Science & Mathematics Education Centre

Using Teacher Action Research to Promote Constructivist Learning Environments in Mathematics Classes in South Africa

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Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

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Abstract

The present research examined whether teachers in South Africa could use feedback from a learning environment instrument to help them to increase the degree to which they emphasised constructivist-oriented teaching strategies in their classroom. The study also investigated the validity of a widely-applicable classroom environment questionnaire, as well as associations between attitudes and classroom environment. The study involved a combination of quantitative and qualitative research methods and was carried out in two phases.

In the first phase of the study, data were collected using the *Constructivist Learning Environment Survey* (CLES), to assess learners' perceptions of the constructivist learning environment, and an attitude scale to assess learners' attitudes towards their mathematics classroom. The instruments were administered to 1864 learners in 34 intermediate (Grades 4 – 6) phase and senior phase (Grades 7 – 9) classes. Data were analysed to determine whether (a) the CLES is valid and reliable for use in South Africa and (b) relationships exist between learners' perceptions of the learning environment and their attitude toward their mathematics classes. Descriptive analysis was used to generate feedback information for teachers based on graphical profiles of learners' perceptions of the actual and preferred learning environment for each class.

Analyses of data collected from 1864 learners in 34 classes supported the factor structure, internal consistency reliability (Cronbach alpha coefficient), and discriminant validity of the CLES, as well as its ability to differentiate between classes. The results suggest that researchers and teachers can be confident about using the modified version of the CLES in mathematics classes in South Africa in the future.

Simple correlation and multiple regression analyses were conducted to examine whether associations exist between learners' attitudes towards their mathematics class and their perceptions of the learning environment. The results indicated that student attitudes were associated with more emphasis on all four CLES scales used. Two scales, Uncertainty and Student Negotiation, were found to contribute most to variance in student attitudes in mathematics classes in South Africa when the other CLES scales were mutually controlled.

Descriptive analysis was used to provide information about the constructivist nature of mathematics classes in the Limpopo Province of South Africa. The results indicate that students would prefer a learning environment that is more positive than the one that they perceive as being present in terms of emphasis on all four CLES scales used.

The second phase involved a 12-week intervention period during which two teachers used the pretest profiles of actual and preferred classroom environment means to assist them to develop strategies aimed at improving the constructivist

orientation of their classroom learning environments. The teachers implemented the strategies and maintained daily journals as a means of reflecting on their teaching practices. Throughout the 12-week period, the researcher made regular support visits that included classroom observations, reviews of daily journals, discussions with teachers and interviews with learners. As well, the researcher had the opportunity of giving support to the teachers in the implementation of their strategies.

At the end of the 12 weeks, the CLES was re-administered to learners to determine whether their perceptions of the constructivist emphasis in their classroom learning environments had changed. The posttest graphical profiles indicated that there was a sizeable improvement in teachers' emphasis on CLES dimensions in their classrooms. Apparently, teachers using action research are able to use learners' responses to the CLES to develop and implement strategies for improving their learning environment.

The study suggests that journal writing, as a tool used by teachers on a daily basis, can improve their professional expertise as reflective practitioners.

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Chapter 1

Introduction and Background

1.1 INTRODUCTION

The primary aim of the research reported in this thesis was to seek information that will assist teachers in South Africa to become involved in teacher action research and become more reflective in their mathematics classroom teaching. The study involved two phases. In the first phase, a large-scale quantitative overview was used to assess learners' and teachers' perceptions of the degree of constructivism in the learning environment and their satisfaction with their mathematics classrooms. At this time, individual profiles were also given to teachers involved in the second phase. During this phase, the quantitative data were used as a means by which teachers could reflect on their own teaching practices and, through teacher action research, involving collaboration and discussion with colleagues, develop new strategies that would improve the learning environment of their classroom. At this phase, qualitative data were gathered from classroom observations, interviews with teachers and learners, and teachers' records of their experiences in the form of journals.

This chapter provides background information regarding developments in education policy and curriculum in post-apartheid South Africa (Section 1.2). Also discussed in this chapter are the purpose of the present study (Section 1.3), the underlying research questions that were delineated (Section 1.4), the theoretical framework from within which the research was conducted (Section 1.5), and the significance of the study (Section 1.6). Finally, the chapter provides an overview of the organisation of the remaining chapters in the thesis (Section 1.7).

1.2 POST-APARTHEID EDUCATION IN SOUTH AFRICA

Since the new South African government came into existence in 1994, the education Minister, Professor Bengu, embarked on changing the education system. It was decided that, from 1998, the old curriculum, under which Blacks, Indians, Coloureds and White students studied different curricula, would be phased out and gradually replaced by Curriculum 2005 which was later called Curriculum 21st Century. Curriculum 2005 is based on the ideal of lifelong learning for all the South Africans, regardless of colour, race or sex. The curriculum focuses on fostering learning that encompasses a culture of human rights, multilingualism, multiculturalism and sensitivity to the values of reconciliation and nation building. To ensure success, the curriculum aims to provide support in the form of inservice teacher training, assessment, guidelines and student orientation. This section examines post-apartheid education in South Africa in terms of Curriculum 2005 (Section 1.2.1), the key principles of

Outcomes Based Education (Section 1.2.2), assessment in Curriculum 2005 (Section 1.2.3), constructivism and Curriculum 2005 (Section 1.2.4) and the realities of teaching in South Africa (Section 1.2.5).

1.2.1 Curriculum 2005

Curriculum 2005 encompasses an outcome-based approach to education. The methods employed are learner-centred and emphasise skills that students require to become better citizens in the future. In outcome-based education, the emphasis is on a shift from the traditional approach to a facilitative approach which changes the relationship between learner and teacher to one which provides: an independent sharing of experience; a flow of information between the teacher; and creative opportunities for the learners to acquire information (UNISA, 2001).

Curriculum 2005 aims also to encourage an integrated and non-disciplinary division of knowledge by providing links between education and training; a holistic view of knowledge and the acceptance of the principle of life-long learning (Department of Education, 2001). The emphasis is on transformational Outcomes-Based Education (OBE), which is said to be a collaborative, flexible, trans-disciplinary, outcomes-based, empowerment-oriented approach to learning. It aims at equipping all learners with knowledge, competence and orientations needed for success after they leave school or have completed their training; hence, its guiding vision is that of a thinking, competent future citizen.

1.2.2 Key Principles of Outcome-Based Education (OBE)

Outcomes Based Education (OBE) puts great emphasis on creating conditions that lead to success. It includes integration of education and training. All learners can and will succeed. Time no longer will control the learning process. This means that not all learners will succeed at the same time. Instead, learners will be able to develop at their own pace. The premise here is 'success breeds success'. Learners will be expected to show what they have learnt in different ways and assessment will not rely only on examinations at the end of the semester. Outcomes are to be assessed in other ways and on an ongoing basis.

Assessment is an integral part of the whole system. Learners are not getting marks just for remembering subject content. Different aspects of the learners' abilities, such as their creativity and critical thinking, are also assessed. The OBE basic principles (Department of Education, 1997a) underlying management of assessment processes are:

- *Design down/delivery up*: Design down refers to planning backwards. In all planning, one will start with the idea of what is wanted in the end. The outcomes to be addressed through teaching and learning are first clearly stated before developing the teaching and learning activities in which the learner will be engaged. When planning assessment, educators must start by identifying outcomes to be assessed from those that are to be addressed through teaching and learning. The next step is to choose

appropriate assessment methods, tools, techniques and activities to be used when assessing the chosen outcomes.

- *Clarity of focus* means that everyone involved must have a clear picture of what is wanted at the end. This implies that educators must ensure that learners are clear about the criteria against which they are to be assessed and therefore what they are expected to demonstrate.

- *High expectations* imply that educators must assist learners to reach their full potential.

- *Expanded opportunities* means that educators must find multiple ways of exposing learners to learning opportunities that will help them to demonstrate their full potential in terms of knowledge, skills, values and attitudes.

It is expected that OBE learners know what they are learning and why and are encouraged to take responsibility for their learning. This is likely to motivate them because they will see the value of the programme. OBE demands that learners are told what is expected from them at the end of their learning.

1.2.3 Assessment in Curriculum 2005

It is envisaged that assessment is an ongoing process that determines what learners know, understand, value and are able to do. Such information is then used to support a learner's development and enables teachers to improve the teaching and learning process. In continuous assessment (CASS), teachers have to plan assessment as part of their learning activities and assess learners' progress over a period of time. The following assessment techniques are included in CASS: diagnostic assessment, achievement-based assessment, self-assessment, peer assessment, portfolio assessment, performance assessment, observation sheets, journals, education and training practitioner-made tests, recognition of prior learning, and project work assessment (that includes self /peer /group /public defended and assessed).

1.2.4 Constructivism and Curriculum 2005

Constructivist theory acknowledges that the teacher is not a transmitter of knowledge, but rather a facilitator and provider of experiences from which learners will learn. Similarly, learners are not absorbers of knowledge but rather are active participants in constructing their own meaning based on strongly-held preconceptions. According to constructivist theory, then, knowledge is a social construct. In this theory, the belief is that, if learners are to make sense of what they learn, it is important for their ideas to be heard and critiqued during

classroom transactions, for them to share control of the classroom, and for the teacher to provide support for learning (Tobin & Fraser, 1998).

Curriculum 2005 advocates the use of constructivist teaching methods to ensure a more learner-centred classroom (Department of Education, 1997b). Curriculum 2005 is rich with the potential for communicative relationships born of open discourse (Taylor & Campbell-Williams, 1993). Such relationships are likely to give rise to increased opportunities for students to:

> ... negotiate with the teacher about the nature of their learning activities, participate in the determination of assessment criteria and undertake self-assessment and peer-assessment, engage in collaborative and open-ended inquiry with fellow learners, and participate in reconstructing the social norms of the classroom. (Taylor, Fraser & Fisher, 1997, p. 295)

This study examined how mathematics teachers in South Africa transform their classrooms from ones that are more traditional and teacher-centred, towards ones that include teaching methods that reflect a more constructivist notion of teaching.

1.2.5 The Realities of Teaching in South Africa

In my experience as a teacher in both primary and secondary schools for nine years and later as curriculum adviser for 19 years, I have found that there were numerous disparities between the black schools found in rural South Africa and

the predominantly white urban schools. Class sizes in rural schools range between 60 and 70 learners, while the class size of urban schools is determined by policy and ranges between 30 and 40 learners (Department of Education, 2001).

There also is disparity between the salary of black and white teachers left over from apartheid. To rectify this, the government is attempting to increase the salary scale annually in an attempt to close the gap. New black teachers entering the field do not differ in salary from their white counterparts.

Unlike the urban schools, rural schools have a desperate shortage of basic equipment available to teachers. Through the programme of Reconstruction and Development initiated by the first democratic government, schools are being built and furnished with computers and other materials each year. Unfortunately, this covers only a very small percentage of the whole country (Fullan, 1994).

There also is a disparity between the levels of teacher qualifications in rural and urban schools, with all teachers in urban schools being qualified to teach nearly all the subjects taught at a particular school, while the rural or black schools are struggling with under-qualified teachers who are unable to teach many of the subjects. In most cases, science and mathematics teachers are under-qualified. A report published by *EduSource* in 1997 found that most science educators were not qualified to teach the subjects – 84% of science teachers were professionally qualified but only 42% were qualified in science – and estimated

that 8200 science teachers needed to be targeted for inservice training to address the lack of subject knowledge. The report also indicated that more than 40% of physical science teachers and 45% of general science educators had less than two years of experience in teaching their subjects.

The realities of teaching in South Africa pose numerous problems in terms of resources and adequately trained teachers. In the light of the new curriculum, currently being put into practice in South Africa, it is important to examine ways to assist teachers to implement the necessary changes. This study examined the viability of using teacher action research as a means of improving teaching practice in South Africa. It is felt that, by providing teachers with the means to critically reflect, plan and implement change, they will be able to develop more constructivist classroom learning environments with limited resources.

1.3 PURPOSE OF THE STUDY

Teaching practices, adopted through Curriculum 2005, require that students participate in classroom activities, become more involved in the learning process, and take responsibility for their own learning. It also requires that teachers give students the opportunity to work at their own pace according to individual abilities and levels of development. Both teachers and learners are required to focus on predetermined results or outcomes that should be achieved during or at the end of each learning process. It is envisaged that the teachers, as facilitators in their own classrooms, will use a range of strategies, such as

cooperative learning, experiential learning, inquiry or investigation, direct instruction, deductive and inductive learning, and problem solving.

Currently, in South Africa, the predominant teaching method tends to be teacher-centred, with teachers being 'all knowing' and the learners, who are taken as '*tabula rasa*' or empty vessels, having no knowledge. In practical terms, many teachers in South Africa do not have the skills to implement classroom practices as demanded by the policy. One means by which teachers might be able to improve their classroom teaching practices could be through reflective practice. This research aimed to assist teachers in the development and implementation of classroom practices through reflection on their students' perceptions of the learning environment. This means that their roles and classroom environment have to change as the curriculum changes.

1.4 RESEARCH QUESTIONS

The research questions for the present study were developed out of the need to help teachers to become more reflective practitioners in a bid to develop more constructivist teaching strategies. The first research question was developed to determine whether an instrument designed and used in a Western context is suitable for use in South African classes to monitor the learning environment developed by teachers:

Research Question #1

> Is it possible to modify and validate an actual and a preferred version of the Constructivist Learning Environment Survey (CLES) for use at intermediate and senior phases of schooling in South Africa?

To provide teachers with a focus upon which they could direct their reflective practice, the second research question was delineated:

Research Question #2

> Do associations exist between learners' perceptions of the constructivist orientation of the learning environment and their attitudes toward their mathematics classroom?

To provide the teachers and researcher with a sense of what classrooms are like in South Africa, the third research question was delineated.

Research Question #3

> Is it possible to describe the learning environment of individual mathematics classrooms using the CLES in South African schools?

To examine whether teachers were able to make use of feedback information, provided through students' responses to the CLES, to improve the extent to which they incorporated constructivist teaching strategies, the fourth and fifth research questions asked:

Research Question #4

> Are teachers able to make use of student responses to the CLES to develop and implement strategies that improve students' perceptions of the constructivist learning environment?

Research Question #5

> How successful is the use of journals as a means of encouraging teachers to reflect on their teaching strategies and improve their learning environments?

1.5 THEORETICAL FRAMEWORK

The paradigm, or basic set of beliefs that guide action, encompasses the concepts of epistemology, ontology and methodology (Denzin & Lincoln, 1994). According to Denzin and Lincoln (1994, p. 157), ethics is related to the moral stance of a researcher, epistemology examines how the researcher came to know, ontology raises questions about the nature of reality and methodology focuses on "the best means for gaining knowledge about the world". These stances each reflect the interpretative framework of the researcher, shaping how

the researcher sees the world and interprets information. This section discusses the framework within which the present study was conducted.

The present study was carried out in two distinct stages. In the first stage, a large-scale administration of questionnaires was undertaken to collect data that could be used to establish the validity and reliability of the questionnaires for use in South Africa. This stage of the study employed a more positivistic framework, which works from a realist ontology and an objective epistemology.

The second stage involved classroom action research on the part of teachers in South Africa in a bid to transform their more traditional, teacher-centred learning environment to a more constructivist learning environment. Action research is motivated by a quest to improve (Kemmis & McTaggart, 1994), and involves the implementation of a plan, observation and evaluation, reflection and then re-planning, with further implementation and reflection, and this happens when the cycle continues. In this study, action research empowers the teachers as reflective professionals and active learners and collaborators in mathematics teaching and learning (Cohen, Manion & Morrison, 2000).

According to Greenwood and Levin (2000, p. 94), action researchers reject the arguments for "separating praxis and theory in social research". For action researchers, social inquiry aims to generate knowledge and action in support of liberating social change by blending praxis and theory. At this stage of the study, the researcher and teachers became involved in *participatory action research*, a

term coined by Kemmis and McTaggart (2000). Epistemologically, the second phase of the study adopted a constructivist, interpretative and hermeneutic approach. Constructivism employs a relativist ontology, transactional epistemology and hermeneutic, dialectical methodology (Guba & Lincoln, 1994).

The field of learning environment was initiated by Walberg and Moos in 1960s. Moos developed his first world-renowned social climate scales, which were used in hospitals for improving the working environments and in correctional institutions (Moos, 1974). At around the same time, Walberg developed the *Learning Environment Inventory* (LEI), which was used for the research and evaluation activities associated with Harvard Project Physics (Walberg & Anderson, 1968). Since that time, researchers have developed numerous questionnaires, designed to measure perceptions of a range of dimensions pertinent to the learning environment (Fraser, 1998a). Taylor, Fraser and Fisher (1997) emphasise that the use of students' perceptions of classroom environment as predictor variables has established consistent relationships between the nature of the classroom environment and student cognitive and affective outcomes.

My study examined how mathematics teachers in South Africa can transform their classrooms from ones that are more traditional and teacher centred, towards ones that include teaching methods that reflect a more constructivist notion of teaching which is learner-centred. To assess and monitor classroom environment, my study used the Constructivist Learning Environment Survey

(CLES; Taylor, Dawson & Fraser, 1995; Taylor & Fraser, 1991; Taylor, Fraser & Fisher, 1997), which has the potential to address the improvement and development of social constructivist classroom learning environments in South Africa. The CLES was developed in 1991 (Taylor & Fraser, 1991) to enable teachers to monitor the transformation from a more teacher-centred approach to more constructivist teaching approaches and to address key restraints to the development of constructivist classroom climates in school science and mathematics.

The CLES has been validated in studies across several countries, including Korea (Kim, Fisher & Fraser, 1999), the United States (Dryden & Fraser, 1998; Johnson & McClure, 2002; Poth & Fraser, 2000), Australia and Taiwan (Aldridge, Fraser, Taylor & Chen, 2000), including internet classrooms (Fisher & Churach, 1998) and science classrooms (Kim, Fisher & Fraser, 1999). In the USA, it has been used to evaluate and assess the impact of systemic reform in promoting constructivist approaches in high school science classes (Dryden & Fraser, 1996). And in Korea, students' attitudes were enhanced when students perceived more of the CLES scales of Personal Relevance, Shared Control and Student Negotiation in their classrooms (Kim, Fisher & Fraser, 1999). The researcher was influenced by these results in deciding to use the CLES in the present study.

1.6 SIGNIFICANCE OF THE STUDY

This present study is timely and significant in a number of ways. First, it uses, for the first time, actual and preferred versions of the Constructivist Learning Environment Survey (CLES) that have been validated for use in the South African context. The study provides validity information to support future use of this widely applicable learning environment questionnaire in South Africa. Second, the study could provide teachers with the skills to be reflective practitioners and researchers within their own classrooms, providing them with the means to improve their teaching and learning in the future. This will assist in changing their roles in classrooms. Third, the findings of the study have the potential to guide curriculum advisers in the organisation and running of inservice training courses for inexperienced teachers in the field of mathematics. Finally, the findings regarding the effectiveness of constructivist classroom learning environments provide useful information when making decisions regarding the training of teachers in South Africa.

1.7 OVERVIEW OF THE CHAPTERS

Chapter 2 – Review of related literature

This chapter reviews literature relevant to the present study. Examined in this chapter is a range of literature related to reform in South Africa, the field of learning environments, constructivist teaching practice, action research, and the

role of reflective practice in teacher development. Literature on the improvement of classroom environment through action research is also reviewed in detail.

Chapter 3 – Methodology used for data gathering

This chapter clarifies the methods that were used in the research. Both qualitative and quantitative approaches were followed. In the first stage, quantitative data was collected using the Constructivist Learning Environment Survey and an attitude scale, both of which underwent modification to ensure their suitability in the South African context. The instruments were administered to 1864 intermediate and senior phase learners in six schools, two of which were from the rural community, two of which were from a township and the last two of which came from a city (urban). The data were analysed in various ways to provide information regarding the reliability and validity of the instruments when used in South Africa. Also the data were analysed, using simple and multiple correlations, to determine whether associations exist between students' perceptions of the learning environment and their attitudes towards their mathematics classes. Finally, descriptive analysis was used to examine students' perceptions of the actual and preferred learning environment of their mathematics classes.

In the second phase, information regarding students' perceptions of their actual and preferred learning environments was used by the teachers and the researcher to formulated strategies for improvement of their teaching practices.

Teacher action research was then used by the teachers through their daily journal writing while attempting to implement the constructivist way of teaching and learning for a period of three months. During these three months interviews and observations were held with learners and teachers in the sampled classes at the chosen schools. To determine whether the action research had led to improvements in the learning environment, a posttest of students' perceptions of the learning environment was administered after the three months of intervention.

Chapter 4 – Analysis and Results

This chapter provides an in-depth picture of the findings of the large-scale data collection during the initial stage of the study. Data are analysed in several stages to answer the research questions provided earlier in this chapter. The results support the reliability and validity of the CLES and the attitude scale when used at the intermediate and senior phases of schooling in South Africa. Also provided in this chapter is information about associations between the dimensions of the CLES and students' attitudes. Finally, the descriptive analyses provide information about the learning environment perceived by students in South Africa and the one that they would prefer. The gathering and analyses of qualitative data provide in-depth information about the strategies implemented by three teachers as they attempted to improve their learning environment using teacher action research. The use of journals as a means of reflection is also discussed at some length.

Chapter 5 – Discussion, Conclusions, Implications and Recommendations

This chapter embraces a summary and discussion of the findings and results reported throughout the thesis. Summaries, implications, limitations and recommendations are also given in this chapter.

Chapter 2

Review of Related Literature

2.1 INTRODUCTION

The present study was undertaken in post-apartheid South Africa. The study was borne out of the need to examine ways in which teachers in South Africa could improve their teaching practice to better conform to the requirements of the new curriculum (C2005, Department of Education, 1997a). Through this literature review, I wanted to appreciate what had already happened around the world with regards to constructivism, action research and learning environments.

