me some explanations. Or, do the teachers usually prepare them only by themselves? Please tell me how frequently you can be involved in helping your teacher control the learning environment? For example, helping

the teacher to decide which activities are best for you, how much time you spend on some learning activities, or which activities you want to do.

5. Please tell me about the differences between modern science and the science of long ago. In this class, to what extent does your teacher reflect the perspectives from modern philosophy of science in your lessons? Can I ask you to present the examples of his/her behaviours?

6. Can you tell me about your learning activities in this class? For example, the enjoyable, confused, or interesting activities. How often do you feel that the learning activities in this class are enjoyable, confused or interesting?

7. How often do you feel that you can get good grades in this subject? Please give me the reasons you feel so. In this class, how often do you help your friends with their homework? Please give me the examples of doing this.

APPENDIX J

Thai Secondary School Science Students' Average Actual and Preferred Classroom Environments for the Whole Sample of 17 Classes of Seven Teachers

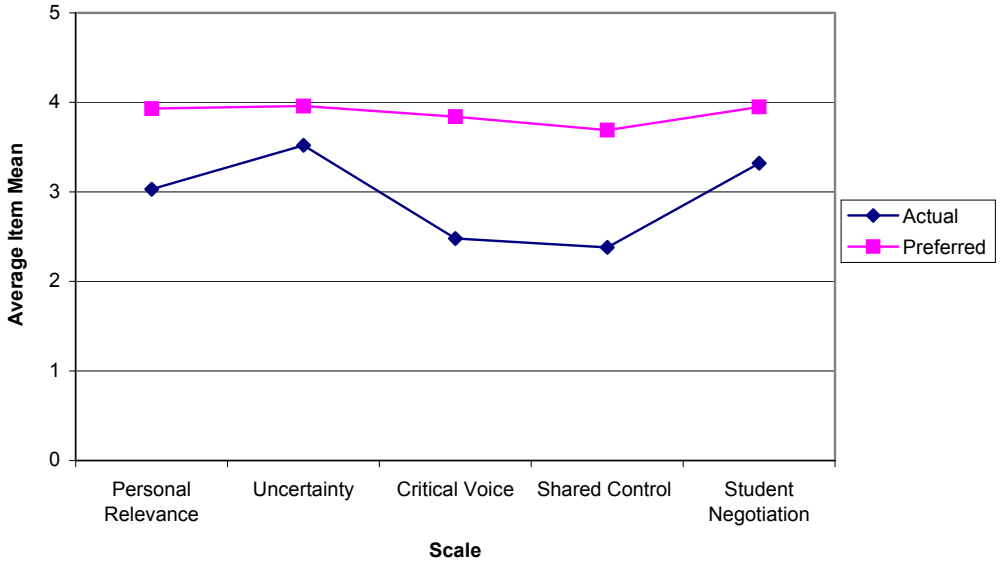

Figure 5.2. Teacher A's average student actual and preferred classroom environments (*n* =71).

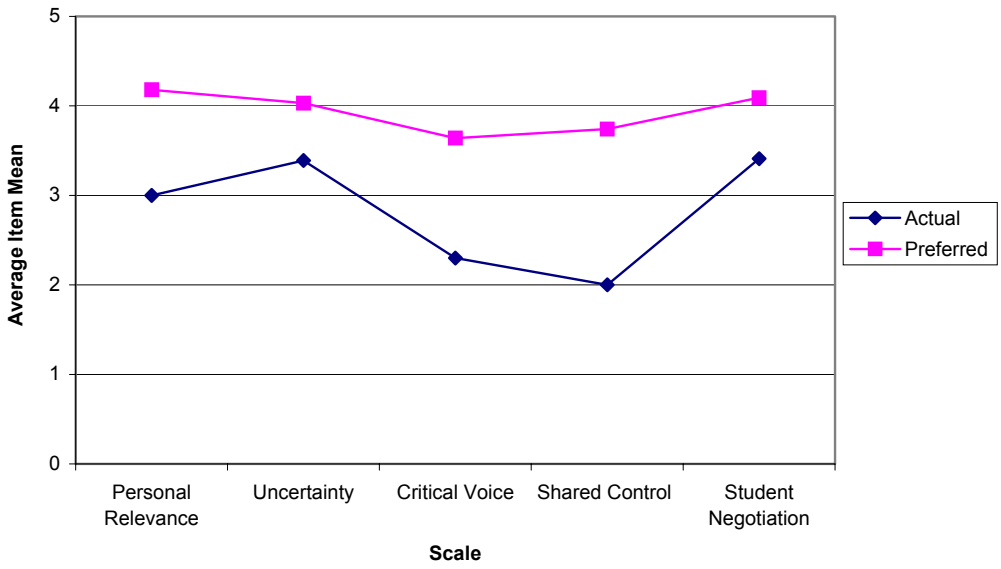

Figure 5.3. Teacher B's average student actual and preferred classroom environments (*n*=122).

