Implementation of Social Constructivist Learning Environments in Grade 9 Natural Science in the Western Cape Province, South Africa

by

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DECLARATION

The thesis *Implementation of Social Constructivist Learning Environments in Grade 9 Natural Science in the Western Cape Province, South Africa* 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

This study monitored the transformation of Grade 9 Natural Science classrooms toward social constructivist learning environments in three contexts described by socio-economic status (SES) (i.e., high, medium and low SES). The study further assessed the influence of social constructivist learning environments on three key student outcomes, namely, students' attitude toward science, achievement and gender equity.

The present study employed a mixed-method approach, which took place in two main sequential data collection phases, namely, the quantitative data collection phase (QUAN) and the qualitative data collection phase (qual). This contemporary approach was employed to triangulate the quantitative data with the qualitative data, in order to provide credible and trustworthy answers to the following research questions, namely,

1) To what extent do teachers implement social constructivist-based learning environments, required by the revised *National Curriculum Statement*, in Grade 9 Natural Science classes?
2) Do different levels of congruence of students' experienced (i.e., actual) and preferred learning environments in selected Grade 9 classrooms occur and, if so, why?
3) Does the students' background, described in terms of their socio-economic status, influence their perceptions of their learning environment?
4) What is the influence of social constructivist-based learning environments in promoting student outcomes of attitude toward science, achievement, and gender equity in three socio-economic contexts?

For the QUAN phase, a newly developed instrument, the—*Social Constructivist Learning Environment Survey* (SCLES)—was developed. The questionnaire assessed students' perceptions of six aspects of the learning environment. Four of the aspects were assessed using dimensions that were adopted and adapted from past learning environment questionnaires (namely, *Scientific Investigations*, *Personal Relevance*, *Collaboration*, *Critical Voice* and *Uncertainty in Science*). Two dimensions were developed specifically for the present study in order to contextualize the questionnaire to the requirements of the new curriculum (namely, *Metacognition* and *Respect for Difference*). The student outcome, *Attitude toward Science*, was taken directly from one of the *Test of Science-Related Attitudes* (TOSRA), and an achievement test was developed to assess the skills related to the drawing of straight line graphs, as well as predicting from and interpreting information from a straight line graph.

After the pilot study of the questionnaire and subsequent modifications to it, data were collected from a random sample meticulously chosen to reflect the heterogenous nature of schools in the Western Cape Province. The sample was stratified according to the education districts that the schools were located in, and the SES of the schools. This method of selecting the sample—as recommended by Creswell (2003)—ensured a total random stratified sample of 1955 Grade 9 Natural Science students in one class in 52 schools representative of urban and public schools in the Western Cape Province, South Africa.

The results show, first, that SCLES and the *Attitude toward Science* scale were valid and reliable, suggesting that SCLES can be used with confidence in Grade 9 Natural Science classes. Second, in order to describe the 52 classes using SCLES, a one-way MANOVA and effect sizes showed that students preferred a more positive learning environment than the one that they presently perceived on all six SCLES scales. These results highlight educationally important differences between students' perceptions of the actual and preferred learning environments in classrooms. Third, students' perceptions were compared by SES using a one-way MANOVA, as well as a Tukey HSD *post hoc* test. These results highlight that SES is a factor that is influential in describing differences between students' actual and preferred learning environment, as well as *Attitude toward Science* and achievement. Fourth, associations between SCLES, and the three student outcomes were examined. The scale *Attitudes toward Science* and the achievement test were examined using simple correlation and multiple regression analyses, while gender equity was examined using one-way MANOVA for repeated measures. These results crucially suggest that in order for teachers to maximize the student outcomes, they should be sensitive to dimensions perceived as important by students in different SES contexts, as there is no 'one size fits all' approach to teaching in a social constructivist learning environment.

The study offers important implications and recommendations to teachers and policy-makers regarding social constructivist learning environments, as well as fruitful avenues for further research.