The present Curriculum 2005 being implemented in South Africa requires educators to change their teaching approaches (Department of Education, 1997a, 2001). In turn, this necessitates that learning environments be changed in order to fit better with the constructivist orientation of Curriculum 2005. Ideally, teachers would use action research strategies during their teaching in order to change their practices. Therefore, it was important to consult literature on classroom learning environment(s).

This chapter reviews literature on the topics of learning environments, constructivism, action research and learner attitudes, which are relevant to the present study, under the following headings:

- Reform in South Africa – Problems and Issues (Section 2.2);
- Background to the Field of Learning Environments (Section 2.3);
- Constructivist Learning Environments (Section 2.4);
- Improving the Learning Environment Through Teacher Action Research (Section 2.5);
- Learner Attitudes (Section 2.6).

2.2 REFORM IN SOUTH AFRICA – PROBLEMS AND ISSUES

In April 1994, centuries of struggle against colonial and apartheid rule culminated in a peaceful transition to democracy. The legacy of apartheid had firmly entrenched a society fragmented along racial, linguistic, gender, religious and class enclaves. Through democracy, fear was replaced by hope, repression by democratic freedom, and exclusion and division by the possibility of inclusiveness and unity. The first task of the government was to overcome the devastation of apartheid and provide a system of education that builds democracy, human dignity, equality and social justice. Thus the first democratic education minister, Professor Sibusiso Bengu, initiated the new curriculum. The

government, as a way to develop the country's human resources, initiated a project called the 'reconstruction and development programme' (Fullan, 1994). The aim of the project was to initiate development in the country, such as people developing skills.

In 2001, a vision and mission were formulated to create a scientifically-literate, technologically-fluent and mathematically-literate society that empowers individuals to participate in the emerging knowledge-based economy and support sustainable development. The mission is to strengthen the teaching and learning of science, mathematics and technology and to further education and training, using appropriate curricula, teaching methods and learning support materials.

Before such a mission could be realised, a number of constraints needed to be overcome, including: a decline in mathematics and science enrolments at high schools and universities; a low pass rate; the low number of teachers qualified to teach mathematics and science (about 42% according to EduSource, 1997); and ill-equipped or non-existent laboratories in schools that offer mathematics and science. As a result, the theory of science is usually taught without experiments aimed at enhancing understanding or application of knowledge to daily life. The present study aimed to examine ways to empower South African teachers, with limited resources, to change their practice through action research.

2.3 BACKGROUND TO THE FIELD OF LEARNING ENVIRONMENTS

This section reviews literature related to the field of learning environments with reference to the historical background of the field (Section 2.3.1), instruments used to measure the learning environment (Section 2.3.2), different lines of past learning environment research (Section 2.3.3), and the limited set of past studies of learning environment in Africa (Section 2.3.4).

2.3.1 Historical Background

The notion that a distinct classroom environment exists begun as early as the 1930s, when Kurt Lewin (1936) recognised that the environment and its interactions with characteristics of the individual are determinants of human behaviour. Following Lewin's work, Murray (1938) proposed a Needs-Press Model in which situational variables in the environment account for a degree of behavioural variance. Stern's (1970) Person-Environment Congruence Theory, based on Murray's Needs-Press Model, proposed that more congruence between personal needs and environmental press leads to enhanced outcomes. Also, following Murray's Needs-Press Model, Getzels and Thelen (1960) put forward a model for the class as a social system that suggests that the interaction of personality needs, expectations and the environment predicts behaviours, including students' outcomes.

Following the work of Lewin and Murray, two instruments were developed which pioneered the use of perceptions to measure the classroom environment. The Learning Environment Inventory (LEI), developed by Herbert Walberg (Anderson & Walberg, 1968), and the Classroom Environment Scale (CES), developed by Rudolf Moos (Moos & Trickett, 1987), paved the way for the development of subsequent instruments. Walberg's Learning Environment Inventory (LEI) was used as part of the research and evaluation activities of Harvard Project Physics (Walberg & Anderson, 1968). The Classroom Environment Scale (CES) was developed by Moos (Moos & Trickett, 1987), based on his world-renowned social climate scales, which include those for use in psychiatric hospitals (Moos & Houts, 1968) and correctional institutions (Moos, 1968). Several literature overviews and books include Moos (1979), Walberg (1979), Fraser (1981a, 1986, 1994, 1998a, 2002), Fraser and Walberg (1991), Goh and Khine (2002), and Fraser and Fisher (1983). A journal entitled *Learning Environments Research* (Fraser, 1998b) has been initiated.

The notion of classroom environment was influenced by the work of Walberg and Moos and expanded in Australia (Fraser, 1981a, 1994, 1998a) and in Germany (Dreesman, 1982; Wolf, 1983). Since that time, researchers have developed numerous questionnaires designed to measure perceptions of a range of dimensions pertinent to the learning environment (Fraser, 1998b).

Moos identified three basic dimensions of human environments: *Relationship Dimensions* 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; *Personal Development Dimensions* assess the basic directions along which personal growth and self-enhancement tend to occur; and *System Maintenance and System Change Dimensions* involve the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change (Tobin & Fraser, 1998).

Fraser (1998a) emphasises that the use of learners' perceptions of classroom environment as predictor variables has established consistent relationships between the nature of the classroom environment and the learners' cognitive and affective outcomes. The literature here indicates that the learner's cognitive and affective development is influenced by his/her environment. It is important, therefore, that teachers consider the learning environments that they create.

2.3.2 Instruments Used to Measure the Learning Environment

This section provides a brief background to the instruments that have been used in previous research to assess students' and teachers' perceptions of classroom learning environments. The instruments discussed in this section include the Learning Environment Inventory (LEI), Classroom Environment Scale (CES), My Class Inventory (MCI), Individualized Classroom Environment Questionnaire (ICEQ), Science Laboratory Environment Inventory (SLEI), What is Happening in this Class? (WIHIC) questionnaire and Constructivist Learning Environment

Survey (CLES). Table 2.1 provides an overview of the instruments, the scales in each and the category into which each scale can be classified according to Moos' scheme (described in Section 2.3.1).

Learning Environment Inventory (LEI)

Herbert Walberg developed the Learning Environment Inventory (LEI) in the 1960s (Anderson & Walberg, 1968; Fraser, Anderson & Walberg, 1982) as part of research associated with Harvard Project Physics. The final version of the LEI contains 105 items with seven items in each of 15 scales, namely, Cohesiveness, Friction, Favouritism, Cliqueness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material Environment, Goal Direction and Disorganisation. Items are arranged in cyclic order and responded to on a four-point scale with the response alternatives of Strongly Disagree, Disagree, Agree, and Strongly Agree. The scoring direction (or polarity) is reversed for some items. Examples of items include "Students do not have to hurry to finish their work" (from the Speed scale) and "All students know each other very well" (from the Cohesiveness scale). Close scrutiny of this instrument reveals that some scales are possibly more suited to traditional, teacher-centred classes than to the learner-centred classes advocated today.

Classroom Environment Scale (CES)

The Classroom Environment Scale (CES) was developed by Rudolf Moos at Stanford University (Moos, 1974) as part of a program of research involving perceptual measures of a variety of human environments including psychiatric hospitals, prisons, university residences and work milieus. The CES has 9 scales with 10 items in each, namely, Involvement, Affiliation, Teacher Support, Task Orientation, Competition, Order and Organisation, Rule Clarity, Teacher Control and Innovation. Items are arranged cyclically and responded to using a two-point (True-False) format. Examples of items in this questionnaire are "New ideas are always being tried out here" (from the Innovation scale) and "Students don't always have to stick to the rules in this class" (from the Teacher Control scale). As with the LEI, some scales are possibly suited better to the learning environments of more traditional classrooms.

My Class Inventory (MCI)

The My Class Inventory (MCI) was modified from the LEI to make it suitable for use with 8-12 year-old learners. It was developed to be used in elementary schools but was later found to be useful with learners in the junior high schools (Fisher & Fraser, 1981; Fraser & O'Brien, 1985). The MCI differs from the LEI in five ways: the number of items was reduced from 105 to 38 to minimise fatigue among learners; it contains only five of the LEI's original 15 scales, namely,

Competitiveness, Difficulty, Friction, Satisfaction and Cohesiveness; item wording has been simplified; the LEI's four-point response format was reduced to a two-point (Yes-No) response format; and learners answer on the questionnaire itself instead of on a separate response sheet. Typical items include "Children in our class fight a lot" (from the Friction scale), "Schoolwork is hard to do" (from the Difficulty scale) and "The class is fun" (from the Satisfaction scale). This instruments has been used recently in Brunei (Majeed, Fraser & Aldridge, 2002) and Singapore (Goh & Fraser, 1998) in studies of the learning environment aimed at improving science teaching and learning at the primary school level.

Individualised Classroom Environment Questionnaire (ICEQ)

The development of the Individualized Classroom Environment Questionnaire (ICEQ) was guided by several criteria of what could be considered an individualised learning environment (Rentoul & Fraser, 1979). It was designed for use in individualised science classrooms at high schools from grade 7. The ICEQ has a total of 50 items with 10 items in each of five scales, namely, Personalisation, Participation, Independence, Investigation, and Differentiation (Fraser, 1990). The instrument makes use of a five-point response scale with alternatives of Almost Never, Seldom, Sometimes, Often, and Very Often. The scoring direction for many of the items is reversed. Examples of items are: "Students would give their opinions during discussion" (from the Participation

scale), "The teacher would be unfriendly to students" (from the Independence scale).

Science Laboratory Environment Inventory (SLEI)

The Science Laboratory Environment Inventory (SLEI) was developed specifically for the use in science laboratory environment classes in senior high schools or higher education (university) levels (Fraser, Giddings & McRobbie, 1995) It has a total of 35 items with seven items in each of five scales, namely, Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment. Each item has a five-point response scale with alternatives of Almost Never, Seldom, Sometimes, Often, and Very Often, with the scoring direction for some items being reversed. Sample items include: "I get along well with students in this laboratory class" (from the Student Cohesiveness scale) and "I find that the laboratory is crowded when I am doing experiments" (from the Material Environment scale). This instrument was used by Wong and Fraser (1996) in Singapore in a science chemistry classroom, and by Henderson, Fisher and Fraser (1998) in Tasmania in a study of attitudes and science classroom environments.

Table 2.1 Overview of Scales Contained in Seven Classroom Environment Instruments

Instrument	Level	Scales Classified According to Moos' Scheme		
		Relationship Dimension	Personal Development Dimension	Systems Change and Maintenance Dimension
Learning Environment Inventory (LEI)	Secondary	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material environment Goal direction Disorganisation Democracy
Classroom Environment Scale (CES)	Secondary	Involvement Affiliation Teacher support	Task orientation Competition	Order and organisation Rule clarity Teacher control Innovation
My Class Inventory (MCI)	Elementary	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	Personalisation Participation	Independence Investigation	Differentiation
Science Laboratory Environment Inventory (SLEI)	Senior secondary Higher education.	Student cohesiveness	Open endedness Integration	Rule clarity Material environment
What is Happening in this Class? (WIHIC)	Secondary	Student cohesiveness Teacher support Cooperation Equity	Investigation	Task orientation Involvement
Constructivist Learning Environment Survey (CLES)	Secondary	Personal relevance Uncertainty	Critical voice Shared control	Student negotiation

Adapted from Fraser (1994) with the permission of the author.

What is Happening in this Class (WIHIC) Questionnaire

The WIHIC was designed by Fraser, McRobbie and Fisher (1996) as a general-purpose learning environment instrument for use with secondary school learners. The final version of the WIHIC has 56 items with 8 items in each of seven scales, namely, Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity (Aldridge & Fraser, 2000; Chionh & Fraser, 1998). The survey departed from traditional measures of the learning environment by grouping together items in the same scale, rather than using the traditional cyclic arrangement, to provide learners with contextual information that would enable them to understand individual items better. No items are scored in reverse as these have caused confusion among learners in past instruments. Responses to the items are made on a five-point frequency scale with the response alternatives of Almost Never, Seldom, Sometimes, Often and Almost Always. Examples of its items in the questionnaire are "I make friendships among learners in this class" (from the Student cohesiveness scale) and "My ideas and suggestions are used during classroom discussions" (from the Involvement scale).

This instrument had been extensively used in countries around the world including Taiwan and Australia (Aldridge & Fraser, 2000), Singapore (Fraser & Chionh, 2000), Canada (Raaflaub & Fraser, 2002), Brunei (Khine & Fisher, 2001), US (Moss & Fraser, 2001), Indonesia (Margianti, Aldridge & Fraser, 2002) and Korea (Kim, Fisher & Fraser, 1999).

Constructivist Learning Environment Survey (CLES)

The Constructivist Learning Environment Survey (CLES) was developed in 1991 (Taylor & Fraser, 1991) to enable teachers to monitor the transformation from a more teacher-centred approach to more constructivist teaching approaches (Taylor, Fraser & Fisher, 1997), and to address key restraints to the development of constructivist classroom climates in school science and mathematics in secondary schools. The CLES assesses learners' and teachers' perceptions of five dimensions pertinent to the notion of constructivism, namely, Personal Relevance, Uncertainty, Student Negotiation, Shared Control, and Critical Voice. It contains five scales with six items per scale, making a total of 30 items (Kim, Fisher & Fraser, 1999). As with the WIHIC, items are grouped together in their own scale, and there are no negative items. The questionnaire items are responded to using a five-point frequency scale consisting of Almost Always, Often, Sometimes, Seldom, and Almost Never. Sample items are "I learn about the world outside of school" (from the Personal Relevance scale), and "It is OK to ask the teacher why do I have to learn this" (from the Critical Voice scale). This instrument has been validated in several countries including Korea (Kim, Fisher & Fraser, 1999; Lee & Fraser, 2001), the USA (Dryden & Fraser, 1998; Johnson & McClure, 2002; Nix, Fraser & Ledbetter, 2003) and Taiwan and Australia (Aldridge, Fraser, Taylor & Chen, 2000).

This CLES was selected for use in the present study and, therefore, it is discussed in more detail later in this chapter under Section 2.5 and in Chapter 3, Section 3.3.1. A copy of the CLES appears in Appendix A and B.

2.3.3 Different Lines of Past Learning Environment Research

This section discusses past research into classroom environments that is relevant to the present study, including: research on associations between the classroom environment and student outcomes; research using perceptions of the environment as criterion variables; and studies combining qualitative and quantitative research methods.

Research on associations between classroom environment and student outcomes

In the past, a tradition in learning environment research has involved the investigation of associations between students' outcomes and their perceptions of the classroom environment (Fraser, 1986, 1991, 1994, 1998a). Such studies have indicated that students' perceptions of the learning environment consistently account for considerable variance in student outcomes (Cheng, 1994; Fisher, Henderson & Fraser, 1997; Goh & Fraser, 2000; Henderson, Fisher & Fraser, 1998; Idiris & Fraser, 1997; McRobbie & Fraser, 1993; Scott & Fisher, 2001; Wong & Fraser, 1996). Meta-analyses have been undertaken to bring together the findings of past research into outcome-environment

associations (Fraser, Walberg, Welch & Hattie, 1987; Haertel, Walberg & Haertel, 1981). These studies indicate that learning posttest scores and regression-adjusted gains in student outcomes were consistently associated with the classroom environment.

A weakness of many of these studies lies in the fact that they fail to address problems associated with the level of analysis, which affects both the interpretation of the data and the magnitude of relationships between the variables (Bock, 1989; Bryk & Raudenbush, 1992; Fraser, 1998a, 1998b). Two studies have dealt with this problem through multilevel analysis (Goh, Young & Fraser, 1995, Wong, Young & Fraser, 1997) by comparing the results of multiple regression analysis with those from analysis involving the hierarchical linear model. Each of the two studies, one involving high school chemistry students using the SLEI (Wong, Young & Fraser, 1997) and the other involving primary school students using a modified version of the MCI (Goh, Young & Fraser, 1995), reported statistically significant results from the multiple regression analysis that were replicated in the HLM analysis.

Research using perceptions of the environment as criterion variables

Classroom environment instruments have been used as criterion variables in the evaluation and implementation of innovations and curricula and their outcomes in terms of the learning environment (Fraser, 1986, 1994; Fraser & Walberg,

1981; Maor & Fraser, 1996). The use of classroom environment instruments in the evaluation of new curricula and innovations have proved to be revealing.

The *Individualised Classroom Environment Questionnaire* (ICEQ) was used to assess a project aimed at increasing the degree of individualisation and found useful for assessing changes in students' perceptions (Fraser, 1994). Another study using students' perceptions of the environment as criterion variables involved the evaluation of the Australian Science Education Project (ASEP; Fraser, 1994). This study revealed that environmental variables differed significantly between curricula when differences in outcomes were negligible.

Actual and preferred forms of classroom assessments have been used to study differences in ways in which teachers and students perceive their classroom environments (Fisher & Fraser, 1983). This research has been replicated in developed and developing countries and provides interesting implications. The results of studies in the Netherlands (Wubbels, Brekelmans & Hoomayers, 1991) and Australia (Fraser & O'Brien, 1985) have shown that teachers consistently perceive their classrooms more favourably than their students. In addition, students and teachers would prefer a more positive classroom environment than is perceived as being actually present.

Ferguson and Fraser (1998) examined classroom environment changes across the transition from primary school to high school. In their study, they explored factors related to learning environments during the transition and found that

changes were related to student sex and school size, with students from smaller primary schools experiencing a larger deterioration in perceptions of the learning environment. In addition, it was found that those students attending primary school on the same site as the high school experienced the most favourable changes in their perceptions of the learning environment during transition.

One aspect of teacher effectiveness is the quality of the learning environment (Fraser, 1986; Fraser, Walberg, Welch & Hattie, 1987). Past studies of exemplary teachers in high school science and mathematics have indicated that these teachers exhibit behaviours that positively affect the learning environment (Ciupryk, Fraser, Malone & Tobin, 1989; Tobin & Fraser, 1989). Tobin and Fraser's (1989) study of student perceptions of the psychosocial environment in classrooms of exemplary teachers (using short forms of the My Class Inventory and Classroom Environment Scale) provided considerable evidence that exemplary teachers can be distinguished in terms of the classroom environments that they create. In addition, they found that exemplary teachers created more favourable classroom environments.

Studies using qualitative information or combining qualitative and quantitative information

Over the past decade, research within the field of learning environments has successfully combined quantitative and qualitative methods (Fraser & Tobin, 1991; Tobin & Fraser, 1998). For example, a study which involved the intensive

gathering of qualitative data from two Grade 10 classes over a 13-week period was complemented by the collection of quantitative data (Tobin, Kahle & Fraser, 1990). The qualitative data included daily interviews with two teachers and their students in addition to classroom observations. When used alongside the quantitative data, collected using questionnaires, students' perceptions of the learning environment were found to be consistent with observers' field records of the patterns of learning activities and engagement in each class.

Fraser and Tobin (1989) combined qualitative and quantitative research methods in examining the classrooms of exemplary teachers and compared them with a group of non-exemplary teachers. In this study, the main data collection was based on interpretative research methods (such as observation, interviews with teachers and students and case studies). However, quantitative data were collected (in the form of questionnaires) to complement and enrich the qualitative data. The findings of this study suggested that, first, exemplary and non-exemplary teachers could be distinguished in terms of their students' perceptions of the learning environments that they created and, second, students' perceptions of the learning environments that the exemplary teachers created were more favourable than for students of non-exemplary teachers.

In a study of 10 science classes (taught by the same teacher), researchers considered the notion of 'grain size', or different levels of intensiveness or extensiveness in their research (Fraser, 1999a). In addition to qualitative information gathered from a variety of sources (including student diaries,

interviews and videotapes of activities), the researchers administered a modified version of the Constructivist Learning Environment Survey (CLES) to three samples (a selection of students in the classes being studied; a selection of students from other teachers in the same school; and a larger representative group). This data were used for comparisons to check the extent to which this teacher was typical within her school and the state. The overall pattern indicated differences between the perceptions of students in this teacher's class and the perceptions of students in the comparison group.

2.3.4 Past Studies of Learning Environment in Africa

Literature reviews reveal that there has been very limited learning environment research conducted in South Africa. With the exception of earlier isolated work on laboratory classroom learning environments (Adams, 1996, 1997), it would appear that this study on learning environments is one of a small set of the first major studies being conducted simultaneously in South Africa (Mailula, Laugksch, Aldridge & Fraser, 2003; Ntuli, Aldridge & Fraser, 2003; Seopa, Laughksch, Aldridge & Fraser, 2003). Three other such studies have been conducted in other parts of Africa, including two in Nigeria (Idiris & Fraser, 1997; Jegede, Agholor & Okebukola, 1995) and one in Rwanda (Earnest & Treagust, 2001a, 2001b).

In Nigeria, a study carried out by Idiris and Fraser (1997) involved developing an instrument to investigate associations between the environment and learner

outcomes. This important study examined the learning environment of agricultural classes in Nigeria. Agriculture, a compulsory subject for junior secondary school learners, is the main revenue source for the country. The questionnaire was administered to 1175 learners in 50 classes from 20 schools, and the findings revealed a low level of Student Centredness, Negotiation and Differentiation. The results indicated that Nigerian learners would prefer low levels of each of these scales in their learning environment (Idiris & Fraser, 1997).

Another study carried out in Nigeria used the Socio-Cultural Environment Scale (SCES) to examine the perceptions of 328 distance education learners (Jegede, Agholor & Okebukola, 1995) in terms of the socio-cultural climate of non-Western science classrooms. This study also included a sample from the Caribbean and Asia. The results revealed that there was a significant difference between the perceived and the preferred forms of classroom climate in each of the regions.