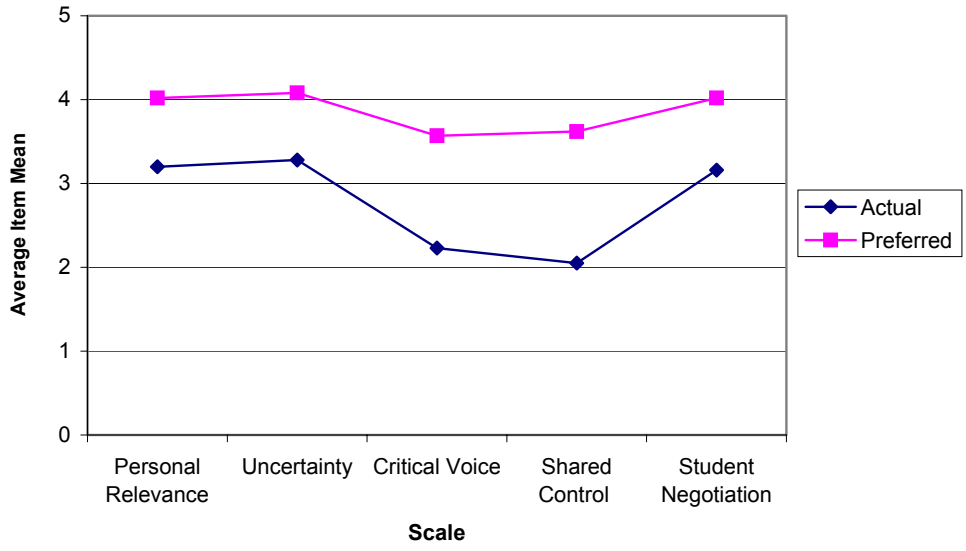

Figure 5.4. Teacher C's average student actual and preferred classroom environments (*n*=83).

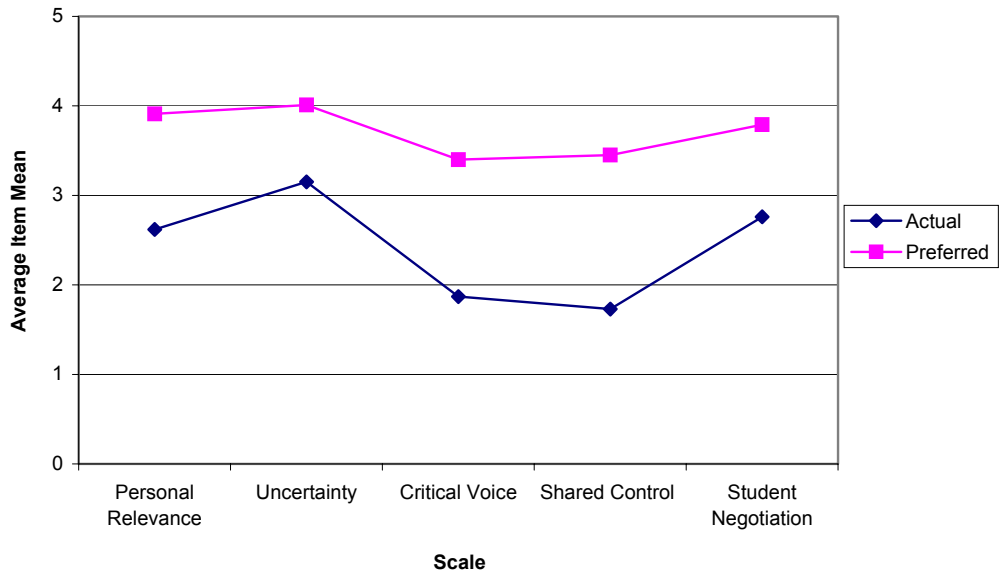

Figure 5.5. Teacher D's average student actual and preferred classroom environments (*n*=88).