Keywords: Learning Environment Research, Social Constructivism, Socio-economic status, Natural Science, Grade 9, Western Cape Province

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LIST OF ABBREVIATIONS

AERA	American Educational and Research Association
ANOVA	Analysis Of Variance
C2005	Curriculum 2005
CES	Classroom Environment Scale
CLEQ	Cultural Learning Environment Questionnaire
CLES	Constructivist Learning Environment Survey
COLLES	Constructivist On-Line Learning Environment Survey
DoE	Department Of Education
EMDCs	Education, Management and Development Centres
GSMOS	General Studies Metacognitive Orientation Scale
HLM	Hierarchical Linear Modelling
HOD	Head of Department
HOTS	Higher Order Thinking Skills
HSD	Honestly Significant Difference test
ICEQ	Individualized Classroom Learning Environment Questionnaire
IKS	Indigenous Knowledge Systems
LEI	Learning Environment Inventory
LER	Learning Environment Research
MANOVA	Multiple Analysis of Variance
MC	Metropole Central
ME	Metropole East
MN	Metropole North
MOLES-S	Metacognitive Orientation Learning Environment Scale
MRI	Metacognition And Reflective Inquiry
MS	Metropole South

OBE	Outcomes-Based Education
PEI	Presidential Education Initiative
QTI	Questionnaire on Teacher Interaction
QUAL	Qualitative Data
QUAN	Quantitative Data
R	Multiple Correlation
rNCS	revised National Curriculum Statement
SACMEQ	Southern and Eastern African Consortium For Monitoring Educational Quality
SASA	South African Schools Act
SCLES	Social Constructivist Learning Environment Survey
SES	Socio-Economic Status
SGB	School Governing Body
SLEI	Science Laboratory Environment Inventory
TOSRA	Test of Science-Related Attitudes
TIMSS	Third International Mathematics and Science Study
TIMSS	Third International Mathematics and Science Study
TIMSS-R	Third International Mathematics and Science Study-Repeat
WCED	Western Cape Education Department
WES	Work Environment Scale
WIHIC	What Is Happening In the Classroom?
ZPD	Zone of Proximal Development

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MAP OF SOUTH AFRICA

Source: http://upload.wikimedia.org/wikipedia/commons/1/1e/Map_of_South_Africa_with_English_labels.svg

Chapter 1
GENERAL INTRODUCTION

This study monitored the transformation of Grade 9 Natural Science classrooms in the Western Cape Province, South Africa, toward social constructivist learning environments in three contexts described by socio-economic status (SES). The study drew on the field of learning environment research (LER) to capture students' perceptions of their classroom learning environment using a newly developed instrument, the *Social Constructivist Learning Environment Survey* (SCLES). In the sections that follow, the study is put into context.

Background and Rationale

In 1994, South Africa saw a significant breakthrough toward a non-racial and democratic society. This breakthrough required social changes to ensure that the country could cater for its people irrespective of race. Such a challenge necessitated a curriculum restructure, which resulted in *Curriculum 2005* (C2005) (Department of Education, 1997a), which, after many revisions, was re-named the revised *National Curriculum Statement* [rNCS] (DoE, 2002). The rNCS (Natural Science) (DoE, 2002) placed strong emphasis on social constructivist-based theories of learning in Natural Science classrooms. Consequently, teachers were to transform their classrooms toward social constructivist learning environments.

A social constructivist learning environment encourages students to construct knowledge in a social setting. Some teaching methods promoting this environment include collaboration (e.g., Roth, 2002), hands-on activity (e.g., Lebow, 1993), making knowledge personally relevant to students (e.g., Stears & Malcolm, 2005), investigations (e.g., Dunlap, 1999), and critically expressing students' opinions (e.g., Savery & Duffy, 2001), in an environment that encourages respect for each others' opinions. These methods should be facilitated by a teacher who encourages students to think beyond their current processes (e.g., Mayer, 1998). In doing so, the learning environment created by the teacher should promote important student outcomes, like students' attitude toward science, students' achievement scores, and enhance gender equity.

The present study was carried out in the Western Cape—one of the wealthiest provinces in South Africa. Nevertheless, schools in this province vary in quality, particularly with regard to the availability of resources, teacher quality, and student quality. Schools range from those that are well-resourced, to those that are under-resourced (i.e., no running water or electricity, an acute shortage of classrooms, etc.) (Fiske & Ladd, 2004); some teachers are highly qualified, while others are unqualified or under-qualified teachers[1] (particularly in science and mathematics and, as a result, many struggle with subject matter) (Arnott, Kubeka, Rice & Hall, 1997); and some students have well-developed foundational knowledge in school science, while others' are under-developed (Reeves, 1999). As a consequence, different contexts exist in schools. The variation in context is partly a result of Apartheid. During Apartheid, schools functioned to condition students for the hierachical roles they would assume as adults, based on race (Kallaway, 1984). The Apartheid system classified South Africans into four distinct racial categories, namely, African, Coloured, Indian and White (Fiske & Ladd, 2004). Africans, Coloureds and Indians were collectively referred to as the "non-white" or "Black",[2] whilst the rest of the population was referred to as "White". The racial classifications[3] were thus a means of differentiating individuals in terms of their rights and opportunities.