Earnest and Treagust's (2001a, 2001b) study of school-level environment in Rwanda involved assessment of four dimensions of school environment. The results obtained from a sample of 125 teachers indicated that teachers perceived a limited amount of work pressure, a lack of resources, low affiliation between staff members, and a great deal of staff freedom.

2.4 CONSTRUCTIVIST LEARNING ENVIRONMENTS

This section examines the notion of constructivism and its implications for the learning environment (Section 2.4.1), the development of the instrument used in my study – Constructivist Learning Environment Survey (Section 2.4.2) and the use of the Constructivist Learning Environment Survey in past studies (Section 2.4.3).

2.4.1 Constructivism and its Implications for the Learning Environment

The notion of a consructivist learning environment originates from the instructional imperatives of the likes of John Dewey, Jean Piaget, Lev Vygotsky and Howard Gardner. According to the constructivist view, the teacher is to act as facilitator and provider of experiences, and learners are active in constructing meaning as individuals. As facilitator, the teacher helps learners to clarify their explanations, assists them to verbalise their thinking, and encourages them to present alternative solutions (Kamii, 1990). Mason (1989, p.153) stresses that "pupils make sense of the world by assembling fragments of their experiences into some sort of story". According to Sinclair (1990) and Volmink (1992), new knowledge acquired by learners grows from existing knowledge, requiring that learners construct their knowledge as active participants rather than receiving knowledge as passive recipients. As such, learners construct understanding, rather than passively absorb or copy the understanding of the instructor.

The radical constructivist view holds that cultural knowledge is continually regenerated through the thinking of individual member of the community, and does not focus on the fact that members of the community form a social and cultural group (Laridon, 1993). Clarifying this idea, in terms of mathematics learning, Taylor and Fraser (1991) emphasise that mathematics is derived from linguistic knowledge. That is, the norms and rules of language in social discourse cannot be divorced from mathematical construction. They also suggest that social processes, such as debate, controversy, rejection or applause, are inherent parts of the process of mathematical construction. According to this view, social interaction is a crucial part of the process of mathematical development. This means that children will freely voice their own opinions without fear. Issues will be debated by the class on their merits, and those they think will fit the situation they are discussing best will be agreed upon by consensus. Such a mathematics constructivist classroom environment would be seen as having a culture where learners are involved in negotiations, explanation, evaluation and the sharing of ideas.

Curriculum 2005 aims to develop learners who are critical thinkers with the skills, knowledge, values and attitudes required to participate as citizens and to play an active, responsible and productive role in the economy of the country (Department of Education 2001). The emphasis is on outcomes-based education, whose philosophy is learner-centred and emphasises teacher-as-facilitator, group work and teamwork in teaching and learning. The learning programmes are seen as guides that allow teachers to be innovative and

creative in designing programmes, while the learners take responsibility for their own learning. All of these are embraced in constructivist theory.

2.4.2 Development of the Constructivist Learning Environment Survey (CLES)

The Constructivist Learning Environment Survey (CLES), developed by Taylor and Fraser in 1991, was considered to be an ideal instrument to adopt in my study to monitor the classes of teachers who are moving towards more constructivist learning environments. The CLES (Taylor, Dawson & Fraser, 1995; Taylor, Fraser & Fisher, 1997) was developed to enable educators and researchers to measure learners' perceptions of the extent to which constructivist approaches are present in classrooms. The development of the instrument was underpinned by the constructivist notion of learners as co-constructors of their own knowledge.

Although the original version of the CLES was found to be reliable when used within Australian high schools and in other countries (Lucas & Roth, 1996; Roth & Bowen, 1995; Watters & Ginns, 1994), the theoretical framework supporting the survey was found to be weak. A new version of the CLES was developed from the perspective of *critical constructivism* (Taylor, 1996) to recognize socio-cultural constraints to the cognitive constructive activity of the individual learner and thereby to strengthen weaknesses in the original version. The new version of the CLES was designed to obtain measures of five key elements of a critical

constructivist learning environment from the learners' perception: the degree of personal relevance in their studies; whether learners have shared control over their learning; the degree to which learners feel free to express concerns about their learning; the degree to which learners 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, 1995; Taylor, Fraser & Fisher, 1997). Table 2.2 provides a description and a sample item for each scale of the CLES.

Table 2.2 Description and Sample Item for each Scale of the CLES

Scale	Description	Sample Item
	The extent to which ...	
Personal Relevance	... teachers relate science to students' out-of-school experiences.	In this science class, I learn about the world outside the school.
Uncertainty	... opportunities are provided for students to experience scientific knowledge as arising from theory dependent inquiry, involving human experience and values, evolving and non-foundational, and culturally and socially determined.	In this science class, I learn that views of science have changed over time.
Critical Voice	... 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.	In this class, it's OK to ask the teacher 'Why do we have to do this?'
Shared Control	... students are invited to share with the teacher control of the learning environment, including the articulation of their own learning goals, design and management of their learning activities, and determining and applying assessment criteria.	In this science class, I help the teacher to plan what I'm going to learn.
Student Negotiation	... opportunities exist for students to explain and justify to other students their newly- developing ideas and to listen to and reflect on the viability of other students' ideas.	In this science class, I ask other students to explain their ideas.

NB Items are scored 1, 2, 3, 4 and 5, respectively, for the responses Almost Always, Often, Sometimes, Seldom and Almost Never.

This version of the CLES (Taylor, Fraser, and Fisher, 1997) assesses the degree to which a particular classroom's environment is consistent with a constructivist epistemology, and can be used to assist teachers to reflect on their epistemological assumptions and reshape their teaching practice. Taylor, Dawson and Fraser (1995) recommend that the CLES be used in evaluations of systemic reform initiatives that utilise constructivism as a major referent for the transformation of school science and mathematics learning environments. As such, the researcher felt that the CLES could provide a focus and assist mathematics and science teachers to cope in their paradigm shift.

This new version of the CLES was trialled in two classroom-based collaborative research studies in Australia (Taylor, Dawson & Fraser, 1995; Taylor, Fraser & White, 1994). The conceptual strength and psychometric structure of the questionnaire were rigorously tested using quantitative and qualitative methods. These studies led to modifications to the survey to enhance comprehensibility by omitting negative items and those items considered 'conceptually complex'. In addition, the survey departed from traditional measures of the learning environment by grouping together items of the same scale and including a simple scale name that would provide learners with a contextual cue (rather than arranging the items from a given scale randomly or cyclically throughout the questionnaire).

A copy of the actual and preferred forms of the CLES used in the present study can be found in Appendix A and B, respectively. The next section provides information regarding the use of the CLES in past studies.

2.4.3 Use of the Constructivist Learning Environment Survey in Past Studies

The CLES has been found to exhibit strong factorial validity and internal consistency reliability when used in countries such as the USA (Dryden, & Fraser, 1998; Harwell, Gunter, Montgomery, Shelton & West, in press; Johnson, 2003; Johnson & McClure, 2002; Nix, Fraser & Ledbetter, 2003), Australia (Taylor, Fraser, & Fisher, 1997), Taiwan and Australia (Aldridge, Fraser, Taylor, & Chen, 2000), and Korea (Kim, Fisher, & Fraser, 1999; Lee & Fraser, 2001).

In a cross-national study of learning environments involving Taiwan and Australia, the CLES was administered to 1081 learners from 50 classes in Australia and 1879 learners from 50 classes in Taiwan. The results revealed a big difference between the learners of the two countries; for example, Australian learners perceived Critical Voice and the Student Negotiation to be occurring more often than Taiwanese learners did. In Taiwan, the learners respect their teachers so that they cannot criticise them, unlike their Australian colleagues who feel they can be critical of their teachers (Aldridge, Fraser, Taylor & Chen, 2000).

A study by Taylor, Dawson and Fraser (1995), with 494 grade 10 biochemistry learners in Australia, involved a teacher's goal of enabling her learners to articulate and evaluate their established ethical values and beliefs by engaging in critical self-reflective thinking rather than memorising factual information for end-of-course assessment. The results of this study revealed that some learners were not in favour of discussions while, on the other hand, some learners felt that it was good to negotiate and plan with the teacher.

In the USA, research by Dryden and Fraser focused on the impact of a reform initiative in changing high school science instruction towards a more constructivist approach. The CLES was administered to over 1600 learners in 120 grade 9-12 science classes in schools where systemic reform was being initiated. Findings indicated that the learners' voices had not been used in a productive way to produce more learner-centred and learner-involved teaching and learning. The teachers were focussing on those skills that they thought were necessary in order to score well during examinations, because they were afraid of being fired if the examination results did not improve. The CLES revealed a low level of shared control (Dryden & Fraser, 1998). The report also indicated that the system focussed on using materials but did not attempt to focus on how learners learn and how 'content' is dependent on the experiences of the learners.

In Korea, Kim, Fisher and Fraser (1999) investigated whether the introduction of a new science curriculum in Grade 10 and 11 produced a more constructivist

science learning environment. The results indicated that general science's emphasis on relevance with everyday life, inquiry-centred learning and social interaction had some effect on classroom environment, but that the positive effect in general is not big enough to change traditional classes into highly constructivist-oriented ones. It was recommended that teachers receive more teacher development in order to improve science learning environments (Kim, Fisher, & Fraser, 1999).

In the US, Nix, Fraser and Ledbetter (2003) used the CLES to evaluate the impact of an innovative teacher development program in school classrooms. The CLES was administered to 1079 students in 59 classes. The factor structure, internal consistency reliability, discriminant validity and the ability to differentiate between classrooms supported the validity and reliability of the CLES. The results indicated that students whose teachers had attended the teacher development program perceived higher levels of Personal Relevance and Uncertainty of Science in their classrooms relative to the classrooms of other teachers in the same school.

In all the studies in the different countries reviewed above, the CLES was found to be reliable and convenient for assessing the emphasis on constructivist approaches in classrooms. Therefore, the CLES questionnaire was chosen for use in my study because, with Curriculum 2005, there is a need to change the methods of classroom teaching and learning from traditional to constructivistic

approaches. This instrument was considered to be suitable because of its impressive validation statistics when used in research in overseas countries.

2.5 IMPROVING THE LEARNING ENVIRONMENT THROUGH TEACHER ACTION RESEARCH AND REFLECTIVE PRACTICE

Because teachers in my study used action research when trying out strategies that they thought would assist them to change their learning environments, literature on teacher action research is reviewed in this section. Action research is a form of practitioner research that can be used as a catalyst to improve professional practice within schools. Teachers themselves conduct the research into their own practice. This section examines what is involved in action research (Section 2.6.1) and past action research studies that have used feedback from learning environment instruments to guide improvements in the learning environment (Section 2.6.2).

2.5.1 Teacher Action Research

Action research is participatory, and it involves people working towards the improvement of their practice. It involves a self-reflexive spiral of strategic planning, achievable steps, implementing the plan, observation and evaluation, reflecting and then replanning, further implementation and further reflecting (Calhoun, 1994; McLean, 1995). Action research is as a powerful tool for change and improvement at a local level (Cohen, Manion & Morrison, 2000).

This implies that, in the classroom, action research typically involves the use of qualitative, interpretive modes of inquiry and data collection by teachers with a view to teachers making judgements about how to improve their own practices (Greenwood & Levin, 2000). Kemmis and McTaggart (2000) support these ideas through emphasising that action research aims to set in motion processes by which participants collectively make critical analyses of the nature of their practices, their understandings, and the settings in which they practice in order to confront and overcome irrationality, injustice and alienation.

Through action research, teachers come to understand what is really happening in their classrooms. Action research increases teachers' feeling of self-worth and confidence and the awareness of classroom issues. Individuals and social groups are empowered to take control over their lives within a framework promoted through action research (Greenwood & Levin, 2000). Action research forces the teacher not to stand back and observe phenomena from a distance, but to take action and make things happen. Continuous action research is supported by Burnaford, Fisher and Hobson (1996) who indicate that discovery is never completed, and that we are constantly learning throughout our careers from learners, from colleagues and from our own experiences.

In my study, action research was used to assist teachers to change into being active, collaborative, critical and self-critical in their teaching practices in mathematics and science in South Africa in the implementation of the new Curriculum 2005 (C2005). Teachers throughout South Africa are used to talking,

while learners are listening and only copying what is said and written by their teacher. In my research, teachers started practising the use of learner-centred methods and keeping journals to record their daily activities so that they could reflect on what they were doing. The methods imply that teachers are facilitating group interaction and learning by setting tasks, posing questions, offering suggestions, and helping learners to evaluate their own learning and progress. Learners also act as researchers who develop hypotheses, design and conduct experiments, and report their findings to their teachers and peers.

2.5.2 Action Research Aimed at Changing the Learning Environment

Action research provides teachers with an opportunity to apply the findings of traditional research to their own situations and to adapt theory to practice. It also involves teachers as participants in their own educational process, and helps them to develop a critical and reflective eye for their own instructional practices along with those of their peers (Lederman & Niess, 1997). The systemic collection of classroom data presents teachers with a view that could *catalyse* a change and facilitate informed decision making with regard to curricular and instructional issues. Southwood (2002) claims that one's knowledge is dependent on the experience that one has and the environment in which one has the experience. Thus data collection using the CLES (Constructivist Learning Environment Survey) enabled mathematics teachers to decide on the strategies that could be employed to assist them to change their way of teaching to a new way according to the demands of Curriculum 2005.

Action research offers participants a flexible approach to classroom improvement through actions and reflection. 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.

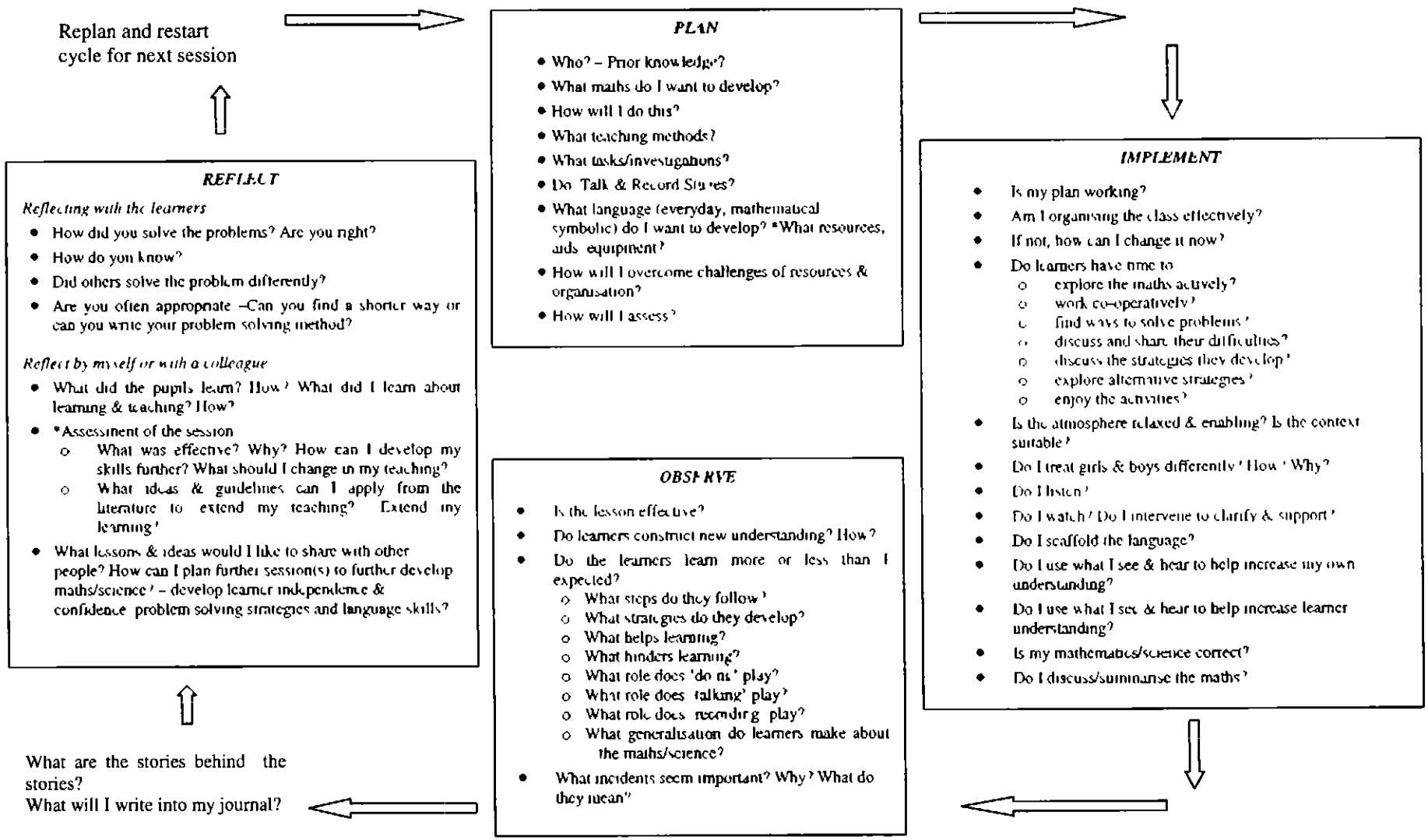
In educational action research, much is spoken about self-reflection. Self-reflection leads educators to consider what they are doing, why they are doing that, and how that could be done more successfully (McNiff, 1995). Action research provides teachers with an opportunity to apply the findings of traditional research to their own situations and to adapt theory to practice. McNiff (1995) views action research as a self-critical vehicle for enabling people to develop their own critique of practice. And this reflection is a process of making sense of one's experience and telling a story of one's journey (Burnaford, Fisher & Hobson, 1996). Reflection leads to better action, and a reflective teacher is a more effective teacher (Schon, 1983). Teachers share their beliefs and approaches and, as they reflect and act upon their reflections, they are engaging in a form of action research. Figure 2.1 depicts an action cycle for classroom intervention (Rakgokong, 1994). Looking at this figure, we realise that teachers have to plan their activities and to implement the plan. While implementing, she/he has to observe what is happening and, to find a reflection time for the learners and himself/herself. The teacher writes down points during the reflection in his/her journal. During reflection, difficulties and problems

discovered are replanned and the cycle continues again. This continuous cycle assists teachers in being researchers in their own fields.

Reflection assists teachers to be critical of whatever they are doing with learners. It also involves teachers as participants in their own educational process, and helps them to develop a critical and reflective eye for their own instructional practices along with those of their peers (Lederman & Niess, 1997). The systematic collection of classroom data presents teachers with a view that could *catalyse* a change and facilitate informed decision making with regards to curricula and instructional issues.

Research into classroom environments has led to small-scale teacher-researcher studies that explore ways in which the assessment of student perceptions can be used to improve the classroom environment (Fisher, Fraser & Bassett, 1995; Fraser, 1981a, 1994; Fraser & Fisher, 1986; Fraser, Malone & Neale, 1989, Thorp, Burden & Fraser, 1994; Yarrow, Millwater & Fraser, 1997). To date, there has been relatively little research into the practical applications of classroom environment assessments.

Figure 2.1 Action Cycle For Classroom Intervention (Rakgokong, 1994)



Fraser (1981a) explored ways in which discrepancies between students' and teachers' perceptions of the preferred and actual classroom environment could be used as a basis for improving the environment. Case studies of attempts to change the classroom environment based on feedback information from classroom environment questionnaires have suggested that it is possible to align students' preferred and actual perceptions of the classroom more closely (Fisher, Fraser & Bassett, 1995, Fraser, Malone & Neale, 1989; Fraser & Fisher, 1986; Thorp, Burden & Fraser, 1993).

A study by Yarrow, Millwater and Fraser (1997) explored the effectiveness of action research and the use of reflective practices for improving the learning environments of primary classes during inservice training. In this study, 117 inservice primary teachers assessed their learners' actual and preferred perceptions of the classroom environment using the *My Class Inventory* (MCI). The teachers were required to produce a 'case writing' to heighten the importance of their 'voice' and were guided by their daily experiences. According to Yarrow, Millwater and Fraser (1997), action research is collaborative and is achieved through critically examining actions made by the participants themselves, providing a link between theory and practice. Their article suggests that the topic of learning environments should be included in university preservice programs, along with action research aimed at improving classroom environments.

Sinclair and Fraser (2002) conducted a study that involved changing classroom environments in urban middle schools in the US. Three teachers were involved in using feedback information on students' perceived and preferred classroom environment to improve their classroom environments. The study involved personalised training with one of the researchers, combined with teachers' participation in action research techniques (based on Fraser, 1986) to improve their classroom environments. In all three cases, student scores on the learning environment scales improved, supporting the notion that teachers who receive support can improve their classroom environments.

My study focused on action research. Using learners' responses to actual and preferred versions of the CLES, teachers identified constructivist aspects of the learning environment that they would like to improve. Using spiralling cycles of questioning, planning, implementing, collecting data and reflecting through journal writing as suggested by Yarrow, Millwater and Fraser (1997), the teachers developed strategies aimed at improving their learning environments, which they implemented in their classrooms and documented in daily journals. Baird (1998) supports this same idea by expressing that the reflection, action, observation and evaluation cycles of action research are likely to provide mathematics and science teachers with practice in strategies for enhancing their knowledge and awareness and control over their own teaching.

2.6 LEARNER ATTITUDES

My study also explored associations between the classroom environment and learners' attitudes. It was considered important that, while teachers attempt to implement new constructivist approaches, the learners' attitudes towards mathematics learning are monitored. Therefore this section reviews some techniques which have been developed for measuring attitudes. The techniques examined are Thurstone scaling, Likert scaling, Guttman scaling and the semantic differential technique. Also a specific questionnaires for assessing attitudes, the Test of Science-Related Attitude (TOSRA), is briefly described below.