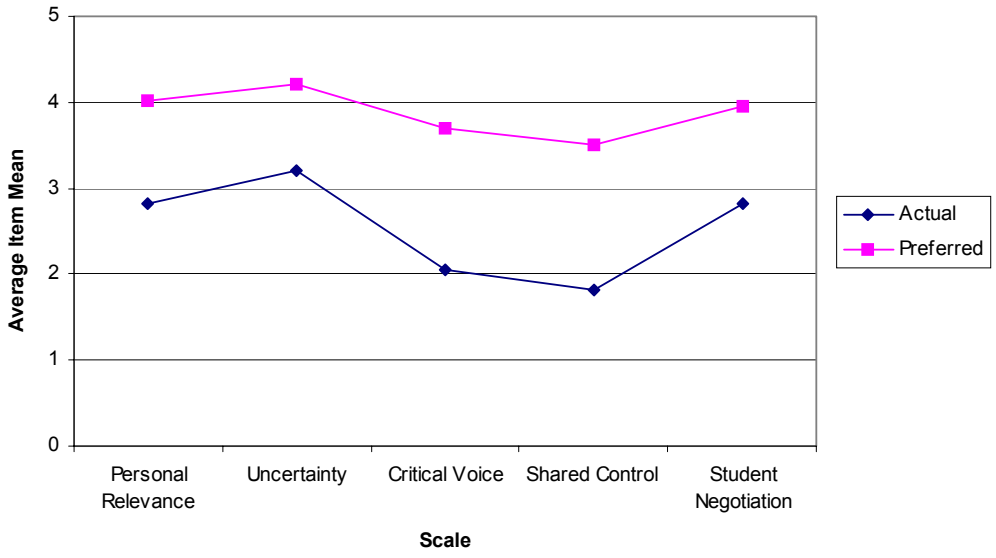

Figure 5.6. Teacher E's average student actual and preferred classroom environments (*n*=101).

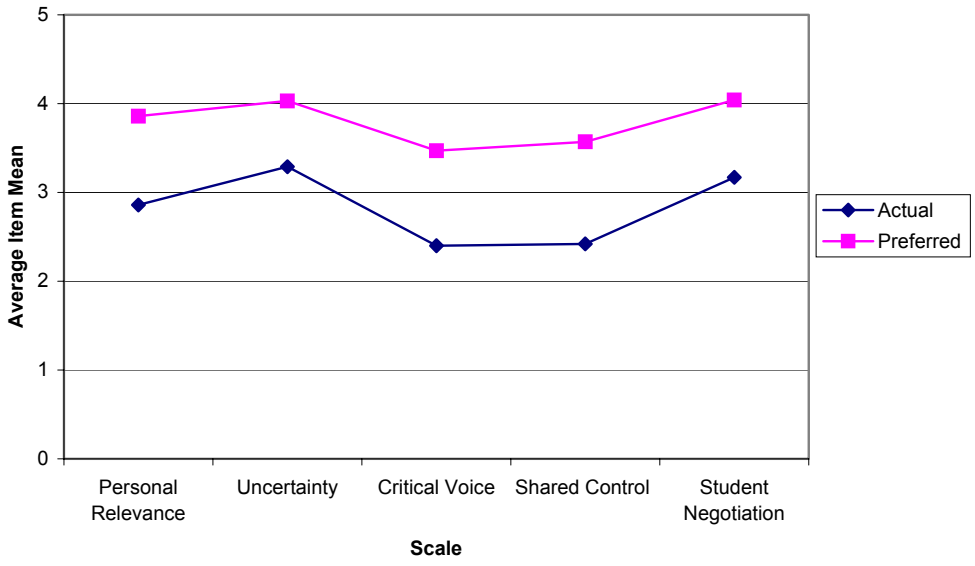

Figure 5.7. Teacher F's average student actual and preferred classroom environments (*n*=63).

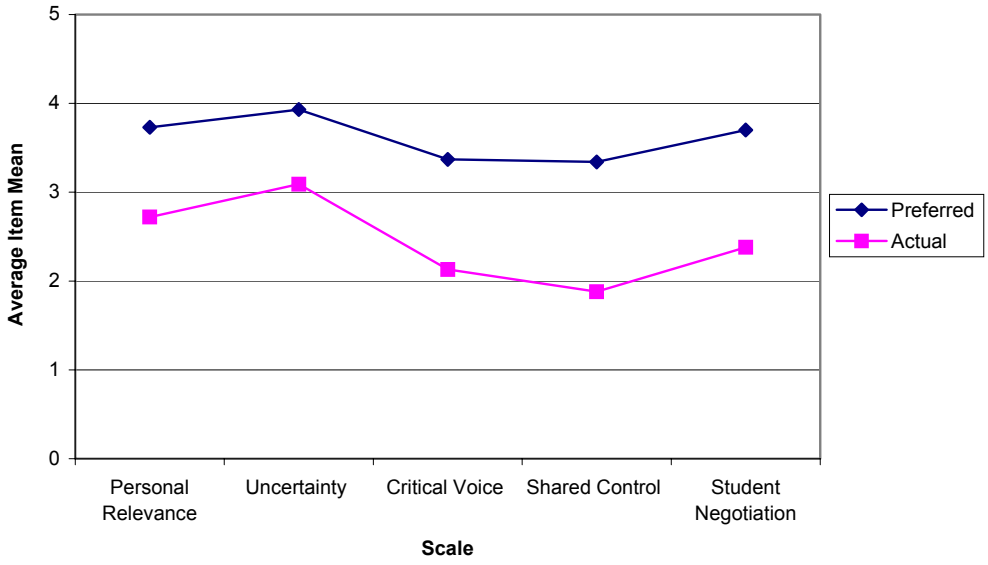

Figure 5.8. Teacher G's average student actual and preferred classroom environments (*n* =78).