During Apartheid a strong connection between race and the nature and quality of children's education existed. Former White schools had access to high quality teachers and school facilities and therefore better quality schools, while school quality for Black students were inferior (Fiske & Ladd, 2004). Moreover, post-1994 studies (Fiske & Ladd, 2004 & 2005; Van den Berg & Burger, 2003; Van der Berg, 2007) suggest that this pattern of access to high quality schools still exists, but includes an small emerging Black middle-class who are also accessing the benefits of the schools (C. Soudien, personal communication, 22 August 2008). This suggests that in the South African context, race is being replaced by socio-economic class (SES)—defined by family income—as a primary determinant of who will go to schools with high quality teachers and school facilities (Fiske & Ladd, 2004). This demarcation of schools by SES lends itself to a societal description in the widely accepted correspondence theory of Bowles and Gintis (1976), who suggested that structures of school mimic structures of society. Similarly, in South Africa, schools mimic society, which implies that SES plays a fundamental role when assessing schooling.

In light of this, the present study intends to investigate the transformation of Grade 9 Natural Science classrooms in the Western Cape Province toward the social constructivist learning environments identified by the new South African curriculum. In order to accomplish this, an instrument to assess students' perceptions of their learning environment was developed and validated.

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[1] In South Africa, teachers are ranked according to a qualification scale. Those at the lowest level have a school-leaving certificate only—commonly referred to as unqualified teachers, while those with a school-leaving certificate, as well as three years of training, are under-qualified teachers (Arnott, Kubeka, Rice & Hall, 1997). During Apartheid, most under-qualified teachers were trained in low quality teacher training colleges (Fiske & Ladd, 2004).

[2] In this thesis, "Black" refers to individuals who—under Apartheid—were classified as African, Coloured or Indian.

[3] As described above, the racial classifications were oppressive social practices constructed during Apartheid. In the present study racial classifications were used for analytical purposes. It provides an essential background to the racial context during Apartheid, and gives an indication of how the country has progressed, and is still progressing toward a more racially equal society.

Problem Statement

Emphasis has been placed on the role of the teacher in establishing the social constructivist learning environments identified by the rNCS (DoE, 2002). Given this, the present study was conducted in order to monitor whether teachers implement social constructivist learning environments within Grade 9 Natural Science classrooms in the Western Cape Province, South Africa. The study further investigated whether social constructivist learning environments promote important student outcomes of students' attitude toward science, academic achievement and gender equity.

Aims and Objectives

The aim of this study is to describe, analyse and compare whether the social constructivist-based learning environments expected by current curricular reforms (DoE, 2002) are being achieved by teachers in the junior secondary phase (Grade 9) in three school settings in the Western Cape Province, South Africa. As associations between the learning environment and student outcomes have been demonstrated in previous research (e.g., Aldridge & Fraser, 2000; Fraser, 1998), a further aim is to investigate possible consequences of a social constructivist learning environment on a number of important student outcomes (i.e., attitude toward science, achievement and gender equity).

Objectives of the study with respect to the Western Cape Province are thus the following:

a) To develop and validate a questionnaire for monitoring social constructivist-based classroom learning environments in South Africa;
b) To describe the learning environment of Natural Science classes in both quantitative terms (using the questionnaire) and qualitative terms (using additional classroom observation and interview data);
c) To determine whether SES influences the classroom learning environment; and
d) To investigate whether social constructivist-based learning environments promote (i) students' attitude toward science, (ii) student academic achievement, and (iii) gender equity, in three socio-economic status contexts.

The study therefore sought to answer the following research questions in regard to the Western Cape Province:

1) To what extent do teachers implement social constructivist-based learning environments, required by the rNCS, in Grade 9 Natural Science classes? (Objectives a & b).
2) Do different levels of congruence of students' experienced (i.e., actual) and preferred learning environments in selected Grade 9 classrooms occur and, if so, why? (Objective b).
3) Does the students' background, described in terms of their socio-economic status, influence their perceptions of their learning environment? (Objective c).
4) What is the influence of social constructivist-based learning environments in promoting student outcomes of attitude toward science, achievement, and gender equity in three socio-economic contexts? (Objective d).