2.6.1 Thurstone Scaling, Likert Scaling, Guttman Scaling and the Semantic Differential Technique

The Thurstone scaling technique was developed by Thurstone (1927), based on the method of Allport and Hartman (Allport, 1935). There are three separate methods used: paired comparisons, equal-appearing interval, and successive intervals. For paired comparisons, the statements are paired and judgements are given as to which one of the statements is more favourable towards the attitudinal object.

In Likert scaling, the researcher locates the respondent's position on a continuum ranging from the extreme end of 'positive' to that of 'negative'. The responses to

the statements are typically given on a five-point continuum of Strongly Agree, Agree, Uncertain, Disagree and Strongly Disagree. An example of an attitude measure that uses the Likert scale technique is the Test of Science-Related Attitudes (TOSRA) developed by Fraser (1981b) to assess the following categories: Social Implication of Science, Normality of Scientists, Attitude to Scientific inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science.

The Guttman (1944) scaling technique focuses on scales that do not have dimensions. The options of this technique are similar to those of Likert and the Thurstone scales.

The semantic differential technique was developed by Osgood (Osgood, Suci & Tannenbaum, 1957). He used factor analysis to identify dimensions of meaning such as evaluation, potency and activity. The respondent selects a response on a seven-point scale using a bipolar adjective continuum (e.g. easy – difficult). The strengths of the semantic differential technique for attitude measurement are that it is usually reliable, easy to construct, and quick to administer.

2.6.2 Test of Science-Related Attitudes (TOSRA)

The Test of Science-Related Attitudes (TOSRA) was developed by Fraser (1978) to measure seven distinct science-related attitudes among secondary school learners. The seven attitudes are measured by using the following scales: Social

Implication of Science, Normality of Scientists, Attitude to Scientific inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science. Each of these scales contains 10 items, making a total of 70 items for the whole instrument. The learners' respond to this instrument on a five-point Likert scale with categories ranging from Strongly Agree to Strongly Disagree.

TOSRA has been used widely in science education in research into associations between students' attitudes to science and their perceptions of classroom learning environment (Adolphe, Fraser & Aldridge, 2003; Fraser & Butts, 1982; Fraser & Fisher, 1982; Schibechi, Rideng & Fraser, 1987; Wong, Young & Fraser, 1997). However TOSRA also can be easily adapted to assess attitudes to mathematics simply by replacing the word 'science' with 'mathematics' (to form the Test of Mathematics-Related Attitudes). Various researchers have used the TOSRA/TOMRA in investigations between students' attitudes to mathematics and their classroom environment perceptions (Goh & Fraser; 1998; Raaflaub & Fraser, 2003; Soerjaningsih, Fraser & Aldridge, 2001; Spinner & Fraser, 2002; Taylor, 2003).

In my study, one scale from the TOSRA, namely, Enjoyment of Science Lessons, was modified to suit mathematics classes and used to examine the attitudes of the learners towards their mathematics classes. This scale was considered appropriate as it examines students' satisfaction with their class with such items as "I look forward to mathematics lessons" and "Mathematics lessons are fun".

The response format was changed so that it was the same as the one used with the CLES (a five-point frequency scale of 'Almost never', 'Seldom', 'Sometimes', 'Often', and 'Almost Always').

2.7 SUMMARY

The present study was undertaken in post-apartheid South Africa. Education reform sweeping the country is shaping the way in which teachers teach. Within the vision encompassed by the new curriculum (Curriculum 2005), teachers are expected to change the way in which they teach from a more teacher-centred to a more learner-centred style. The present study investigated how teachers might utilise action research to implement strategies that are in line with the constructivist approaches advocated by the new South African curriculum. In particular, the present study examined the value of using a learning environment instrument as a means of encouraging reflective practice and action research among teachers in South Africa.

The field of learning environments was initiated in the 1960s and, since that time, researchers have attempted to conceptualise and measure a range of different learning environments. To this end, they have developed numerous questionnaires designed to measure students' perceptions of a range of dimensions pertinent to the learning environment. The instruments reviewed in this chapter include the Learning Environment Inventory (LEI), Classroom Environment Scale (CES), My Class Inventory (MCI), Individualized Classroom

Environment Questionnaire (ICEQ), Science Laboratory Environment Inventory (SLEI), What is Happening in this Class? (WIHIC) questionnaire and Constructivist Learning Environment Survey (CLES). In past studies, the CLES has been used to monitor the development of constructivist learning environments, and it was considered pertinent to the present study and to the climate of reform in South Africa. Based on validation studies carried out in different countries such as USA, Korea, England, Australia and Taiwan, I was confident to choose the CLES for use in my study in the South African development context.

Only a handful of studies have been carried out world-wide to assess whether teachers are able, through action research, to improve the learning environment in their classrooms. Action research is widely considered to be a powerful tool for change that empowers teachers, enabling them to take control of their own development. Improvement through action research involves the teachers in the critical analyses of the nature of their own practice, and a cyclic process in which they plan for change, implement their plans and evaluate the success of the changes. Feedback information from administering the CLES was used in my study to help mathematics teachers to decide on the strategies that they could employ to assist them to change their approaches to teaching in a new way that is more constructivist in nature, as demanded by Curriculum 2005.

As practitioners, teachers were required to implement a range of strategies, gleaned from literature provided in conjunction with C2005. An important step in

the research was to examine whether the attitudes of the learners are affected by these changes. A range of techniques, designed to assess learners' attitudes, have been developed including Thurstone scaling, Likert scaling, Guttman scaling, and the semantic differential technique. A scale from the Test of Science-Related Attitudes (TOSRA) was modified for use in the present study to assess learners' attitudes towards their mathematics lessons.

From this literature review, it seems that the CLES was a good choice for monitoring and changing teaching approaches in South African classroom environments. Curriculum 2005, which is being introduced, emphasises outcome-based education that is associated with the constructivist teaching and learning situations. Thus, my study tried to investigate ways in which teachers might be able to create healthy constructivist classroom learning environments suitable for South Africa. The review, as well, shows us that learning environment research still is in its infancy in South Africa.

The following chapter examines the research methods that were used in the present study. This chapter outlines instruments used to collect the quantitative data and the statistical procedures used during the analysis. Methods for qualitative data collected during the teachers' action research studies are also described.

Chapter 3

Research Methods

3.1 INTRODUCTION

The present study had two phases. In the first phase, it examined whether the Constructivist Learning Environment Survey (CLES) could be modified and validated for use in South Africa. In addition, this phase of the study examined whether associations exist between the learning environment and students' attitudes towards their mathematics classes. In the second phase, the study investigated the usefulness of the CLES as a feedback tool that teachers could use to help them to implement more constructivist methods in their classrooms. In addition, the study examined the usefulness of teacher journals as a tool for reflection to aid the implementation of new strategies for change. This chapter provides information about how the research was conducted under the following headings:

- Sample for the Main Study (Section 3.2);
- Instruments Used in the Present Study (Section 3.3);
- Modifying and Field Testing the Instruments (Section 3.4);

- Large Scale Quantitative Data Collection (Section 3.5);
- Statistical Analysis Methods (Section 3.6); and
- Intervention Phase Aimed at Improving the Learning Environment (Section 3.7).

3.2 SAMPLE FOR THE MAIN STUDY

This section describes the sample for the main study with reference to the selection of: schools, teachers and students for the large-scale quantitative data collection (Section 3.2.1); teachers and schools for the classroom intervention phase (Section 3.2.2); and the student sample for the collection of qualitative data during intervention (Section 3.2.3).

3.2.1 Selection of Schools, Teachers and Students for Quantitative Data Collection

South Africa is divided into nine provinces, and this research was carried out in the Limpopo province, located in the northern part of the country (see Appendix D for a map of South Africa). The schools were purposefully selected for this study from rural, semi-rural and urban areas in the Capricorn region of this province (see Appendix E). Semi-rural schools are situated in black townships and urban schools were traditionally white-only schools during apartheid era. To date, this is still the case. There are no white learners enrolled in rural or semi-

rural schools in the Limpopo Province and, whilst there is a mixture of black and white learners in urban schools, white students are in the majority. Students attending urban schools are taught mainly by white teachers.

From each of the areas, a primary and a secondary school were purposefully selected to ensure that they were representative of other schools in the area. During the selection process, factors such as the size of the school, access to water and electricity and availability of resources were considered. Four mathematics teachers who were teaching intermediate-phase classes (Grade 4 to Grade 6) were selected from each area, making a total of 12 intermediate-phase mathematics teachers. Two mathematics teachers who were teaching senior-phase classes (Grade 7 to Grade 9) were also selected from each area, making a total of six senior-phase mathematics classes (see Table 3.1). Every attempt was made to ensure that the sample selected was representative of the classes and schools in the area from which they were drawn.

Class sizes in the intermediate phase averaged around 60 students, while class sizes in the senior phase averaged around 45 students. The sample provided a total of 1864 learners, 557 of whom were from urban areas, 448 from semi-rural areas and 859 from a rural area. Table 3.1 provides a breakdown of the number of students, classes and teachers in each area.

Table 3.1 Sample Size and Distribution of Teachers and Students from Rural, Semi-Rural and Urban Areas

Area	Phase	Number of Teachers	Number of Classes	Number of Students
Rural	Intermediate	4	7	564
	Senior	2	4	295
Semi-rural	Intermediate	4	8	316
	Senior	2	2	132
Urban	Intermediate	4	9	393
	Senior	2	4	164
Total		18	34	1864

3.2.2 Selection of Schools and Teachers for Intervention

Of the six schools included in the large sample, two schools were selected for intervention. The selection of these schools was based largely the teachers' willingness to be involved in this phase of the study and on the proximity of the schools to the researcher. The two schools were located, respectively, two kilometres and twenty-three kilometres from the researcher's office. From one school, a teacher teaching Grades 5, 6 and 7 (Intermediate and Senior phase) was selected while, from the other school, two teachers teaching Grades 6 and 7 (Intermediate and Senior phase) were selected.

3.2.3 Student Sample for Qualitative Data Collection

Interviews were conducted three times during the intervention phase, namely, during the fifth, ninth and thirteenth week. For each set of interviews, five students were selected from one of the classes of each of the two teachers (i.e.

a total of 10 students). To ensure that a representative sample of students with a range of academic abilities was selected, the teacher assisted in the selection process.

3.3 INSTRUMENTS USED IN THE PRESENT STUDY

Two instruments were used in the research, namely, the Constructivist Learning Environment Survey (described in Section 3.3.1) and a student attitude scale (described in Section 3.3.2).

3.3.1 The Constructivist Learning Environment Survey (CLES)

As described in the previous chapter, the Constructivist Learning Environment Survey (CLES) was developed during 1991 and has been used to help teachers to monitor the transformation from more teacher-centred approaches to more constructivist teaching approaches and to address key restraints to the development of constructivist classroom climates in school science and mathematics (Taylor, Dawson & Fraser, 1995; Taylor & Fraser, 1991; Taylor, Fraser & Fisher, 1997).

The CLES instrument had been validated in different countries over the world like Australia, Korea, Taiwan, and US. A more detailed description of the development and use of the CLES in past study are provided in Chapter 2.3 and 2.5 respectively.

The original version of the CLES was designed to assess students' and teachers' perceptions of five dimensions of their science classroom, namely:

- *Personal Relevance* (the extent to which teachers relate science and mathematics to students' out-of-school experiences)

- *Uncertainty* (the extent to which opportunities are provided for learners to experience mathematics and science knowledge as arising from theory-dependent inquiry, involving human experience and values, evolving and non-foundational, and culturally and socially determined)

- *Student Negotiation* (the extent to which opportunities exist for students to explain and justify to other students their newly developing ideas and to listen and reflect on the viability of other students' ideas)

- *Shared Control* (the extent to which students are invited to share with the teacher control of the learning environment, including the articulation of their own learning goals, design and management of their learning activities, including determination and application of assessment criteria)

- *Critical Voice* (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).

The CLES is available in both an actual and preferred form (Kim, Fisher & Fraser, 1999). As with the development of the preferred form related to other learning environment instruments, the CLES preferred form is concerned with goals and value orientations and measures the students' perceptions of the learning environment that they would ideally like, while the actual form measures what is actually happening in the class (Fraser, 1994, 1998a). Sample items from the actual and preferred forms of the CLES are provided in Table 3.2.

Table 3.2 Sample Items for the Actual and Preferred Forms of the Constructivist Learning Environment Survey (CLES)

Scale	Actual Form	Preferred Form
Personal Relevance	In this class, I learn about the world outside of school.	In my ideal class, I would learn about the world outside of school.
Uncertainty	In this class, I learn that mathematics has changed over time.	In my ideal class, I would learn that mathematics has changed over time.
Critical Voice	In this class, it is OK for me to question the way I'm being taught.	In my ideal class, it would be OK for me to ask the teacher: "Why do I learn this?"
Shared Control	In this class, I help the teacher to plan what I'm going to learn.	In my ideal class, I would help the teacher to decide how well I am learning.
Student Negotiation	In this class, I get the chance to talk to other students about how to solve problems.	In my ideal class, I would get the chance to talk with other students about how to solve problems.

The response format includes a five-point frequency scale of 'Almost never', 'Seldom', 'Sometimes', 'Often', and 'Almost Always'.

The statements of this CLES questionnaire are answered on a five-point frequency response scale consisting of Almost Never, Seldom, Sometimes, Often and Almost Always.

The CLES has been used in studies in the US (Dryden & Fraser, 1998; Johnson, 2003; Johnson & McClure, 2002; Nix, Fraser & Ledbetter, 2003),

Australia and Taiwan (Aldridge, Fraser, Taylor & Chen, 2000) and Korea (Kim, Fisher & Fraser, 1999, Lee & Fraser, 2001). In each case, strong validation statistics were reported, making the selection of the CLES for use in the present study a sensible one. A copy of the actual version of the CLES as used in the present study can be viewed in Appendix A and a copy of the parallel preferred version can be viewed in Appendix B.

3.3.2 Student Attitude Scale

To examine and monitor changes in students' attitudes to their mathematics classes, as well as to investigate associations between students' attitudes and their perceptions on the CLES, an attitude scale was adapted for use from the Test of Science Related Attitudes (TOSRA). The TOSRA was originally developed by Fraser (1981b) as a means of assessing and monitoring changes in the science-related attitudes of individual learners and three learning environment studies have since incorporated the TOSRA as a measure of students' attitudes (Adolphe, Fraser & Aldridge, 2003; Soerjaningsih, Fraser & Aldridge, 2001; Wong & Fraser, 1996). One of the TOSRA scales, Enjoyment of Science Lessons, was selected and modified to suit primary school mathematics classes for use in the present study.

Details concerning the measurement of students' attitudes and the development and use of the original instrument are outlined in Chapter 2, Section 2.7.2. A copy of the attitude scale used in the present study is in Appendix C. A typical

item is: "I look forward to mathematics lessons". The response alternatives are Almost Never, Seldom, Sometimes, Often and Almost Always.

3.4 MODIFYING AND FIELD TESTING THE INSTRUMENTS

To ensure that the instruments were suitable for use with primary mathematics learners in South Africa, the CLES and attitude scale underwent a degree of modification (described in Section 3.4.1). The instruments were then pilot tested in South African mathematics classrooms, the results of which were the basis for further modification (described in Section 3.4.2).

3.4.1 Modifications Made to the Instruments

The CLES was originally developed to assess the perceptions of high school science and mathematics students, but the present study aimed to use it with primary school mathematics students. When the CLES was used in countries outside of Australia, such as Taiwan (Aldridge, Fraser, Taylor & Chen, 2000), the US (Dryden & Fraser, 1998; Fraser & Dryden, 1996; Johnson & McClure, 2002), Nigeria (Idiris & Fraser 1997) and Korea (Kim, Fisher & Fraser, 1999; Lee & Fraser, 2001), it was found necessary to modify it to ensure its suitability to that country. It was important, therefore, that the CLES underwent a degree of modification to ensure its suitability for learners in South Africa.

Although the medium of instruction in South African schools is English, some terms and phrases within the CLES were unlikely to be understood by the learners. To avoid confusion, the word 'learner' was substituted for 'student'. In addition, changes were made to make the CLES suitable for use in 'mathematics' classes, as opposed to 'science' classes (where it was originally designed to be used). Preceding each item the phrase "In this mathematics class ..." was added. Other than these two changes, the instruments used in my study were the same as the original versions. The results of the pilot test led to further modifications of the CLES, which are described in the following section.

3.4.2 Field Testing and Further Changes Made to Instruments

The modified CLES and TOSRA scale were pilot tested in three classes (located in the same schools as the rest of the study), selected from a rural, semi-rural (township area) and urban area. From the rural school, a combined Grade 6 and 7 class with 35 learners was selected. From the semi-rural area, a Grade 7 class with 40 learners was selected. And, from the urban area, a Grade 8 class with 25 learners was selected. Six learners from each class were interviewed to check the readability, that items were being interpreted as intended, that the instructions and methods of responding were clear, and whether there were any other problematic or ambiguous phrases or items.

The interviews with students indicated that, when talking about the Critical Voice scale, the learners generally were not happy about asking the teacher about their learning during mathematics class. They felt that they do not have many life experiences and that their parents are in a better position to interact with the teachers about such matters. In addition, these interviews indicated that this scale was causing a degree of confusion amongst learners. Therefore, it was decided that the Critical Voice scale would be omitted altogether in my study. The final version of the preferred and actual forms of the CLES used in this study was composed of four scales, with six items in each: Personal Relevance, Uncertainty, Shared Control and Student Negotiation.

3.5 LARGE-SCALE QUANTITATIVE DATA COLLECTION

The initial phase of the present study involved the administration of the questionnaires to provide data that could be used to validate the modified version of the preferred and actual forms of the CLES and the attitude scale for use in mathematics classes in South Africa. To achieve this, the CLES and attitude scale were administered to 1864 learners in 34 classes (as described in Table 3.1). Administration of the questionnaires took place in the middle of the first term, in February 2001, to allow teachers sufficient time to establish a stable learning environment. The South African school year begins in January and ends in December, with the first term ending in March.

3.6 STATISTICAL ANALYSIS METHODS

The statistical analyses used in the present study are described below in terms of: the choice of unit for statistical analysis (Section 3.6.1); validation of the questionnaires (Section 3.6.2); associations between attitudes and learning environment (Section 3.6.3); and descriptive analyses (Section 3.6.4).

3.6.1 Choice of Unit for Statistical Analysis

Fraser (1998b) stresses the importance of choosing the appropriate unit or level of statistical analysis. He indicates that, through the use of different units of statistical analysis, variables with the same operational definition could have different substantive interpretations. There also is a possibility that relationships found by using a particular unit of statistical analysis could differ in size and even in sign from those obtained using another unit.

In this study, two units of statistical analysis were used, namely, the individual and the class mean. Comparisons were made between students (individual student) and between classes (class mean score). The use of these two units of analysis permitted comparison of the results of my study with those of past research.

3.6.2 Validation of the CLES and Attitude Scale

Data collected from the 1864 learners from 34 classes in the Central region of the Limpopo province were analyzed in various ways to investigate reliability and validity of the actual and preferred forms of the CLES including factor and item analysis, alpha reliability, discriminant validity and ability to differentiate between classes.

Factor and Item Analysis

Validation of the CLES involved a series of factor and item analyses whose main purpose was to examine the internal structure of the *a priori* 24-item, four-scale version used in the present study. During item analysis, problematic items (those which were not reasonably well correlated with the total score for its scale) were removed to improve scale internal consistency. Following item analysis, principal components factor analysis with varimax rotation was used to check the factor structure. It was anticipated that each item in the actual version of the CLES would have a loading of 0.30 or more on its own scale but not on other scales.

Alpha Reliability

To examine each scale's internal consistency reliability, the Cronbach alpha coefficient was calculated for two units of analysis, the individual and the class

mean. The alpha reliability coefficient was examined for both the actual and preferred versions of the CLES and the attitude scale.

Discriminant Validity

Another feature considered important in the classroom environment instrument is the extent to which each scale measures a dimension different from that measured by any other scale. The mean correlation with the other scales was used as a convenient index of scale discriminant validity of raw scores on CLES scales.

Ability to Differentiate Between Classes

An important step in the validation of a learning environment questionnaire is to determine whether the actual form of each scale can differentiate between the perceptions of students in different classes. To do this, an analysis of variance (ANOVA) was used, with class membership as the independent variable, to determine the ability of each CLES scale to differentiate between the perceptions of learners in the different classes.

3.6.3 Associations Between Learning Environment and Attitudes

An aim of the study was to explore associations between the learning environment and student attitudes. A simple correlation analysis of relationships

between student attitudes and the CLES's four learning environment scales was performed to provide information on bivariate associations. A multiple correlation analysis of relationships between student attitudes and the set of four environment scales was conducted to provide a more complete picture of the joint influence of correlated environment dimensions on attitudes and to reduce the Type I error rate associated with the simple correlation analysis. To interpret which scales were making the largest contribution to explaining variance in student attitudes, the regression weights were used to describe the influence of a particular environment variable on student attitudes when all other environment variables were mutually controlled. Both the simple correlation and multiple regression analyses were conducted for two units of analysis (the student and the class mean).

3.6.4 Descriptive Analysis

Descriptive analysis focuses on groups and their activities that change over a period of time (McMillan & Schumacher, 1997). The descriptive analysis provided through the calculation of the means and standard deviations helped to describe the perceptions of the students and changes in these perceptions during the process of intervention. In this study descriptive analysis helped the researcher to portray relevant data about the effectiveness of strategies implemented by teachers through graphical profiles of students' perceptions of the constructivist nature of the learning environment.

3.7 INTERVENTION PHASE AIMED AT IMPROVING THE LEARNING ENVIRONMENT

The second phase of the study focused on action research. From the 34 classes of data collected in the initial phase of the study, two classes were selected as case studies. Using learners' responses to actual and preferred versions of the CLES, these two teachers identified constructivist aspects of the learning environment that they would like to improve. Using spiralling cycles of questioning, planning, implementing, collecting data and reflecting (described in more detail in Chapter 2, Section 2.6.2), the teachers developed strategies aimed at improving their learning environments. Based on the success of past studies (Sinclair & Fraser, 2002; Thorp, Burden & Fraser, 1994; Yarrow, Millwater & Fraser, 1997) this phase examined the effectiveness of using the Constructivist Learning Environment Survey as a tool that teachers could use to provide feedback information about, and to guide improvements in, their learning environments.

To enhance the validity of the qualitative data throughout the intervention, a combination of strategies, as suggested by McMillan and Schumacher (1997), were used, including prolonged and persistent fieldwork in the form of classroom observations, participant language, member checking and interviews with participants.

The qualitative data collection used in the present research involved a prescriptive set of techniques and evaluation, as suggested by Guba and Lincoln (1989). Although this part of the research sits within the paradigm of qualitative research, the epistemological beliefs of constructivism align the study with fourth generation evaluation and interpretive methodology by incorporating a constructivist perspective (Guba & Lincoln, 1989).

During this intervention phase of the study, data were gathered using feedback data collected using the CLES (Section 3.7.1), classroom observations (Section 3.7.2), interviews with teachers and students (Section 3.7.3) and journals kept by teachers (Section 3.7.4).

3.7.1 Feedback Data Collected Using the CLES

Prior to the commencement of the 12-week intervention period, the actual and preferred version of the CLES was administered to students in the mathematics classes of the two teachers. The mean scores of student responses were used to generate profiles of the actual and preferred responses of the students. To determine whether the difference between actual and preferred scores were significant, *t* tests for paired samples were conducted. To estimate the magnitudes of the differences (in addition to their statistical significance), effect sizes were calculated as recommended by Thompson (1998a, 1998b).

The teachers then used the profiles to help them to identify those aspects of the learning environment that they would like to improve. With the help of the researchers, teachers then formulated strategies that they could use to increase the constructivist orientation of their classes. At the end of the 12-week intervention period, the actual version CLES was administered again to ascertain whether the strategies had been successful.

3.7.2 Classroom Observations

Classroom observations were used as a main source of data over the 12-week intervention period. Observations were carried out twice a week for around 30 minutes in the two classes taught by each of the two teachers (i.e., each teacher was observed for 60 minutes per week). Observations focused on the actions of the teacher and the way in which lessons were presented (including the strategies used) and the reactions of the learners to the way in which the teacher presented the lessons. Observations were recorded as field notes and anecdotal records. These observations were used also to provide feedback to the teachers and points of interest during subsequent interviews. These notes were intended to assist teachers to reflect on their teaching practices and to be used in conjunction to their own journal entries (see Section 3.7.3).

During observation visits, the researcher generally sat with a group of students to enable him to observe and note interactions between students and between students and the teacher. As such, the researcher took on the role of participant

observer. The researcher was aware that his presence in the classroom would create a difference and, as suggested by Wolcott (1990), took steps to ensure that he did not rely on a single approach. In keeping with Wolcott's (1990) suggestion, interviews were considered an important component of the collection of qualitative data, as discussed in the following section.

3.7.3 Interviews

Interviews were used as an additional source of data. This approach is in keeping with the hermeneutic dialectic process, suggested by Guba and Lincoln (1989). Interviews were held with each of the teachers and a sample of learners selected from each of the six mathematics classrooms during the 12-week intervention phase.

At the end of each classroom observation, an informal interview was conducted with the teacher. This provided an opportunity for the teacher to reflect upon the lesson and for the researcher to clarify observations and discuss issues that arose. It was originally intended that more in-depth interviews would be conducted with the teacher after each observation, but this was not always possible as the teachers often had to leave to teach another class. To overcome this, more in-depth interviews were conducted with teachers on a different day.

Five learners from each class were interviewed three times during the intervention period, once during the fifth week, once during the ninth week and

once in the week after the intervention period was over. The purpose of these interviews was to provide the researcher with deeper insights into students' attitudes towards the changes made by teachers and as a source of information regarding students' perceptions of the learning environment being created.

Both structured and informal unstructured interviews were used to gain insights into the character and intensity of respondents' attitudes, motives, feeling, and beliefs (Deobold & Van Dalen, 1979). The researcher also used open-ended questions, in a discussion-type format, in which the order was neither planned nor pre-determined. Interviews were recorded as notes during each session and later written in the form of narratives after each session.

3.7.4 Teacher Journals

Teachers were encouraged to keep a journal as a means of reflection on their teaching. Through this, they were encouraged to continuously evaluate their own progress and become critics of their own activities (Galbraith, Blum, Booker & Huntley, 1998). They were requested to make entries into their journals on a daily basis, and it was expected that they (teachers) would write about their experiences as they implemented more constructivist practices into their teaching. Reflections were also expected to include examples of problems and successes and ways in which they could improve their teaching in subsequent lessons. The researcher discussed the journal entries with the teachers on weekly bases.

3.8 SUMMARY

This chapter informs the reader about the design of the present study. The two overarching aims of the present study were, first, to investigate whether a survey, designed in the West to assess students' perceptions of the constructivist learning environment, could be modified and validated for use in South Africa and, second, to examine the usefulness of feedback from this instrument in assisting teachers to create more constructivist learning environments in their classrooms. The study was carried out in intermediate-phase and senior-phase mathematics classes in the Limpopo province of South Africa.

During the initial phase of the study, data were collected from a total of 1864 students in 34 classes from six schools. From each of the areas, four of the teachers were teaching intermediate-phase and two were teaching senior-phase classes. In the second phase of the study, which involved a period of intervention, three of the six original teachers and their students were selected as case studies.

The Constructivist Learning Environment Survey (CLES) and an attitude scale were modified for use in South Africa. Four of the original five CLES scales, namely, Personal Relevance, Uncertainty, Student Negotiation and Shared Control were used in the data collection. One of the original scales, Critical Voice, was removed because it was considered unsuitable for the South African

context. One attitude scale was selected from the Test of Science-Related Attitudes for use in this study.

Data collected from the 1864 students were analysed in various ways to determine the reliability and validity of the CLES when used in South African mathematics classes. Factor and item analysis were used to examine the internal structure of the CLES. In addition, each scale's internal consistency, discriminant validity, and ability to differentiate between classrooms were calculated to provide additional support for the reliability and validity of the CLES.

To examine whether associations exist between students' perceptions of the learning environment and students' attitudes towards their mathematics classes, simple and multiple correlation analyses were conducted.

The intervention phase of the study involved examining whether teachers could make use of the CLES to help them to improve and monitor their transition towards more constructivist approaches. Three teachers were selected as case studies for this phase. Using graphical profiles of students' perceptions of the actual and preferred learning environments created in their classrooms, teachers designed and implemented strategies to improve constructivist emphases in their learning environments. At the end of the intervention period, the CLES was re-administered to determine whether any changes had been made. During this phase, largely qualitative methods were used to gather the

data including classroom observations, interviews with teachers and students, and journals kept by teachers.

The role of the researcher during the intervention of the study was to guide and support teachers in implementing a constructivist approach and in effecting change from traditional ways of teaching. Therefore, teachers' written journals were discussed to assist them in the reflection of their classroom activities.

The following chapter examines the findings and results of this study.

Chapter 4

Analyses and Results

4.1 INTRODUCTION

The present study was carried out in two stages. In the first stage of the study, four scales of the original Constructivist Learning Environment Survey (CLES) and an attitude scale were administered to the 1864 learners in 34 classes from six schools. Analyses of these quantitative data were conducted initially to determine the validity and the reliability of these instruments when used in South Africa. This data was also used to examine whether associations exist between students perceptions of the learning environment and their attitudes towards their mathematics classes.

Analysis of the data was used to provide information about students' perceptions of the actual and preferred learning environment in mathematics classes in the Limpopo province. Finally, the data was used to generate profiles of students' perceptions of their actual and preferred learning environments in two classrooms. The two teachers then used this feedback information to help them to develop strategies to improve the learning environment in their mathematics classrooms.

This chapter provides the results of various analyses that were conducted to answer the study's research questions using the following headings:

- Reliability and Validity of the Constructivist Learning Environment Survey and Attitude Scale (Section 4.2);
- Associations Between Student Attitudes and their Perceptions of the Learning Environment (Section 4.3);
- Describing Mathematics Classrooms Using the CLES (Section 4.4);
- Using the CLES to Guide and Monitor Changes in the Learning Environment (Section 4.5); and
- Using Journals as a Tool for Reflection (Section 4.6).

4.2 RELIABILITY AND VALIDITY OF THE CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY AND ATTITUDE SCALE

To determine whether the CLES, designed and used in a Western context, is suitable for use in South African classes to monitor the learning environment developed by teachers, the first research question asked:

> Is it possible to modify and validate an actual and a preferred version of the Constructivist Learning Environment Survey (CLES) for use at intermediate and senior phases of schooling in South Africa?

To answer this research question, the data collected from 1864 learners in 34 classrooms with 18 teachers from six schools were analysed to investigate

the reliability and validity of the Constructivist Learning Environment Survey (CLES) and attitude scale. Analyses of the CLES data included factor and item analyses (discussed in Section 4.2.1), internal consistency (discussed in Section 4.2.2), discriminant validity (discussed in Section 4.2.3) and ability to differentiate between classes (discussed in Section 4.2.4). As well, the reliability of the attitude scale is reported in Section 4.2.5.

A modified version of the CLES was developed, with six items in each of the four scales of Personal Relevance, Uncertainty, Shared Control and Student Negotiation. (See Chapter 3, Section 3.4 for more details regarding the modification of the CLES for use in the present study.) The items of the questionnaire were modified to make them more suitable for use in our South African classrooms. This questionnaire was used to collect data from the 1864 learners indicated above. (A copy of the modified actual and preferred versions of the CLES used in the present study can be viewed in Appendix A and B, respectively.)

4.2.1 Item and Factor Analyses

A principal components factor analysis with varimax rotation (commonly used in learning environment research) was used to check the structure of the 24-item four-scale version of the CLES. A separate analysis was conducted for the actual and preferred forms. In both cases, the factor analysis was constrained to four factors. Tables 4.1 and 4.2 show the factor loadings obtained for the sample of 1864 learners in 34 classrooms from six schools for the actual and preferred form of the CLES, respectively.

The factor analysis depicted in Table 4.1 supports the 24-item four-scale structure of the actual form of the CLES. All of the items have a loading of at least 0.30 on their *a priori* scale and no other scale, with the exception of Item 6 (whose loading is less than 0.30 on every scale). This item is negatively worded, which might be the reason why it does not load well. The percentage of the total variance extracted and the eigenvalue associated with each factor are recorded at the bottom of Table 4.1. The percentage of variance for the actual form ranges between 4.75% and 18.10% and the eigenvalues range between 1.14 and 4.34. The total proportion of variance accounted for by these 24 items in four scales is 35.7%.

Table 4.1 Factor Loadings for a Modified Version of Actual Form of the CLES in South Africa

Item No	Factor Loadings			
	Personal Relevance	Uncertainty	Shared Control	Student Negotiation
1	0.35			
2	0.48			
3	0.41			
4	0.49			
5	0.45			
6	–			
7		0.30		
8		0.42		
9		0.32		
10		0.31		
11		0.44		
12		0.39		
13			0.40	
14			0.44	
15			0.46	
16			0.48	
17			0.49	
18			0.36	
25				0.45
26				0.51
27				0.51
28				0 40
29				0 51
30				0 38
% Variance	6.18	4.75	6 65	18 10
Eigenvalue	1.48	1.14	1 60	4.34

Factor loadings smaller than 0.30 have been omitted.
The sample consisted of 1864 students in 34 classes in South Africa.

Although using principal components factor analysis with varimax rotation is widespread when validating learning environment questionnaires, it is acknowledged that it could be more appropriate to use principal axis factor analysis with oblique rotation because one can assume that the factors are related (Coakes & Steed, 2001). Therefore, a principal axis factor analysis with direct oblimin rotation was conducted for the data for the actual form of the CLES. The results reported in Appendix F. These results in Appendix F for the principal axis factor analysis are similar to those found in Table 4.1 for the principal components factor analysis, with each item loading on its *a priori* scale and no other scale. The only exceptions in Appendix F are Items 1, 6 & 7, whose loadings were less than 0.30 on every scale.

Table 4.2 reports the results of the principal components factor analyses for the preferred form of the CLES. For this version of the questionnaire, it would appear that items in the Uncertainty scale load on the same factor as those from the Personal Relevance scale when the analysis constrained to four factors.

Because Items 6 and 7 are negatively worded items, these could have much in common with each other. This possibly could have led to the other items in Personal Relevance and Uncertainty loading on the same scale. To exlore this idea further, the factor analysis for the preferred version was run unconstrained. Five factors emerged. Four of these corresponded to the four *a priori* factors and the two negatively-worded items (Items 6 and 7) loaded on a fifth factor. See Appendix G for the results.

The percentage of variance for the preferred form in Table 4.2 ranges between 4.81% and 22.27% and the eigenvalues range between 1.15 and 5.34. The total proportion of variance accounted for by these 24 items in four scales is 35.1%.

Table 4.2. Factor Loadings for a Modified Version of Preferred Form of the CLES in South Africa

Item No.	Factor Loadings			
	Personal Relevance	Uncertainty	Shared Control	Student Negotiation
1	0.43			
2	0.38			
3	0.41			
4	0.50			
5	0.48			
6		0.56		
7		0.42		
8	0.41			
9	0.42			
10	0.41			
11	0.43			
12	0.41			
13			0.52	
14			0.58	
15			0.60	
16			0.58	
17			0.59	
18			0.42	
25				0.47
26				0.55
27				0.60
28				0.60
29				0.59
30				0.47
% Variance	7.96	4.81	22.27	6.61
Eigenvalue	1.91	1.15	5.34	1.59

Factor loadings smaller than 0.30 have been omitted.
The sample consisted of 1864 students in 34 classes in South Africa.

The findings for the factor structure of the preferred form of the CLES (Table 4.2 and Appendix G) are interesting and tentatively suggest that the presence of two negatively-worded items (Items 6 and 7) could detract from the overall factorial validity of the instrument. It is possible that the rewording of these items (to give them a positive scoring direction) would be desirable in future research. It is recommended that this be tried out in future studies.

4.2.2 Internal Consistency Reliability

The internal consistency reliability (Cronbach alpha coefficient) was calculated to determine the extent to which each item in a CLES scale measures the same construct. Table 4.3 reports the Cronbach alpha coefficient for the actual and preferred versions of the CLES for each of the scales for two units of analysis (the individual and the class mean). For the actual version of the CLES, scale reliability estimates range from 0.60 to 0.63 using the individual as the unit of analysis and from 0.88 to 0.91 using the class mean as the unit of analysis. For the preferred version of the CLES, the scale reliability estimates range from 0.56 to 0.75 using the individual as the unit of analysis and from 0.83 to 0.97 for the class mean as the unit of analysis. These reliability values can be considered satisfactory for short scales containing only six items (Fraser, 1986).

4.2.3 Discriminant Validity

The mean correlation of a scale with the other scales was used as a convenient index of discriminant validity, or scale independence, and is reported in Table 4.3. For the actual form of the CLES, the mean correlation of a scale with the other scales varies between 0.33 and 0.40 with the individual as the unit of analysis and between 0.56 and 0.68 with the class mean as the unit of analysis. For the preferred form of the CLES, the mean correlation of a scale with the other scales varies between 0.35 and 0.44 with the individual as the unit of analysis and between 0.62 and 0.76 with the class mean as the unit of analysis. These values generally can be regarded

as small enough to support the discriminant validity of raw scores on the CLES, although some values are relatively high at the class level of analysis. This suggests that raw scores on each CLES scale generally measure distinct aspects of the classroom learning environment. Moreover, the factor analysis attests to the independence of factor scores on the actual form of the four CLES scales.

Table 4.3 Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation With Other Scales) and Ability to Differentiate Between Classrooms (ANOVA Results) for Two Units of Analysis for the Modified Version of the CLES

Scale	Unit of Analysis	Alpha Reliability		Mean Correlation with other Scales		ANOVA Eta^2
		Actual	Preferred	Actual	Preferred	Actual
Personal Relevance	Individual	0.61	0.56	0.35	0.44	0.23**
	Class Mean	0.88	0.83	0.56	0.76	
Uncertainty	Individual	0.60	0.61	0.40	0.41	0.26**
	Class Mean	0.90	0.93	0.68	0.74	
Shared Control	Individual	0.63	0.78	0.33	0.43	0.20**
	Class Mean	0.90	0.97	0.61	0.75	
Student Negotiation	Individual	0.63	0.75	0.34	0.35	0.15**
	Class Mean	0.91	0.94	0.68	0.62	

** $p<0.01$
The sample consisted of 1864 students in 34 classes in South Africa.
The eta^2 statistic (which is the ratio of 'between' to 'total' sums of squares) represents the proportion of variance explained by class membership.

4.2.4 Ability to Differentiate Between Classrooms

An analysis of variance (ANOVA) was used to determine the ability of the actual form of each CLES scale to differentiate between the perceptions of students in different classes. The eta^2 statistic was calculated to provide an estimate of strength of the association between class membership and the

dependent variable (CLES scale). The ANOVA results, presented in Table 4.3, indicate that each scale is able to differentiate significantly between classrooms (p<0.01). The amount of variance in scores accounted for by classroom membership (i.e. eta^2) ranged from 0.15 to 0.26 for different scales. These figures suggest that students perceive the learning environments of different mathematics classrooms quite differently.

4.2.5 Reliability of the Attitude Scale

Student attitude scale was adapted from the Test of Science-Related Attitudes (TOSRA), originally developed by Fraser (1981b), and modified to suit mathematics classrooms in the South African context (refer to Section 3.3.2 for more details). Data collected from 1864 learners in 34 classrooms were analysed to determine the internal consistency reliability (Cronbach alpha coefficient) of the eight-item attitude scale (see Appendix C). The results supported its reliability, with estimates of 0.59 using the individual as the unit of analysis and 0.63 using the class mean as the unit of analysis.

4.3 ASSOCIATIONS BETWEEN STUDENT ATTITUDES AND THEIR PERCEPTIONS OF THE LEARNING ENVIRONMENT

The second research question was delineated as:

> Do associations exist between learners' perceptions of the constructivist orientation of the learning environment and their attitudes towards their mathematics classroom?

To investigate associations between student attitudes and the four CLES scales for the sample of 1864 students in 34 South African classes, simple and multiple correlation analyses (see Table 4.4) were conducted for two units of analysis (the individual and the class mean). The results of the simple correlation analysis indicate that all four of the CLES scales are statistically significantly ($p<0.05$) associated with student attitudes towards their mathematics class at both the individual and class mean levels of analysis. The correlation between student attitudes and CLES scales range between 0.06 and 0.23 for the individual as the unit of analysis and between 0.43 and 0.71 for the class mean as the unit of analysis. The results of the simple correlation analysis suggest that improved student attitudes are associated with more emphasis on all of the aspects of constructivism assessed by the CLES.

The multiple correlation (R) reported in Table 4.4 for the set of four CLES scales is 0.25 at the individual level and 0.77 for the class mean as the unit of analysis. The result was statistically significant ($p<0.05$) in both cases.

To identify which classroom environment scales contribute most to the variance in student satisfaction, the standardised regression weights (β) were examined (see Table 4.4). When using the individual as the unit of analysis, the two CLES scales of Uncertainty and Student Negotiation were significantly ($p<0.01$), positively and independently related to student attitudes. When using the class mean as the unit of analysis, the Uncertainty scale was a positive and significant ($p<0.05$) independent predictor of student

attitudes. These results suggest that the more Uncertainty and Student Negotiation that there is in mathematics classes, the more likely it is that learners enjoy their mathematics lessons.

Table 4.4 Simple Correlation and Multiple Regression Analyses for Associations Between Student Attitudes and Dimensions of the CLES in South Africa

CLES Scale	Unit of Analysis	Student Attitudes	
		r	*β*
Personal Relevance	Individual	0.10**	0.01
	Class Mean	0.69**	0.29
Uncertainty	Individual	0.17**	0.10**
	Class Mean	0.43**	-0.31
Shared Control	Individual	0.06*	-0.04
	Class Mean	0.54**	0.21
Student Negotiation	Individual	0.23**	0.21**
	Class Mean	0.71**	0.58*
Multiple Correlation (*R*)	Individual		0.25**
	Class Mean		0.77**

* $p<0.05$ ** $p<0.01$
The sample consisted of 1864 students in 34 classes in South Africa.

These results replicate the findings of the past studies, cited by Fraser (1998a), that generally indicate associations between student attitudes and dimensions of the classroom environment.

4.4 DESCRIBING MATHEMATICS CLASSROOMS USING THE CLES

To provide the researcher and the teachers with a sense of what mathematics classrooms are like in South Africa, the third research question asked:

> Is it possible to describe the learning environment of individual mathematics classrooms using the CLES in South African schools?

To provide information about how students perceive the learning environment in the crowded classes that prevail in the Limpopo Province (most schools have an enrolment of not less than 50 learners per class) and how they would prefer it to be, their responses to the actual and preferred versions of the CLES were analysed. The average item mean (or the scale mean divided by the number of items in that scale) for students' scores on the actual and preferred forms are tabulated in Table 4.5 and graphed in Figure 4.1. The average item mean allows meaningful comparison of scores for scales that might contain different numbers of items. Figure 4.1 shows that students would prefer a much more positive learning environment than the one that they presently perceive on each CLES dimension. This finding has important practical implications for mathematics teachers and professional developers in South Africa.