Clarification of terms

In this study, key concepts are defined as follows:

Constructivism

Constructivism is not a unified theory, but rather a conglomeration of different positions with varying emphases (Tynjala, 1999). As discussed in detail in Chapter 2 (page 19), there are many disagreements and criticisms about constructivism as a learning theory (Phillips, 1995). However, constructivists agree on five areas about learning, namely, that: (a) knowledge is constructed; (b) cognitive structures are activated in the process of construction; (c) these cognitive structures are constantly constructed and result in growth; (d) there is no external reality; and (e) acceptance of constructivist tenets leads to the adoption of constructivist pedagogy (Anderson and Piazza, 1996: 52). Each of these areas will be outlined in more detail in Chapter 2.

Revised National Curriculum Statement (rNCS)

Curriculum 2005 (C2005) was the new South African curriculum model introduced in 1998 which is competency-based (Taylor & Vinjevold, 1999). In 2000, C2005 was re-defined through the formulation of curriculum statements rNCS specific to each subject (DoE, 2002). Statements in the document express the skills, concepts and content that students are expected to have at each grade level (DoE, 2002). In the subject Natural Science the focus is to attain core skills and knowledge competencies through the attainment of three learning outcomes, that is, scientific investigations, constructing science knowledge and science, society and the environment.

Science

Science refers to the subject Natural Science for Grade 9, as outlined in the rNCS (DoE, 2002).

Learning Environment

This is a social, physical, psychological and pedagogical context in which learning occurs and which affects student achievement and attitudes (Fraser, 1998). The learning environment is often referred to as a classroom's climate, atmosphere, tone, ethos or ambience, and it is considered to be both important in its own right and influential in terms of student learning (Fraser, 1994).

Context of the study

At the time of data collection, teachers used the final version of the new curriculum—the rNCS (DoE, 2002). Subsequent to this, on-going transformation of the education system occurred. Numerous authors (e.g., Harley & Wedekind, 2004; Jansen & Christie, 1999) have reviewed the nature of these changes. In the next section, I provide a brief sketch of two central features of transformation in education, namely, changes in the curriculum (curriculum reform) and changes in schooling (composition of schooling), and then seek a pattern of schooling in the Western Cape Province.

Curriculum reform

After the democratic elections in 1994, the new government introduced a national core curriculum to reflect the political, social and economic needs of the country. *Curriculum 2005* (C2005) was launched in March 1997. A central feature of the new curriculum was that the authoritarian values and top-down pedagogical approaches of Apartheid-era education were out—replaced by new values and teaching methods that emphasise democratic participation and the potential of every child to succeed (Fiske & Ladd, 2004). In public discourse, this translated to a transition from teacher-centred to learner-centred pedagogy. Notably, the curriculum followed a South African form of outcomes-based education (OBE). The South African Council of Education Ministers described OBE as:

> an instructional method in which curriculum planners define the general knowledge, skills, and values that the learners should acquire. Teachers then work backward to design teaching strategies for reaching these outcomes tailored to the situation and needs of the particular learners. It thus differs in a fundamental way from traditional instruction, in which curriculum planners define specific sorts of knowledge and skills that are to be transferred from teacher to pupil. (Fiske & Ladd, 2004, p. 157)

During the initial implementation phase, it became clear that there were extensive problems with C2005 and its implementation. The problem was mainly because the curriculum was underspecified, with many key terms unclear. Teachers at former Black schools, a large percentage of whom are underqualified and who teach in classrooms with higher than average teacher to pupil ratios, were at a distinct disadvantage. In general, these teachers lacked the necessary resources combined with the support from textbooks, and therefore paid little attention to the conceptual development of knowledge (see the next section below). This was particularly problematic in a subject like Natural Science, where knowledge develops vertically, from foundational to 'increasing abstraction' (Taylor *et al.*, 2003, p. 133). In these contexts, teachers who lacked well-developed content knowledge and pedagogical content knowledge (Shulman, 1987), needed clearly specified, explicit guidelines from the curriculum in order to pace and sequence lessons appropriately. Other problems included teachers struggling with the short time frame for implementation and inadequate teacher training. In light of these problems, the curriculum was severely criticised (e.g., Jansen & Christie, 1999). In 2000, the Education Ministry commissioned a committee to review the national curriculum. The review committee recommended that a simpler, clearly specified and more streamlined curriculum be developed (Chisholm *et al.*, 2000), culminating in the revised *National Curriculum Statement* (rNCS) approved by cabinet on 20 March 2002.