The graphical profile, depicted in Figure 4.1, indicates that students would prefer activities associated with CLES items to occur between 'sometimes' and 'often' for each of the scales. However, Figure 4.1 also shows that the level of each CLES dimension perceived to be actually present is lower for every scale. The lowest average item mean in Figure 4.1 occurs for Shared Control, for which activities are perceived to occur approximately 'seldom'.

Actual-preferred differences in classroom environment were explored using a one-way MANOVA. The multivariate test yielded significant results ($p<0.01$) in terms of Wilks' lambda criterion, indicating that there were differences in the set of criterion variables as a whole. Therefore, the univariate ANOVA was interpreted for each CLES scale. The results

reported in Table 4.5 indicate that a statistically significant difference ($p<0.01$) between actual and preferred scores exist for all four learning environment scales for both units of analysis.

To estimate the magnitude of the differences between students' scores on the actual and preferred forms of the CLES, effect sizes, in terms of the differences in means divided by the pooled standard deviation, were calculated (Thompson, 1998a, 1998b). The effect size for the different CLES scales, reported in Table 4.5, range between approximately one standard deviation (1.15) and one and three quarters standard deviations (1.85) with the individual as the unit of analysis, and between approximately two standard deviations (2.32) and four standard deviations (3.97) with the class mean as the unit of analysis. These results suggest very large and educationally important differences between students' perceptions of the actual and preferred environment. In fact, the magnitudes of actual-preferred differences found in our study in South Africa are considerably larger than the sizes of the actual-preferred differences typically found in past research in numerous other countries (Fraser, 1998a).

Descriptive analyses were used to provide graphical profiles (similar to the one drawn above) to individual teachers. The next section examines whether selected teachers were able to make use of these profiles to improve the constructivist emphasis within their classroom learning environments.

Table 4.5 Average Item Mean, Average Item Standard Deviation and Difference (Effect Size and Results of MANOVA for Repeated Measures) between Actual and Preferred Scores on each CLES Scale for Two Units of Analysis

CLES Scale	Unit of Analysis	Average Item Mean		Average Item Standard Deviation		Difference	
		Actual	Preferred	Actual	Preferred	Effect Size	*F*
Personal Relevance	Individual	2.64	3.48	0.75	0.71	1.15	6.45**
	Class Mean	2.62	3.49	0.37	0.38	2.32	4.02**
Uncertainty	Individual	2.29	3.56	0.70	0.73	1.78	2.81**
	Class Mean	2.23	3.59	0.36	0.43	3.44	4.18**
Shared Control	Individual	2.09	3.47	0.67	0.91	1.75	7.90**
	Class Mean	2.06	3.47	0.29	0.49	3.62	4.35**
Student Negotiation	Individual	2.35	3.79	0.78	0.78	1.85	8.05**
	Class Mean	2.31	3.78	0.39	0.35	3.97	4.80**

**$p<0.01$

The sample consisted of 1864 students in 34 classes.

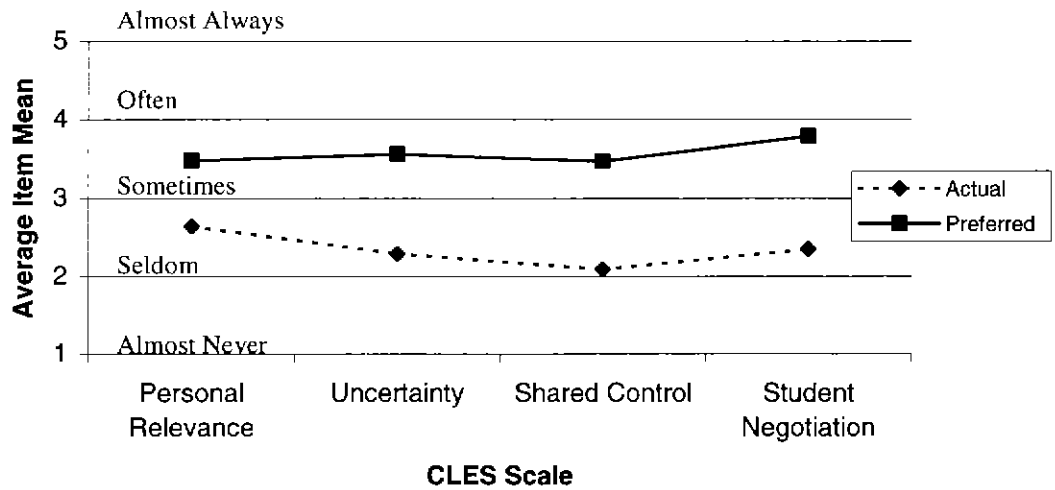


Figure 4.1 Differences in Students' Perceptions of the Actual and Preferred Learning Environment on the CLES

4.5 USING THE CLES TO GUIDE AND MONITOR CHANGES IN THE LEARNING ENVIRONMENT

The second phase of the study involved the investigation of whether the CLES could be used to guide and monitor changes to mathematics classes in South Africa. To this end, the fourth research question asked:

> Are teachers able to make use of student responses to the CLES to develop and implement strategies that improve students' perceptions of the constructivist learning environment?

This intervention phase aimed to investigate whether teachers were able to make use of feedback information based on learners' responses to the CLES to develop and implement action research strategies aimed at improving the environment of their classrooms (see Section 2.6 and 3.7). To examine whether teachers were able to make use of the CLES to guide and monitor changes in their teaching towards a more constructivist approach, a case study approach involving two teachers was utilised. This section introduces the two case study teachers (Section 4.5.1), describes how they used feedback from the CLES to assist them to design strategies for improvement (Section 4.5.2), and reports how they implemented and monitored the effectiveness of a range of strategies in their classrooms (Section 4.5.3).

4.5.1 Introducing the Teachers

The two case study teachers for this phase of the study were both female, one was teaching in the intermediate phase (Grade 4 to Grade 6) and the

other in the senior phase (Grade 7 to Grade 9) of schooling in the Limpopo Province of South Africa. The two teachers selected as case studies for the research both had class sizes ranging between 40 and 50 learners. Although they taught in schools that have electricity, they lacked many resources. They each volunteered to be part of the study because they felt that it would assist them to teach in ways that were more constructivist and learner-centred.

Teacher 1 is in her fifties and holds a two-year primary teachers' certificate, which she was awarded in 1969. She has since studied privately to obtain a further diploma in teaching through distance education. She has been teaching for over 30 years and is still energetic and enthusiastic. She is eager to change from the more teacher-centred methods, to which she is accustomed, to more student-centred methods. Though nearing retirement, she is dedicated to her job and was keen to be observed by the researcher. This teacher's mathematics class had 46 learners.

Teacher 2 is teaching Grade 6 mathematics in a different school from the first teacher. She has 21 years of teaching experience and holds a primary teachers' certificate passed and awarded in 1970s. She is presently attempting to improve her qualification through distance education studies. She has attended inservice training workshops, which were organised during the apartheid era, on the teaching of mathematics in primary schools. The mathematics classes that she is teaching are composed of around 50 learners in each of the classes.

4.5.2 Using the CLES to Assist in Designing Strategies for Improvement

Teachers used graphical profiles, generated through student responses to the CLES, as a focus for attempting to improve their learning environment (see Section 3.7.1). At the end of the intervention period, the CLES was re-administered to students to determine whether they perceived that teachers had made positive changes to the learning environment.

This section describes how two case study teachers used student responses to the CLES to help them to design strategies for improving the learning environment in their classes. The two teachers were each provided with the results of students' responses to the actual and preferred versions of the CLES in the form of a graphical profile (see Figures 4.2 and 4.3). These were discussed with the teachers who were optimistic that they would be able to implement more constructivist teaching strategies, and therefore improve their students' perceptions of the learning environment over a 12-week intervention period. (See Chapter 3 for more detail on the selection of case study teachers).

Student scores on the actual and preferred forms of the CLES were similar for both teachers. In both cases, students would prefer that the dimensions assessed by the CLES occurred more than 'often' in their classroom, but perceived them actually occurring less than 'sometimes' (see Figures 4.2 and 4.3). *T* tests for paired samples, using the individual as the unit of analysis, were used to investigate whether differences in actual and preferred scale scores were statistically significant. The results in Table 4.6 indicate that, for

both teachers, the differences between actual and preferred scores were statistically significant for all four CLES scales ($p<0.05$). The effect sizes for actual-preferred scores were calculated to provide an estimate of the magnitude of the differences. For Teacher 1, the effect sizes were generally higher (ranging between 1.91 and 2.25) than for Teacher 2 (ranging between 0.52 and 2.04). Both of the teachers appreciated that students' scores on the actual learning environment scales were below those that they would prefer and were keen to attempt to close the gap between the two.

Table 4.6 Average Item Mean, Average Item Standard Deviation and Difference (Effect Size and *t* Test Results) between Actual and Preferred Scores on each CLES Scale for the Individual as the Unit of Analysis for Teachers 1 and 2

CLES Scale	Teacher	Average Item Mean		Average Item Standard Deviation		Difference	
		Actual	Preferred	Actual	Preferred	Effect Size	*t*
Personal Relevance	Teacher 1	3.49	4.74	0.67	0.44	2.25	12.62**
	Teacher 2	3.64	3.91	0.69	0.34	0.52	2.51*
Uncertainty	Teacher 1	2.96	4.07	0.78	0.38	1.91	9.07**
	Teacher 2	2.85	3.79	0.78	0.50	1.47	8.03**
Shared Control	Teacher 1	2.79	4.08	0.80	0.47	2.03	10.37**
	Teacher 2	2.56	3.74	0.82	0.51	1.77	9.11**
Student Negotiation	Teacher 1	2.73	4.11	0.80	0.43	2.24	12.23**
	Teacher 2	2.35	3.99	0.98	0.63	2.04	9.23**

**$p<0.01$ The samples consisted of 46 students in Teacher 1's class and 56 students in Teacher 2's class.

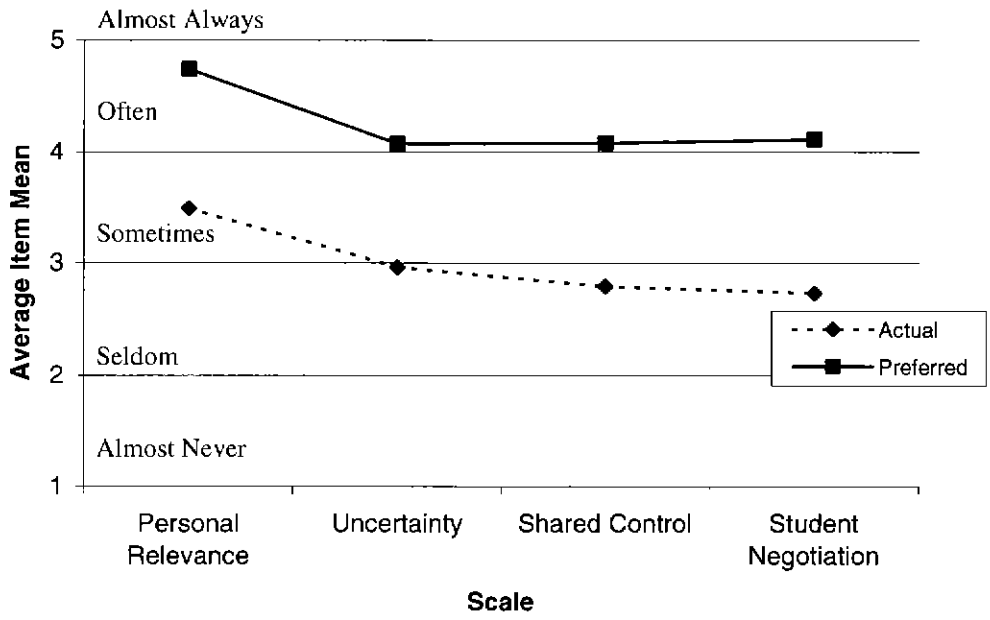


Figure 4.2 Average Item Mean for Students' Actual and Preferred Scores on the CLES for Teacher 1

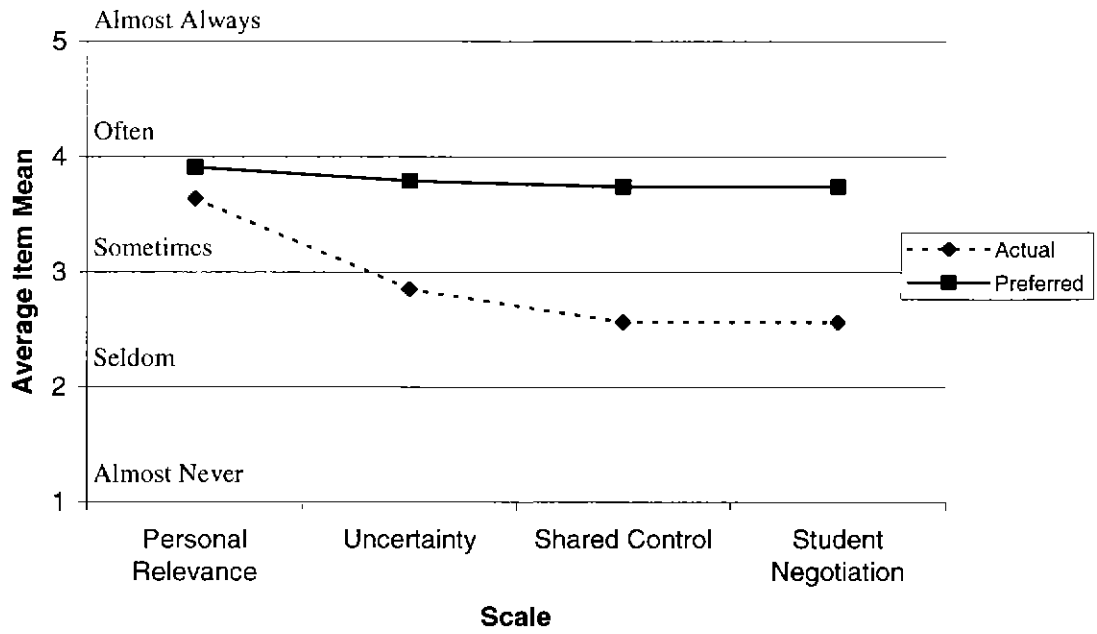


Figure 4.3 Average Item Mean for Students' Actual and Preferred Scores on the CLES for Teacher 2

Each teacher selected a particular dimension of the CLES that they felt was important. Teacher 1 opted to improve the Personal Relevance scale, while

Teacher 2 chose the Student Negotiation scale. Using the items within these dimensions as a guide, the teachers designed strategies that would assist them to improve their constructivist teaching practices. A summary of strategies used by the teachers for increasing the emphasis on each CLES dimension is presented below.

4.5.3 Strategies Implemented by Teacher 1

Teacher 1 decided to implement strategies to improve the *Personal Relevance* scale. In an attempt to do this, she decided on the following two strategies of:

(i) discussing and impressing on students the importance of mathematics to their future lives.

(ii) making the problems that she presented to students more relevant to their daily lives.

Discussing the Importance of Mathematics to Students' Futures

The teacher considered that a key aspect of the Personal Relevance scale was the importance of mathematics to the future of the learners. To give learners an appreciation of the role of mathematics in their future, the teacher decided that she would give the learners the task of asking their parents about the role of mathematics in their lives. Learners were then asked to discuss their findings in groups before reporting back to the whole class. In addition, this teacher sought to integrate the mathematics lessons into a

language lesson by asking learners to write a composition entitled '*The importance of mathematics in our daily life and our future.*' In response, one student wrote: "Mathematics is the foundation subject to all careers. If you want to be accountant, mathematics must be studied in Form 4 and Form 5. Plumbers must be good at figures so that they can fit pipes correctly." Another student wrote: "In cooking, we are using mathematics for measuring flour. We are always using mathematics when we do sewing." Yet another student pointed out: "If I know mathematics, they will not rob me of change."

It would appear that the teacher's emphasis on the importance of mathematics to learners made quite an impact on the students. Interviews with students indicated that the discussions with parents and in groups helped students to regard their mathematics classes in a more positive light and attitude. The teacher noticed that students were more eager to have homework on daily basis.

Making Problems More Relevant to Students' Daily Lives

In an attempt to increase the students' perceptions of the level of Personal Relevance, the teacher decided that it was important to make the mathematics that was taught to them more related to their daily lives. In the past, Teacher 1 had not paid much notice to the types of problems that she presented to students. She was often content to use examples that might have lacked relevance to the learners. To address this, she tried to give students exercises that involved their surroundings. For example, when teaching measurement, she provided opportunities for the learners to

measure distances around buildings and classrooms. She also involved the learners in practical examples, such as measuring their own heights using metre sticks or rulers.

When teaching money, addition and subtraction, she decided that she would use shopping lists that included items that students would commonly purchase. Such questions involved calculating the amount of change that would be given to them after purchasing grocery items at the supermarket.

During lessons that involved the drawing and interpretation of graphs, the teacher made the exercise more relevant by getting the learners to collect the data themselves. She also ensured that, if she used graphs that were not constructed by the learners, the graphs would be related to their everyday lives, such as the graphs found in newspapers that show rainfall and population settlements.

A big step for this teacher was to implement her ideas using group work, which is something with which she had not had much experience. As a first step, she changed the way in which desks were arranged in her classroom so that students were no longer facing the chalkboard, but were seated in groups of four or five students. She felt that learning would be more meaningful and more relevant to learners' everyday lives if she could guide them through practical examples and hands-on experiences rather than telling or giving them information.

The introduction of group work, according to this teacher, was the most difficult aspect of the intervention period. She experienced numerous problems, particularly at the beginning of the 12-week period. She found that learners tended to talk over each other, without realising that they had to give others an opportunity to have their say. Learners were much noisier than they had been in the past and the noise created during mathematics classes could be heard along the corridors, thus causing the teacher to be most concerned about the reactions of her fellow teachers.

According to the teacher's journal, one of the biggest problems that she experienced during this time was ascertaining whether the students had learned what they were supposed to. She found that, without the use of formal tests, she had difficulties determining which students were making adequate progress or had grasped a particular concept.

It was at this stage of the intervention period that the teacher required the most support. Without guidance, support and encouragement at this stage, it is felt that the teacher would have stopped using the ideas and strategies that she had selected. According to the teacher's comments during discussions with the researcher, she was tempted on numerous occasions to revert back to her more teacher-centred ways as she felt that students were easier to control using these methods and that it was easier to assess students' progress.

Her persistence with the use of groups appears to have paid off. Towards the end of the 12-week intervention period, the teacher used groups to make

good use of the limited resources, to engage the students in activities, and to report students' findings to the class. She was able to discover that, through groups, the children got from colleagues information that she might not have provided.

Examining the Success of Teacher 1's Strategies

The teacher gradually became more confident with the use of groups and developed management strategies that helped her to control the class. She developed strategies that helped her to maintain a healthy noise level and assisted the students to learn to give all members of the group an opportunity to have their say without talking over them. Interviews with students indicated that they appreciated the use of activities that involved them in their learning and the use of group activities.

Table 4.7 and the graphical profile shown in Figure 4.4 provide the results of the posttest administration of the actual form of the CLES. The graphical profile also reports the same information for students' actual pretest and preferred scores as was depicted in Figure 4.2. These results indicate that students perceive a more favourable learning environment (in terms of the CLES) for all scales on the posttest relative to the pretest. It seems that the strategies employed by the teacher to improve the Personal Relevance scale have affected students' perceptions of all four CLES scales. *T* tests for paired samples were calculated to examine whether the differences between the pretest and posttest scores were significant. The results indicate a statistically significant ($p<0.01$) improvement in learning environment scores

for all four CLES scales and the effect sizes for differences between pretest and posttest scores range between 0.94 and 1.60 for different scales.

Table 4.7 Average Item Mean, Average Item Standard Deviation and Difference (Effect Size and *t* Test Results) between Pretest and Posttest Scores on each CLES Scale for the Individual as the Unit of Analysis for Teacher 1

CLES Scale	Unit of Analysis	Average Item Mean		Average Item Standard Deviation		Difference	
		Pretest	Posttest	Pretest	Posttest	Effect Size	*t*
Personal Relevance	Individual	3.49	4.21	0.69	0.57	1.14	5.27**
Uncertainty	Individual	2.96	3.91	0.78	1.24	0.94	4.93**
Shared Control	Individual	2.79	3.75	0.60	0.80	1.37	7.48**
Student Negotiation	Individual	2.73	3.86	0.80	0.61	1.60	8.08**

**$p<0.01$
The sample consisted of 46 students in Teacher 1's class.

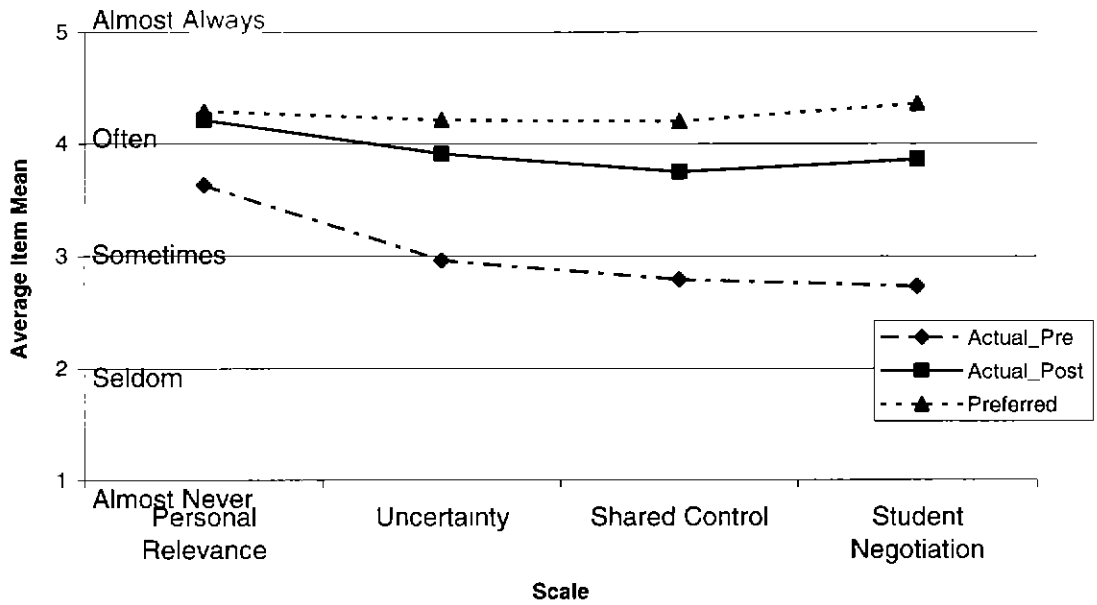


Figure 4.4. Average Item Mean for Students' Actual Pretest, Actual Posttest and Preferred Scores on the CLES for Teacher 1

These results indicate a substantial improvement of student scores for all CLES scales. It would appear that the nature of the changes that the teacher attempted to make to her learning environment and her use of group work has led to the improved levels of Uncertainty, Shared Control and Student Negotiation. It is interesting to note that the results shown in Table 4.7 and Figure 4.4 indicate that the learning environment perceived by students at the end of the intervention period is close to the learning environment that they would prefer.