The Structure of Schooling

During Apartheid, education was controlled by seperate departments of education along a race-biased hierarchy from White, Indian, Coloured to African students (Mncwabe, 1990). White students were administered by the House of Assemblies (HoA), Indian students by the House of Delegates (HoD), Coloured students by the House of Representatives (HoR), and urban Black students in 'townships'—which are areas on the outskirts of suburbs (Fiske & Ladd, 2004)—were administered by the Department of Education and Training (DET). In addition, Black students outside the townships, located in rural "independent" homelands, that is, Bophuthatswana, Ciskei, Transkei and Venda, were governed by their own homeland department of education. Other "independent" states also had separate departments of education. In total there were nineteen separate education departments. Similarly, residential areas were strictly demarcated along racial lines in terms of the so-called Group Areas Act (Fiske & Ladd, 2004). Thus, White schools were located in White residential areas and Indian students in Indian residential areas, and so forth. Students were thus separated educationally and spatially, with White students benefiting most from the arrangement.

One of the tasks of the new government in 1994 was to unify the fragmented education systems into a single administration and national curriculum. Under the Apartheid regime, the 19 racially defined education systems offered very different education. Following the termination of the separate education systems, public schooling followed a semi-private model. Parents became involved in their children's schooling through the school governing body (SGB). The primary responsibility of the SGB was to compile an admissions policy in line with the South African Schools Act (SASA) and the constitution (Republic of South Africa, 1996), and to decide on the school fees charged. School fees enhanced the limited public funds (i.e., revenue from general taxes) in public schools (Fiske & Ladd, 2004), and are set in line with the fee-paying potential of the community, where the school community is commonly referred to as the feeder area. However, after 1994, the legacy of the Group Areas Act left privileged state schools to be located in White areas (Fiske & Ladd, 2004). Students drawn from the feeder area were predominantly White, together with a small emerging Black group (C. Soudien, personal communication, 22 August 2008) whose parents could afford to live in expensive suburbs because of their high family income—a proxy of their socio-economic status (SES) (see Chapter 2, page 42). This implies that SES is replacing race as a primary determinant of who would go to high quality schools. Thus, the composition of the student body at the time of data collection for the present study can roughly be described as follows: firstly, those parents within the school feeder area who can afford to pay high school fees and whose student body is predominantly White, but racially mixed. Secondly, those parents who live outside the school feeder area (on the periphery of suburbs and in townships) who occupy schools charging lower school fees, primarily in ex-Model C,[4] ex-HoR and ex-HoA schools, whose student body was racially mixed, with fewer White students. Thirdly, working-class parents who send their children to low fee ex-DET schools or "no fee" schools (see Chapter 3, page 61), whose student body are primarily Black. Thus, SES more likely defines the composition of schooling at the time of data collection than race. This implies that one cannot assess schooling in South Africa without considering SES, having strong implications for the design of the study (see Chapter 3, page 60).

The stratification of schools by SES has significant implications for how teachers interpret the curriculum. Whether teachers attain outcomes is largely dependent on their support structures at three levels, namely, resources, teachers' subject and pedagogical knowledge, and the student body composition. These three factors are more likely SES influenced. Firstly, outcomes are more likely to be achieved through good resource support. Constructivist epistemology requires that teachers scaffold (see Chapter 2, page 17) in order to gradually construct knowledge. Scaffolding through support structures like textbooks, science laboratories, audiovisual materials, computers and so forth, guide conceptual learning ultimately leading to higher order thinking skills (HOTS) (Chapter 2, page 14). Secondly, students are more likely to develop conceptual knowledge if teachers guide them appropriately. It has been shown that teachers with weak conceptual frames teach in a superficial manner. For instance, the curriculum's emphasis on the constructivist principle of relating knowledge to "everyday life" has been found to be implemented superficially in a range of small-scale studies on "best practices" funded by the Presidential Education Initiative (PEI) and unveiled by Taylor and Vinjevold (1999). One of the most consistent findings of a number of the PEI projects point to teachers' low levels of conceptual knowledge, their poor grasp of their

[4] From the early 1990s White government schools were able to enroll Black students if the SGB agreed. The schools became known as 'Model C' schools. However, this term is no longer used, but the term, 'ex-Model C', as well as ex-DET, and so forth, is commonly used.

subjects, as well as the range of errors made in the content and concepts presented in their lessons. In their analysis of teachers relating knowledge to "everyday life", Taylor and Vinjevold (1999) stated:

> The learning programme seems designed to encourage the most superficial approach to hundreds of activities, most of which could be related to the personal experiences of learners, but few if any which are likely to result in solid conceptual development. (p. 121)