4.5.4 Strategies Implemented by Teacher 2

Teacher 2 elected to work on strategies that could help to improve the level of Student Negotiation in the classroom. To improve this dimension, she decided to place more emphasis on discussions between learners during lessons. To facilitate discussions between learners, the teacher arranged the desks into groups of six, enabling students to face each other rather than the chalkboard.

Even though the teacher felt that there was merit in allowing time for student discussions, she was most concerned that the learners would be disruptive and would all talk at once. One of her biggest concerns was the possibility of creating a noisy classroom. The researcher felt that this teacher was most ambitious in her decision to improve Student Negotiation and in the strategies that she implemented to achieve this.

To facilitate discussion, the teacher tried to provide opportunities for students to work in groups. At the beginning of the intervention period, she would give a problem to the whole class, for learners to solve individually. She then got them to discuss how they solved the problem and arrived at the solution. As a group, they were required to decide on the best explanation and to report back to the class.

Over a period of time, she gradually modified this strategy, as she found that some groups were struggling with problems. She started to present different problems to different groups, particularly if some learners appeared to be having difficulty solving a particular problem. After the group got the problem correct, it was then given to the next group. Different groups were assisting their colleagues if they got stuck.

Observations of such sessions indicated that, whilst the groups remained the same, the teacher ensured that the reporters changed from time to time. She encouraged the learners to report back their findings using the chalkboard and invariably the explanations of the different groups would be slightly different.

Examining the Success of Teacher 2's Strategies

The teacher's prediction of classroom disorder, in many ways, was true, particularly at the beginning of the 12-week intervention period. The students were not used to being seated in groups and had not experienced lessons in which they were encouraged to discuss their ideas with their peers.

According to the teacher's journal, she felt that she lacked control because of the amount of noise in the room. As with the first teacher, this teacher required much encouragement and support to persist with her selected strategies. It appeared that the students were not aware of what was required of them at all times and, as a result, became restless and noisy. This, in turn, created an apparent lack of control on the part of the teacher. Discussions with the researcher, based on her journal entries, led to the preparation of worksheets and other learning support materials for individuals and groups to guide them during lessons. Interviews with the teacher about the introduction of the learning support materials indicated that those students without learning support materials misbehaved more than learners with materials in their possession. Interviews with learners indicated that they felt that the learning support materials helped them to understand what they were doing and learning.

Although the teacher was generally pleased with the way in which her learners interacted during such lessons, she indicated in her journal that she encountered difficulties in controlling time and that she was often left without the opportunity to conclude the lesson as well as she would have liked. She found that, for some lessons, there was not enough time to finish the work that she had set out to accomplish and, in these cases, she found that she had to set it for homework. She did not stop using the strategies. The problem was that not all groups could report because of time constraints. To rectify this, she tried to change the way in which the learners reported each day. Learners who did not report one day were then supposed to be the first

group to report the next day. During discussions, she did not have any discipline problems because her learners tried not to talk at the same time as other students. Instead, students were listening to colleagues and then answering one after the other.

At the end of the 12-week period, the CLES was administered again to students as a posttest. The results for the differences between pretest and posttest scores on the CLES are reported in Table 4.8 and presented graphically in Figure 4.5. Figure 4.5 also includes the initial preferred scores on the CLES that were presented in Figure 4.3. The results for *t* tests for paired samples (reported in Table 4.8) indicate a statistically significant ($p<0.01$) improvement on student scores for all four CLES scales. The effect size for pre-post differences for Teacher 2 range between 0.44 and 1.49, with students perceiving a more favourable learning environment on all four CLES scales. As with Teacher 1, the teacher's attempt to improve one of the learning environment scales was accompanied by an improvement in students' perceptions of all four scales. It would appear that the introduction of group work, during which students were encouraged to negotiate their answers and the way in which they solved problems, led students to feel that there was more Personal Relevance, Uncertainty and Shared Control in the classroom. Observations and interviews with learners and the teacher also support this finding. The learners indicated that they enjoyed the discussions that were generated during these group opportunities and that, since this strategy was introduced, they were experiencing greater enjoyment of mathematics.

Table 4.8 Average Item Mean, Average Item Standard Deviation and Difference (Effect Size and *T* Test Results) between Pretest and Posttest Scores on each CLES Scale for the Individual as the Unit of Analysis for Teacher 2

CLES Scale	Unit of Analysis	Average Item Mean		Average Item Standard Deviation		Difference	
		Pretest	Posttest	Pretest	Posttest	Effect Size	*t*
Personal Relevance	Individual	3.64	3.91	0.67	0.56	0.44	3.71**
Uncertainty	Individual	2.85	3.47	0.78	0.69	0.84	4.28**
Shared Control	Individual	2.56	3.40	0.82	0.69	1.11	5.38**
Student Negotiation	Individual	2.35	3.59	0.98	0.68	1.49	5.95**

**$p<0.01$ The sample consisted of 56 students in Teacher 2's class.

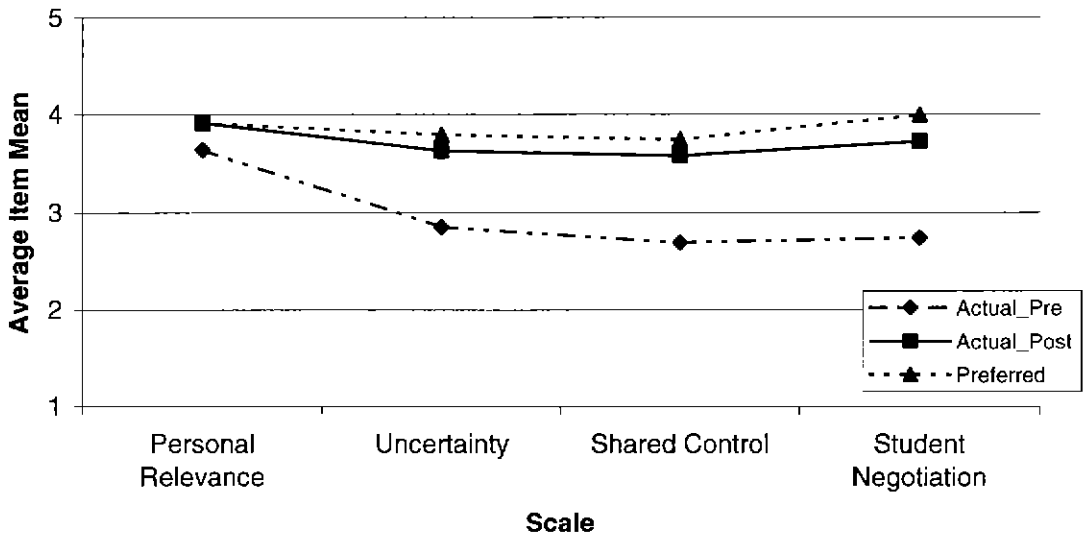


Figure 4.5 Average Item Mean for Students' Actual Pretest, Actual Posttest and Preferred Scores on the CLES for Teacher 2

In many ways, the results for the two teachers are similar. In both cases, there were sizeable pre-post changes in test scores, not only for the scale for which they were attempting to increase emphasis, but also for the other three CLES scales. The similarity in the pattern of changes could be attributed to

the strategies employed by the teachers, as both involved the introduction of group work and discussions in their mathematics classes. It is interesting to note that, in both cases, the posttest actual scores are close to what students would prefer to happen in their mathematics classes.

4.6 USING JOURNALS AS A TOOL FOR REFLECTION

A further aim of the study was to explore whether the use of journals is a useful tool for helping teachers in their bid to improve the learning environment. The fifth research question asks:

> How successful is the use of journals as a means of encouraging teachers to reflect on their teaching strategies and improve their learning environments?

Throughout the 12-week intervention period, the two teachers were asked to keep a daily journal in which they wrote about and reflected upon strategies that they were implementing in their classrooms. The teachers used the journals to reflect on issues such as: "Today I failed to allow the freedom that would allow my learners to ask me questions freely. I must see to it that I practice having a healthy classroom atmosphere that allows the learners to express themselves freely." In most cases, the teachers wrote about issues with which they were confronted, such as: "Today I failed to facilitate a group discussion because learners seemed to be talking and discussing irrelevant things instead of the geometric figures which were given to them." The teacher then wrote about a strategy that could be used to overcome this issue in the next lesson. "The solution that I will use to try to guard against

irrelevant discussions during group work is to have worksheets prepared for the different groups."

Teacher 2, who experienced difficulty with time management, wrote: "How can I control the time so that, at the end, I am able to say that my learners have completed this section of the syllabus?" This is a problem that was experienced by the two teachers because, when inspectors visit the school, they would expect to see exercises written by the students and the scope of the syllabus that had been covered. To address the problem, the teacher wrote: "The solution is that, as the group talks, they must write (with the scriber keeping one record for the whole group). This will involve group assessment and the allocation of marks."

Interviews were conducted with both of the teachers to determine whether they felt that the use of journals was advantageous. When asked whether they felt that the journals had helped them to improve their professional skills, the teachers generally agreed. One teacher stated: "Writing a journal is like doing lesson preparation in a reflective way because you are writing about what happened, and you are being introspective about all that you did during the lesson and, as well, you think about what could be done in the following lesson." The other teacher responded: "I know that I have improved because I am no longer teaching in the same way that I was taught at the teachers' college. I allow my learners to talk amongst themselves, to ask me questions and to assess themselves in their groups. I am also not feeling challenged when learners ask questions."

Both of the teachers agreed that the use of journals was useful, although they both complained that it was time consuming. Generally they felt that they did not appreciate the value of journal writing, just as they did not truly appreciate the importance of daily lesson preparations, feeling that they were too time consuming. Both of the teachers were already pressed for time with more than 40 learners whose work they needed to mark and report on. Throughout the intervention period, the teachers required constant support and encouragement from the researcher to make entries into and use the journals.

It would appear that, despite the reluctance to write the journals, journal writing did help to keep the teachers on track and to think about possible solutions. With respect to the use of journals as a means of reflection to encourage these teachers to change their teaching practice, the findings tentatively suggest that, whilst teachers were reluctant to use their journals at the beginning of the study because of the additional work that was required, they did find them useful in guiding their reflection and in helping them to successfully plan future lessons and activities.

4.7 SUMMARY

This chapter reported the results of this study into ways in which mathematics teachers can use feedback information from the Constructivist Learning Environment Survey (CLES) to improve their teaching and learning practice through action research and reflection. In the first phase of the study,

the main data-gathering instrument was the CLES, which was administered to 1864 students in 43 classes.

Various analyses of the CLES data supported its suitability for use in South African classrooms in both its actual and preferred versions. The factor loadings for the sample of 1864 learners from the 34 classes in six schools supported a 24-item four-scale structure for the CLES.

For the actual version of CLES, the scale reliability estimates ranged from 0.60 to 0.63 using the individual as the unit of analysis, and from 0.88 to 0.91 using the class mean as unit of analysis. The scale reliability estimates of the preferred version ranged between 0.56 and 0.97 at both the individual and class mean levels of analysis. When the mean correlation of a scale with other scales was used as a convenient index of discriminant validity, the values for the discriminant validity could be regarded as small enough to confirm that each scale generally measures distinct aspects of the classroom learning environment. Also the actual form of one CLES scale was able to differentiate between the perceptions of students in different classrooms.

Simple and multiple correlation analyses were conducted to investigate associations between student attitudes and the four CLES scales. The results of the simple correlation analysis indicated that all four of the CLES scales were statistically significantly ($p<0.05$) associated with student attitudes towards their mathematics class at both the individual and class mean levels of analysis. The multiple correlation for the set of four CLES scales was statistically significant ($p<0.05$) at both the individual and class

mean level of analysis. The standardised regression weights suggest that, with the individual as the unit of analysis, the two CLES scales of Uncertainty and Student Negotiation were significantly ($p<0.01$), positively and independently related to student attitudes. When using the class mean as the unit of analysis, the Uncertainty scale was a positive and significant ($p<0.05$) independent predictor of student attitudes. These patterns of associations are generally consistent with past research (Fraser, 1998a).

The use of MANOVA showed a statistically significant difference ($p<0.01$) between students' actual and the preferred scores for each of the four learning environment scales for both units of analysis. The large effect sizes (ranging between approximately one standard deviation (1.15) and one and three quarters standard deviations (1.85) with the individual as the unit of analysis, and between approximately two standard deviations (2.32) and four standard deviations (3.97) with the class mean as the unit of analysis) suggest that there is an educationally significant difference between students' perceptions of the actual and the preferred environment.

The second phase of the study examined whether teachers were are able to to make use of feedback provided through learners' responses to the CLES to improve their constructivist learning environments. The results reported in this chapter indicates that teachers were able to use feedback from the CLES to design teaching strategies that were successful in improving the level of one of the CLES dimensions. Teacher 1 used the following two strategies: discussing the importance of mathematics to learners' futures; and making problems more relevant to learners' daily lives. Teacher 2 planned to work on

strategies to improve the level of Student Negotiation in the classroom. She decided to facilitate discussions between learners and to arrange desks into groups. Her strategies made her aware that, if a group of learners do not have enough resource materials or worksheets, they are likely to resort to making more uncontrolled noise.

The results of the pre-posttest changes indicate that both teachers were successful in improving student scores on the CLES. In both cases there was a statistically significant ($p<0.01$) and positive difference on the pretest and posttest scores. For both teachers, the posttest actual scores are close to what the students would prefer to happen in their classes.

Over a 12-week intervention, the researcher supported the teachers with journal writing and its interpretation as they maintained daily records of their teaching in a reflective way. In these journals, the teachers recorded their problems and possible solutions. The results of the study indicated that the use of journals helped the teachers to keep on track and to think about possible solutions to problems, as well as encouraging them to reflect and plan future activities. Although both teachers complained that journal writing consumed a lot of time, they still valued the use of journal writing and felt that the journals were advantageous. Thus this study supports the usefulness of introducing journal writing in teaching and learning situations.

The results of the study support the efficacy of using the Constructivist Learning Environment Survey to provide feedback that can guide teachers in changing their classroom towards a more constructivist orientation. The

results of this study are consistent with past researches that have used learning environment instruments to improve the learning environment (Sinclair & Fraser, 2002; Yarrow, Millwater & Fraser, 1997).

The next chapter provides a discussion of the results and concludes the thesis.

Chapter 5

Discussion and Conclusions

5.1 INTRODUCTION

The present study examined ways in which mathematics teachers can improve their teaching and learning practice through action research and reflection. The initial phase of the study involved the large-scale collection of quantitative data using the Constructivist Learning Environment Survey (CLES) and attitude scale. Data collected from a sample of 1864 students in 34 classes was analysed to provide information about the reliability and validity of the CLES when used in South Africa and about associations between students' perceptions of the learning environment and their attitudes towards mathematics. In the second phase of the study, two teachers used students' perceptions of the learning environment, provided through their scores on the CLES, to assist them to monitor and increase the extent to which constructivist practices were used in their classrooms. This chapter summarises the study (Section 5.1) and discusses its implications (Section 5.2), limitations (Section 5.3) and importance (Section 5.4). Finally, this chapter makes recommendations for future research (Section 5.5).

5.1 SUMMARY OF THESIS

Since 1994, the old south African curriculum, under which Blacks, Indians, Coloureds and White students studied different curricula, is gradually being replaced by Curriculum 2005. The methods employed in Curriculum 2005 are learner-centred and emphasise a shift from the traditional approach to a more constructivist approach.

Constructivist theory acknowledges that the teacher is not a transmitter of knowledge, but rather a facilitator and provider of experiences from which learners will learn. Curriculum 2005 advocates the use of constructivist teaching methods to ensure a more learner-centred classroom (Department of Education, 1997b).

This study examined how a large sample of learners in South Africa perceived the constructivist orientation of the mathematics classroom, as well as how two mathematics teachers transform their classrooms from ones that are more traditional and teacher-centred, towards ones that include teaching methods that reflect a more constructivist notion of teaching. It was felt that the Constructivist Learning Environment Survey (CLES; Taylor, Dawson & Fraser, 1995; Taylor & Fraser, 1991; Taylor, Fraser & Fisher, 1997) had potential for monitoring the development of social constructivist classroom learning environments in South Africa.

The Constructivist Learning Environment Survey (CLES) was originally developed in 1991 to help teachers to monitor transformation of their teaching from more teacher-centred approaches to more constructivist teaching approaches (Taylor, Dawson & Fraser, 1995; Taylor & Fraser, 1991; Taylor, Fraser & Fisher, 1997). The original version of the CLES was designed to assess students' perceptions of five dimensions of their classroom, namely, Personal Relevance, Uncertainty, Student Negotiation, Shared Control and Critical Voice.

The CLES has been found to be valid and reliable in a number of studies undertaken in non-Western countries including Taiwan (Aldridge, Taylor, Chen & Fraser, 2000), Korea (Kim, Fisher & Fraser, 1999) and Nigeria (Idiris & Fraser, 1997). In each of these studies, the CLES was found to be convenient for monitoring the development of the constructivist approach in classrooms. The CLES was considered an ideal instrument for the purpose of the present study as the new South African curriculum, Curriculum 2005, espouses the constructivist notion of teaching. Its modification and validation in the South African context could provide a useful tool to teachers in the future.

Careful modification and pilot testing of the Constructivist Learning Environment Survey (CLES; developed originally in the West) ensured its suitability for use in mathematics classrooms in South Africa. Data were collected from 1864 learners in 34 classes in six schools. The schools that were selected for this

study were sampled from rural, semi-rural and urban areas in the Capricorn region of the Limpopo Province.

The data were analysed to answer the first research question:

> Is it possible to modify and validate an actual and a preferred version of the Constructivist Learning Environment Survey (CLES) for use at intermediate and senior phases of schooling in South Africa?

The modification and validation of a preferred and an actual version of the CLES for use in intermediate and senior phases of schools in South Africa is a major contribution of the study. The CLES has the potential to be used to monitor the development of constructivist learning environments and to assist teachers to improve their learning environments.

Analyses of data collected from 1864 learners in 34 classes in six schools supported the factor structure, internal consistency reliability (Cronbach alpha coefficient), and discriminant validity of the CLES, as well as the instrument's ability to differentiate between classes. The results indicate that the Constructivist Learning Environment Survey displays similar reliability and validity in South Africa as in other studies in countries such as the US (Dryden & Fraser, 1998; Johnson & McClure, 2002), Korea (Kim, Fisher & Fraser, 1999), Australia and Taiwan (Aldridge, Fraser, Taylor & Chen, 2000) and Nigeria (Idiris & Fraser, 1997) These results suggest that the researcher and teachers can be

confident about using the modified version of the CLES in mathematics classes in South Africa in the future.

In addition to the CLES, an attitude scale was also modified and used to permit investigation of associations between the constructivist nature of the learning environment and students' attitudes towards their mathematics classrooms. The data collected from 1864 learners in 34 classes suggested that this scale has satisfactory internal consistency reliability at both the individual and class mean levels of analysis.

The data collected using the CLES and an attitude scale were analysed to examine the second research question:

> Do associations exist between learners' perceptions of the constructivist orientation of the learning environment and their attitudes towards their mathematics classroom?

To examine whether associations exist between learners' attitudes towards their mathematics class and their perceptions of the learning environment, simple correlation and multiple regression analyses were conducted. To identify which of the CLES scales contributed most to variance in learner attitudes, standardised regression weights were examined. The results were consistent with past research (Kim, Fisher & Fraser, 1999; Lee & Fraser, 2001) indicating that student attitudes were associated with more emphasis on all four CLES scales. Two scales, Uncertainty and Student Negotiation, were found to

contribute most to variance in student attitudes in mathematics classes in South Africa when the other CLES scales were mutually controlled.

Descriptive analysis was used to provide information about the constructivist nature of mathematics classes in the Limpopo Province of South Africa to answer the third research question:

> Is it possible to describe the learning environment of individual mathematics classrooms using the CLES in South African schools?

The results indicate that students would prefer a learning environment that is more positive than the one that they perceive as being present for all four CLES scales. These results are consistent with previous research in several other countries (Aldridge & Fraser, 2000; Fraser, 2002; Goh & Khine, 2002), but indicate unusually large effect sizes.