The researchers also found that although teachers were implementing forms of 'learner-centred' practice and co-operative learning, very little learning was taking place, a result similarly supported by Brodie *et al.* (2002). Schollar (2004), conducting a large-scale study across nine provinces on teaching methods, identified three common misconceptions in teaching that led to an achievement crisis in schools. First, that memorisation itself is largely negative and should not be part of learning. Second, that teaching should only be done through discovery learning, not through direct teacher-centred approaches. Third, children are never wrong and that answers should largely be arrived at through discussion and reflection. The study concluded that teachers misinterpreted the curriculum by failing to teach students basic methods, the uptake of methods was unprincipled and procedural, and finally, that lessons lacked pacing and sequencing. This occurred more frequently amongst teachers teaching in low SES contexts than those in high SES contexts. Furthermore, other studies on teachers' pedagogic knowledge show similar trends to those studies related to teachers' subject knowledge (e.g., Kuhne, Van den Heuvel-Panhuizen & Ensor, 2005). Overall, the results suggest that teachers in high SES contexts were better skilled to teach using OBE.

On the other hand, the lack of support in low SES contexts had serious consequences to students' achievement. Taylor and Vinjevold (1999) concluded in the PEI report:

> At all levels investigated by the PEI projects, the conceptual knowledge of students is well below that expected at the respective grades. Furthermore, students are infrequently required to engage with tasks at any but the most elementary cognitive level, the development of higher order thinking skills is stunted. (p. 231)

If students lack basic science knowledge, then they are less likely to develop knowledge to abstraction, leading to low achievement in science and mathematics tests. The very disappointing low average scores in the Third International Mathematics and Science Study (TIMSS) in 1999 and the follow-up Trends in International Mathematics and Science Study (TIMSS-R) in 2003 (both involving Grade 8 students) occurred primarily because of lack of emphasis on knowing basic science facts and understanding (Reddy, 2005 & 2006). Fleisch (2008) quotes an example from the 2003 TIMSS study. In this study, a basic mathematical skill for Grade 8 students, namely, whether students are able to divide a whole number by a fraction was tested. In the example, students were to divide 6kg by a fraction, and only 7 in 100 of South African students got full credit for this problem; while in Singapore, 78 in 100 students got full credit. Indeed, the low levels of achievement might also have a social influence. Middle-class students typically have better social capital which means that they arrive with fairly broad experiences and a foundation for making the leap from personal experiences to formal knowledge (Bernstein, 1996). The lack of social capital in children attending low SES contexts schools, more likely, will disadvantage students (Fleisch, 2008). Thus, with varying SES contexts, it is evident that teachers and students in high SES context schools are more likely to adapt to the challenges of OBE.

Pattern of Schooling in the Western Cape Province

Empirical research on classroom issues in South Africa has been limited, the vast majority being problematic both conceptually and methodologically (Fleisch, 2008; Taylor *et al.,* 2003). Studies to date, many small-scale, have provided useful and illuminating insights into classroom issues, but these only provide an outline to the educational landscape in South Africa. However, the few reputable local studies that are available can only claim to provide at best clues about the pattern of education in the country. Indeed, countrywide studies, for instance, the Monitoring Learner Achievement in 1999 (Fleisch, 2008) show that the basic numeric and literacy competency of Grade 4 students were 30.2% and 48.1%, respectively. These results are disappointingly lower than those in other African countries, for instance, Namibia, Senegal and Malawi. However, more alarmingly, students are performing progressively worse in preparation for high school. For instance, a study by the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) (Moloi & Strauss, 2005) showed that 84% of Grade 6 South African students were unable to read a text and extract basic meaning.

Fleisch (2008) presents compelling evidence about primary school studies specific to the Western Cape Province. Particularly, that student achievement in primary schools has a strong SES influence. Indeed, as suggested earlier, this pattern of achievement at primary school level also provides disparate pieces to the puzzle of achievement in the Western Cape Province. However, an advantage is that one can, at best, extrapolate information from these studies to the secondary school level. For instance, a range of studies show that historically advantaged students in primary schools in the Western Cape Province score higher average scores for Grade 3 literacy and Mathematics than their historically disadvantaged counterparts, who make up the majority of students in the province. Furthermore, much of the evidence suggests that there is a significant ‘lag’ in relation to the specified curriculum in reading and in Mathematics at Grade 3. For instance, studies conducted between 2004 and 2005 (DoE, 2005) regarding the Grade 3 literacy results, show that 90.6% of students in historically advantaged schools achieved basic literacy levels, in contrast to 12.9% in historically disadvantaged schools. In addition, between 2003 and 2005, 86.9% of Grade 3 students in historically advantaged schools in the Western Cape Province attained basic level skills in Mathematics, compared to 4.7% in historically disadvantaged schools (Western Cape Education Department [WCED], 2004 & 2006). These results suggest that schooling the Western Cape Province might be SES influenced, and additionally, that primary school students are under-prepared for high school which could seriously influence them mastering the demands of secondary school, and, consequently, university.

Overview of the Thesis

The conceptualization, implementation, and results of the present study are presented in five chapters. In Chapter 1 the background and rationale, problem statement, aims and objectives, context of the study, and a brief overview of the whole thesis is provided.

In Chapter 2, a detailed review of the research literature about constructivism, the field of learning environments research (LER), and socio-economic status (SES), as well as an analysis of the revised *National Curriculum Statement* (rNCS), will be provided. First, a review of the literature on constructivism is given. Two forms of constructivism, namely, the individual and social forms, are described. These two forms contribute toward the current understanding of constructivist epistemology as required by the rNCS. Thereafter, the criticisms of constructivist theory are discussed in relation to the theories of learning. Second, a background analysis of the rNCS is given. It is argued that for the rNCS, social constructivism is the theory-of-choice to accomplish a learning outcome, and relevant examples from the new curriculum are quoted to show this. Consequently, key features of an environment with a social constructivist focus are identified, and these are operationalised to scales, which are used in questionnaires in the field of LER. Third, by reviewing the LER field, appropriate and essential research methods previously employed in similar studies within the LER framework are identified. This field has a long history of using numerous valid and reliable quantitative surveys to assess the learning environment. The development of the new questionnaire, the *Social Constructivist Learning Environment Survey* (SCLES), was guided by this field. Finally, the literature on SES is reviewed, and here it is argued that in the context of South African schooling, family background best describes SES, amidst the numerous definitions of the term.

In Chapter 3, details related to the research methods are presented. Firstly, the research design is described. The data were collected in two main sequential data collection phases, namely, the quantitative data collection phase and the qualitative data collection phase. For the quantitative data collection phase, the SCLES was used to assess students' perceptions of six aspects of the learning environment, and associated with the key student outcomes, namely attitude toward science, achievement and gender equity. The questionnaire was piloted and modified accordingly, and administered to a sample of students meticulously chosen to represent the heterogenous nature of schools in the Western Cape Province. The method of choosing the sample ensured an overall random sample of 1955 Grade 9 Natural Science students in one class in 52 schools, representative of urban and public schools in the Western Cape Province, South Africa. Once collected, the data were captured, cleaned and analysed. Graphic profiles generated for students in all 52 classrooms were analysed. Five classrooms were chosen for the qualitative data collection phase in the form of classroom observations, and teacher and student interviews.

In Chapter 4, a detailed account of the data analyses and results which relate to the four research questions is provided. The chapter is divided into two main sections. In the first section, the quantitative data results are presented in four main sections—first, the validity and reliability of the questionnaire; second, the associations with the student outcomes; third, the associations with SES are presented; and finally, profiles of typical classrooms are described. The qualitative data are presented in the form of five class profiles.

In Chapter 5, the purpose of the study, as well as the research design is rehearsed. The limitations of the study are highlighted and answers to the research questions are provided and discussed. The implications of the findings for education researchers, education policy-makers and classroom teachers are discussed, and recommendations for classroom practice, teacher professional development programmes and education policy-makers are made. Finally, concluding comments are provided.

Chapter 2
CONCEPTUAL FRAMEWORK

Introduction

In this chapter, a detailed review of the research literature about constructivism, the field of learning environments research (LER), and socio-economic status (SES), as well as an analysis of the revised *National Curriculum Statement* (rNCS), will be provided.

In the first part of the chapter, a review of the literature on constructivism is given. Many argue that the literature on constructivism is broad, and consequently, it is not a unified theory on how students learn (Phillips, 1995). Thus the chapter starts with a brief outline of those areas of constructivism that researchers agree on, and then delineates the literature into two forms of constructivism, namely, the individual and social forms, in order to contribute toward the current understanding of constructivist epistemology. Thereafter, the criticisms of constructivist theory are discussed in relation to the theories of learning when practiced in the classroom.