Descriptive information related to students' perceptions of the actual and the preferred learning environments was provided to the teachers who participated in the study. Two teachers, who were especially keen to attempt to improve their students' perceptions of the constructivist orientation of their learning environments, were selected as case studies to help to answer the fourth research question:

> Are teachers able to make use of student responses to the CLES to develop and implement strategies that improve students' perceptions of the constructivist learning environment?

Both of the teachers were provided with a graphical profile depicting their students' perceptions of their actual and preferred learning environment (based on student scores on the CLES). These profiles were used by the teachers to select a CLES dimension that they would like to attempt to improve and to develop strategies that would assist them to do so. One teacher selected the Personal Relevance scale and the other selected the Student Negotiation scale. They each implemented a range of strategies aimed at improving the degree of constructivism in their mathematics classrooms. Using a journal, teachers recorded their attempts to improve the degree of constructivism, the problems that were encountered and the strategies that were used to overcome these problems. Records in journals and continuous discussions with the teacher forced and motivated them to keep on track and to be thorough in their preparations for their daily lessons. Continuous support from the researcher ensured that teachers persisted with their attempts over the 12-week intervention period.

At the end of this period, the actual version of the CLES was re-administered to students to determine whether changes had taken place. It would appear that, in both cases, the teachers introduced small-group settings in which students were encouraged to discuss ideas and report findings. To improve student scores on the selected CLES scales, the teachers introduced other strategies specific to those scales. In both cases, a comparison of pretest and posttest scores indicated a notable improvement in students' perceptions on all four CLES scales during the intervention period. It is felt that the dramatic improvements in

students' scores on the CLES during the intervention period were due, largely, to the introduction of small-group work during which students were involved in student-centred activities that encouraged discussion and negotiation.

This study provides an example of how teachers can use feedback from the CLES to promote reflective practice and help them to become researchers within their own classrooms, thus providing them with skills for improving their teaching in the future. The use of journals as a means of recording teachers' experiences would also appear to be an effective means of encouraging teachers to reflect on their teaching. Using an action research cycle that incorporated the use of a journal, the two teachers both achieved sizeable changes in their CLES scores as they incorporated more constructivist methods.

5.2 PRACTICAL IMPLICATIONS OF THE STUDY

The findings of this study suggest that learners in the Limpopo province of South Africa would prefer a more constructivist learning environment than that which they presently experience in classrooms. This implies that mathematics teachers and professional curriculum advisers could need to consider how changes in classroom environment might be effected to accommodate this.

The findings of the present study suggest strong associations between the learning environment and students' attitudes towards their mathematics class. These positive associations between student attitudes and dimensions of the

CLES suggest practical ways in which the learning environment might be changed to enhance student attitudes.

Despite large class sizes and a lack of material resources, the two case study teachers involved in the present study were able to introduce more constructivist teaching methods in their mathematics classrooms. Through reflective practice and action research, they were able to bring about effective change. The effective use of journal writing during their attempts to change the learning environment were found to be useful tools in terms of reflection and planning. Educators and curriculum advisors should consider these results and utilise the technique for changing classroom practice.

The success of using feedback from the CLES as a means of monitoring and improving classroom practice implies that perhaps it could be usefully included as a topic in the inservice curriculum. The CLES could be used as a tool during inservice teacher training to guide and monitor teachers' introduction of more constructivist learning environments.

5.3 LIMITATIONS TO THE STUDY

Although the sample size for questionnaire administration was large (N=1864), the study was limited to only one province within South Africa. It is difficult, therefore, to generalise the results of the study to other areas outside of the Limpopo Province. As the present study included students from intermediate

and senior phases of schooling only, it also is difficult to generalise the findings to other grade levels.

Because of the scope of this professional doctorate, which combined quantitative and qualitative methods, it was only possible to include two case study teachers. A larger case study sample would have provided more confidence in the generalisability of the promising findings that emerged with these two teachers. Also, the small sample sizes included in the case studies make the results of the significance tests less dependable.

A further limitation of the study is the limited scope in terms of student outcomes, which included only one student attitude measure. In particular, the absence of any achievement outcome can be seen as a limitation.

In the researcher's experience, teachers who have taught for a number of years often resort to their old ways of teaching rather than continuing with new strategies. Throughout the case studies, the researcher was close at hand to encourage teachers to keep trying and it is felt that this contributed to the teachers' success. Although not possible within the timeframe of the present study, it would be interesting to visit the classes of these teachers in the future to ascertain whether or not they continue to use the teaching strategies that they implemented during the 12-week intervention period.

5.4 RECOMMENDATIONS FOR FUTURE RESEARCH

It is recommended that this promising study, as one of the first learning environment studies in South Africa, be used as a springboard for more learning environment research for a variety of purposes in South Africa. Future research could tap into the wealth of instruments that have been developed.

An important contribution of this study is that it supported the validity, reliability and usefulness of the CLES when used for the first time in South Africa with a particular sample of secondary-school mathematics in the Limpopo Province. In future research in South Africa, it will be important to cross-validate the CLES and further explore its usefulness with other samples, at other grade levels and in other provinces.

In terms of validating the CLES in future studies, researchers take into consideration that the factors of the CLES are related and therefore use principal axis factor analysis with an oblique rotation rather than the more commonly used principal components factor analysis with varimax rotation. Furthermore, it would be desirable in future validation studies involving the CLES in South Africa to use confirmatory factor analysis techniques, which have shown considerable promise in recent learning environment studies by Johnson and Stevens (2001) and Dorman (in press).

The results reported in Section 4.2.1 suggest that the two negatively worded items of the CLES (Items 6 and 7) are problematic for the preferred version. When the factor analysis of the preferred version was run unconstrained, five factors emerged, four of which corresponded to the four *a priori* factors and a fifth factor made up of the two negatively worded items. Barnette (2000) questions the utility of negatively-worded items, as they cannot be considered direct opposites of their positively worded counterparts. It would be appropriate in future studies to consider the potential problems in using negatively worded items and to ensure that all of the items of the CLES have a positive scoring direction.

Whilst insights gleaned from this study are educationally important in their own right, it is essential that the study be extended. It is recommended therefore that future studies examine whether the findings of the present study can be generalised to other provinces within South Africa by including more grade levels and other provinces. It is suggest also that future studies include outcomes beyond student attitudes, such as academic achievement and academic efficacy.

The present study made use of two case study teachers to examine the usefulness of using the CLES as a means of monitoring and guiding change in their teaching practices. It would be useful to examine whether other teachers with a range of backgrounds and amounts of experience also would be able to

use the information as effectively as these case study teachers. Future studies could include more teachers from a range of areas and provinces.

Currently, most teachers in South Africa are more comfortable with teaching methods that favour more teacher-centred practices. In many cases, teachers are unfamiliar with constructivist teaching approaches and their classes usually reflect this. With the introduction of Curriculum 2005, which espouses the use of more student-centred approaches, it is important to look for ways that will assist teachers to move away from their old methods of teaching. The second phase of the present research examined one way in which teachers might transform and monitor there teaching. Future studies could investigate further the use of teacher action research, using a learning environment instrument as the catalyst for change.

With the introduction of Curriculum 2005, large numbers of teachers are being expected to change their teaching practices. Future studies could examine the effectiveness of inservice training courses, organised to help teachers to move to more constructivist teaching methods, when they incorporate the use of the CLES as a means for encouraging and facilitating reflection.

5.5 EDUCATIONAL IMPORTANCE OF THE STUDY

An important methodological contribution of the present study is the development and validation of an actual and preferred version of the

Constructivist Learning Environment Survey (CLES) that can be used to assist researchers and teachers to monitor their classroom learning environments in South Africa. The present study involved the use of the CLES for the first time in South Africa. The large sample size involved in the present study (N=1864) enabled the researcher to provide important information regarding the reliability and validity of the CLES when used in South Africa. The reliability and factorial validity was found to be similar to other countries including Taiwan and Australia (Aldridge, Taylor, Fraser & Chen, 2000; Taylor, Fraser & Fisher, 1997), USA (Dryden & Fraser, 1996, 1998; Johnson & McClure, 2002) Brunei (Khine & Fisher, 2002), Korea (Kim, Fisher & Fraser, 1999) and Nigeria (Idiris & Fraser, 1997).

Students' attitudes towards mathematics are likely to influence their participation in this subject in the future. The findings of the study indicate strong positive associations between students' attitudes and the constructivist orientation of the learning environment. These associations provide ideas about how teachers might change the learning environment to improve students' attitudes towards mathematics.

Changes to the education system in South Africa, brought about by the introduction of Curriculum 2005, has meant that teachers are required to use more student-centred strategies in their classrooms. Curriculum 2005 embraces a more constructivist view of teaching than previously prevailed in South Africa.

The results of the study tentatively indicate that the CLES can be used to monitor the implementation of ideas embedded within Curriculum 2005.

In line with the practical implications outlined in Section 5.2, the study suggests that, by using the CLES as a tool for reflection, teachers can be encouraged to make changes to their teaching practice. More importantly, the use of the CLES in conjunction with journals and an action research cycle, provides teachers with the skills to be reflective practitioners and researchers within their own classrooms. As such, teachers are given the means to improve their teaching in the future.

The results of the study indicate that teachers' use of journals as a means of reflection enabled them to see the changes they are making on daily basis. Such reflections also were found to assist teachers with their daily preparations. Even though the use of journal writing adds to the already heavy load of teachers, this study suggest the value of journal writing to teacher educators and curriculum advisors as an important tool to assist with facilitating change to teaching practice.

Overall, the findings of the present study are educationally important and have the potential to guide curriculum advisers and teacher educators in the organisation and running of inservice training courses to teachers in the field of mathematics. Because many teachers in South Africa are unfamiliar with constructivist teaching methods, the use of the CLES, in conjunction with action

research, provides one promising mean by which they can monitor and implement changes to their teaching practice.

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Appendix A

Constructivist Learning Environment Survey (CLES)
(Actual Form)

Name: _____ School: _____ Grade: _____

Sex: Male/Female Teacher's Name: _____

Instructions

This questionnaire contains statement about practices that could take place in your classroom. You are asked how often each practice (activity) takes place.

There are no "right" or "wrong" answers. Your opinion is what is wanted. Think about how each statement describes what this class is like for you. Mark *a Cross* or *Draw a circle* around your correct choice.

Mark *a Cross* or *Draw a circle* around your correct choice:

1 if the practice takes place **Almost Never.**

2 if the practice takes place **Seldom.**

3 if the practice takes place **Sometimes.**

4 if the practice takes place **Often.**

5 if the practice takes place **Almost Always.**

Be sure to give answers for all the questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar statements. Don't worry about this. Simply give your opinion about all of the statements.

Practice Example:

Suppose you were given the statement, "I would choose my partners for group discussions." You need to decide whether you would choose your partner *'Almost Always', 'Often', 'Sometimes', 'Seldom', or 'Almost Never'*. If you select 'Often' then you would circle the number 4 on your questionnaire.

Learning about the world	Almost Never	Seldom	Some times	Often	Almost Always
In my mathematics class ...					
I learn about the world outside of school.	1	2	3	4	5
My new learning starts with problems about the world outside of school.	1	2	3	4	5
I learn how mathematics can be part of my out-of-school life.	1	2	3	4	5
I get a better understanding of the world outside of school.	1	2	3	4	5
I learn interesting things about the world outside of school.	1	2	3	4	5
What I learn has nothing to do with my out-of-school	1	2	3	4	5
Learning about mathematics	Almost Never	Seldom	Some times	Often	Almost Always
In my mathematics class					
I learn that mathematics cannot provide perfect answers to problems.	1	2	3	4	5
I learn that mathematics has changed over time.	1	2	3	4	5
I learn that mathematics is influenced by people's values and opinions.	1	2	3	4	5
I learn about the different mathematics used by people in other cultures.	1	2	3	4	5
I learn that modern mathematics is different from the mathematics of long ago.	1	2	3	4	5
I learn that mathematics is about creating theories.	1	2	3	4	5
Learning to learn	Almost Never	Seldom	Some-times	Often	Almost Always
In my mathematics class ...					
I help the teacher to plan what I am going to learn.	1	2	3	4	5
I help the teacher to decide how I am learning.	1	2	3	4	5
I help the teacher to decide which activities are best for me.	1	2	3	4	5
I help the teacher to decide how much time I spend on activities.	1	2	3	4	5
I help the teacher to decide which activities I do.	1	2	3	4	5
I help the teacher to assess my learning	1	2	3	4	5
Learning to communicate	Almost Never	Seldom	Some times	Often	Almost Always
In my mathematics class ...					
I get the chance to talk to other learners.	1	2	3	4	5
I talk with other learners about how to solve problems.	1	2	3	4	5
I explain my understanding to other learners.	1	2	3	4	5
I ask other learners to explain their thoughts.	1	2	3	4	5
Other learners ask me to explain my ideas.	1	2	3	4	5
Other learners explain their ideas to me.	1	2	3	4	5

Appendix B

Constructivist Learning Environment Survey (CLES)
(Preferred Form)

Name: _____ School: _____ Grade: _____

Sex: Male/Female Teacher's Name: _____

Instructions to learners

This questionnaire contains statement about practices which could take place in your classroom. You are asked how often each practice (activity) takes place.

There are no "right" or "wrong" answers. Your opinion is what is wanted. Think about how each statement describes what this class is like for you. Mark *a Cross* or *Draw a circle* around your correct choice.

Mark *a Cross* or *Draw a circle* around your correct choice:

1 if the practice takes place **Almost Never.**

2 if the practice takes place **Seldom.**

3 if the practice takes place **Sometimes.**

4 if the practice takes place **Often.**

5 if the practice takes place **Almost Always.**

Be sure to give answers for all the questions. If you change your mind-about an answer, just cross it out and circle another.

Some statement in this questionnaire are fairly similar statements. Don't worry about this. Simply give your opinion about all the statement.

Practice Example:

Suppose you were given the statement, "I would choose my partners for group discussions." You need to decide whether you would choose your partner *'Almost Always', 'Often', 'Sometimes', 'Seldom', or 'Almost Never'*. If you select 'Often' then you would circle or cross the number 4 on your questionnaire.

Learning about the world	Almost Never	Seldom	Some times	Often	Almost Always
In my ideal mathematics class ...					
I would learn about the world outside of school.	1	2	3	4	5
My new learning would start with problems about the world outside of school.	1	2	3	4	5
I would learn how mathematics can be part of my out-of-school life.	1	2	3	4	5
I would get a better understanding of the world outside of school.	1	2	3	4	5
I would learn interesting things about the world outside of school.	1	2	3	4	5
What I learn would have nothing to do with my out-of-school	1	2	3	4	5
Learning about mathematics	Almost Never	Seldom	Some times	Often	Almost Always
In my ideal mathematics class ...					
I would learn that mathematics cannot provide perfect answers to problems.	1	2	3	4	5
I would learn that mathematics has changed over time.	1	2	3	4	5
I would learn that mathematics is influenced by people's values and opinions.	1	2	3	4	5
I would learn about the different mathematics used by people in other cultures.	1	2	3	4	5
I would learn that modern mathematics is different from the mathematics of long ago.	1	2	3	4	5
I would learn that mathematics is about creating theories	1	2	3	4	5
Learning to learn	Almost Never	Seldom	Some times	Often	Almost Always
In my ideal mathematics class ...					
I would help the teacher to plan what I am going to learn.	1	2	3	4	5
I would help the teacher to decide how I am learning.	1	2	3	4	5
I would help the teacher to decide which activities are best for me.	1	2	3	4	5
I would help the teacher to decide how much time I spend on activities.	1	2	3	4	5
I would help the teacher to decide which activities I do.	1	2	3	4	5
I would help the teacher to assess my learning	1	2	3	4	5
Learning to communicate	Almost Never	Seldom	Some times	Often	Almost Always
In my ideal mathematics class ...					
I would get the chance to talk to other learners.	1	2	3	4	5
I would talk with other learners about how to solve problems.	1	2	3	4	5
I would explain my understanding to other learners.	1	2	3	4	5
I would ask other learners to explain their thoughts.	1	2	3	4	5
Other learners would ask me to explain my ideas.	1	2	3	4	5
Other learners would explain their ideas to me.	1	2	3	4	5

Appendix C

Student Attitude Scale

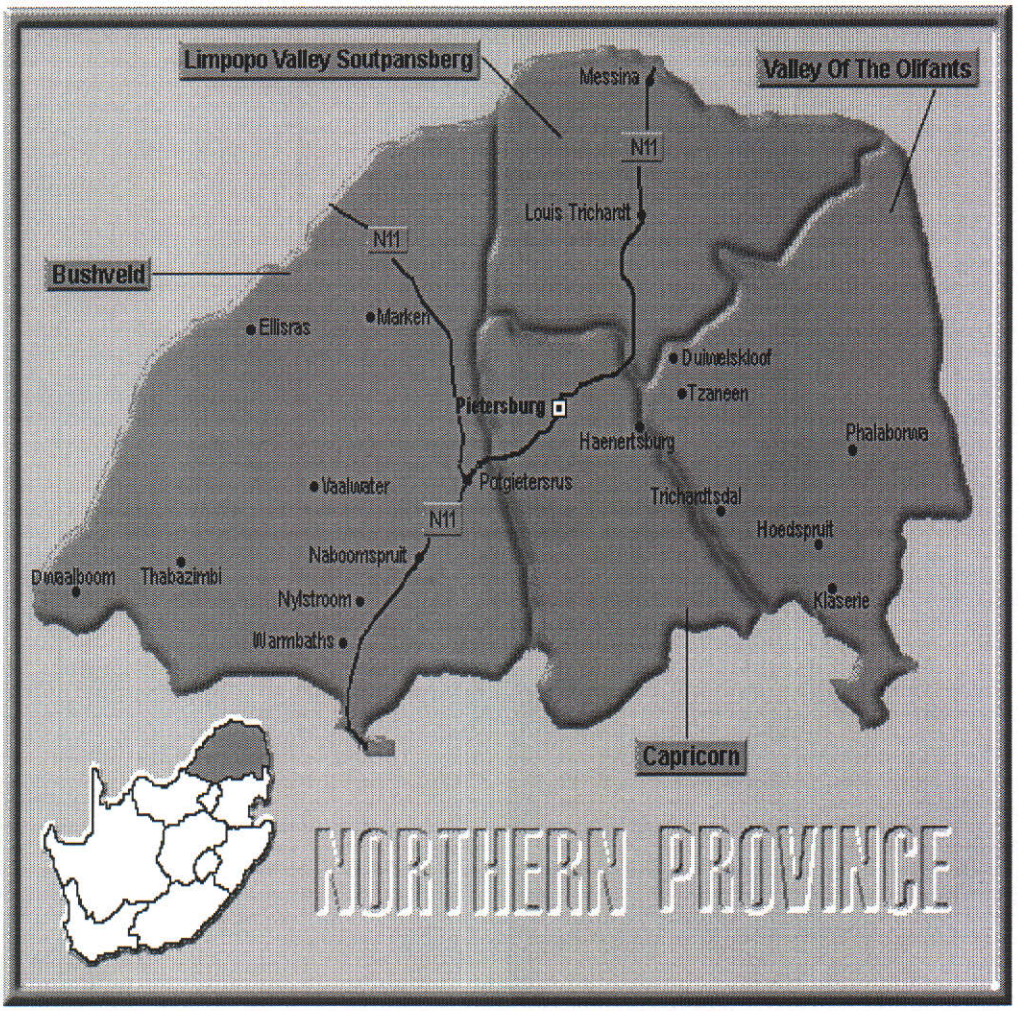
	Almost Never	Seldom	Some times	Often	Almost Always
I look forward to mathematics lessons.	1	2	3	4	5
Mathematics lessons are fun.	1	2	3	4	5
I dislike mathematics lessons.	1	2	3	4	5
Mathematics lessons bore me	1	2	3	4	5
Mathematics is one of the most interesting subjects.	1	2	3	4	5
I enjoy mathematics lessons.	1	2	3	4	5
Mathematics lessons are a waste of time.	1	2	3	4	5
Mathematics lessons make me interested.	1	2	3	4	5

Appendix D

Map of South Africa

Appendix E

Map of Limpopo Province



Appendix F

Factor Loadings for a Modified Version of Actual Form of the CLES in South Africa using Principal Axis Factoring with Oblique Rotation

Item No.	Factor Loadings			
	Personal Relevance	Uncertainty	Shared Control	Student Negotiation
1	–			
2	-0.49			
3	-0.46			
4	-0.54			
5	-0.52			
6	–			
7		–		
8		0.48		
9		0.41		
10		0.41		
11		0.49		
12		0.45		
13			0.43	
14			0.49	
15			0.49	
16			0.50	
17			0.51	
18			0.42	
25				-0.50
26				-0.53
27				-0.53
28				-0.43
29				-0.53
30				-0.40
% Variance	1.55	14.92	3.01	3.45
Eigenvalue	1.14	4.34	1.48	1.60

Factor loadings smaller than 0.30 have been omitted.
The sample consisted of 1864 students in 34 classes in South Africa.

Appendix G

Factor Loadings for Five Factors for a Modified Version of Preferred Form of the CLES in South Africa

Item No.	Factor Loadings				
	Personal Relevance	Uncertainty	Student Control	Student Negotiation	Factor 5
1	0.35				
2	0.32				
3	0.31				
4	0.58				
5	0.41				
6					0.48
7					0.55
8		0.42			
9		0.47			
10		0.37			
11		0.48			
12		0.44			
13			0.52		
14			0.58		
15			0.60		
16			0.60		
17			0.59		
18			0.45		
25				0.47	
26				0.55	
27				0.60	
28				0.60	
29				0.59	
30				0.72	
% Variance	4.42	6.08	9.27	8.93	3.02
Eigenvalue	1.15	1.46	5.34	2.14	0.98

Factor loadings smaller than 0.30 have been omitted.
The sample consisted of 1864 students in 34 classes in South Africa.