In the second part of the chapter, a background analysis of the rNCS is given. It is argued that for the rNCS, social constructivism is the theory-of-choice to accomplish a learning outcome, and relevant examples from the new curriculum are quoted to show this. Consequently, key features of an environment with a social constructivist focus are identified, and these are operationalised to scales which are used in questionnaires in the field of LER.

The field of LER is used to frame the present study. Through the review of the LER field, appropriate and essential research methods previously employed in similar studies within the LER framework are identified. This field has a long history of using numerous valid and reliable quantitative surveys to assess the learning environment. The development of the new questionnaire, the *Social Constructivist Learning Environment Survey* (SCLES), was guided by this field.

Finally, as was shown in Chapter 1, it is difficult to assess schooling in South Africa without taking into account SES. In this review, it is argued that family background best describes SES in the present study amidst the numerous definitions of the term.

Constructivism

Many argue that the constructivist model of learning reflects the best understanding of the brain during learning (Abbot & Ryan, 1999). There are, however, issues regarding this model that are widely debated (Phillips, 1995). The arguments about constructivism mainly stem from the fact that it is not a unified theory, but rather a conglomeration of different positions with varying emphases (Tynjala, 1999). However, within the varying positions are four areas of agreement (Fosnot, 1989; Noddings, 1990). First, constructivists metaphorically describe the acquisition of knowledge as a building process, in which knowledge is actively constructed (Brooks & Brooks, 1999; Bruner, 1986; Confrey, 1990; von Glaserfeld, 1990) by individuals or social communities, thus rejecting the idea that knowledge is passively received through teachers or textbooks. Second, constructivists value students' prior knowledge during learning, as they believe that students' acquisition of new knowledge is influenced by their prior experiences. Third, constructivists believe that there is no external reality as knowledge is subjective following von Glasersfelds' radical constructivism (von Glasersfeld, 1989). Last, constructivists believe that if teachers accept constructivist tenets, then it leads to the adoption of constructivist pedagogy. Overall, constructivists believe that knowledge is constructed, adaptive, with no external reality, and that teachers play an important role in adopting constructivist pedagogy.

Authors who reviewed the literature on constructivism (e.g., Geelan, 1997; Good, 1993; Phillips, 1995) generally agree that there are differences in views about the constructivist model of learning. They further suggest that two forms succinctly delineate the differences in constructivism, namely, the individual and social forms. Some theorists emphasise the individual construction of knowledge, (e.g., Kelly, 1955; Piaget, 1972; von Glaserfeld, 1989), while others emphasise the social construction of knowledge (e.g., Gergen, 1995; Vygotsky, 1978). Phillips (1995) further emphasises that there are differences within these two forms. Indeed, at times, the two forms merge leading to an integrated approach (e.g., Cobb, 1994; Fosnot, 1996). However, the movements or groups focused on in the next section are those related to the individual forms of constructivism (i.e., cognitive constructivism, personal constructivism and radical constructivism) and the social forms of constructivism (i.e., social constructivism and socio-cultural constructivism), each discussed in turn.

Individual forms of constructivism

Individual forms of constructivism emphasize the importance of the individual during learning. Within these forms there is a focus on how teachers guide students toward cognitive development. In the next section three main forms of constructivism at the individual level, namely, cognitive constructivism, personal constructivism and radical constructivism, succinctly encapsulate these views.

Cognitive Constructivism

Cognitive constructivists argue that individuals cannot passively receive knowledge. Rather students try to make sense of new knowledge by testing it against existing knowledge. Moreover, students develop knowledge by using two mental processes, namely, assimilation and accommodation. During assimilation, students interpret information and attach meaning to the information; while the process of accommodation allows students to change and develop the information (Slavin, 1994). These two mental processes occur simultaneously, allowing students to attain balance between previous knowledge and new knowledge, which eventually leads to equilibration (Piaget, 1971). Therefore, in many science classrooms, the lack of active involvement through equilibration might lead to lack of engagement by students, which could result in them passively receiving information.

Personal Constructivism

Personal constructivists argue that we change and learn through our growth in behaviour (Slavin, 1994). They claim that individuals grow internally (personal constructs) to make sense of their experiences, and to predict future experiences (Kelly, 1955). Furthermore, as individuals grow, they are able to learn meaningfully by linking their personal and prior knowledge (Ausubel, 1968). The influence of Kelly's (1955) and Ausubel's (1968) theories, has led to progress in the understanding of how students develop cognitively by conceptualization, especially with regard to the cognitive learning theory and the conceptual change theory.

The cognitive learning theory relates to the reasoning and thinking processes used by students as they acquire knowledge[5] and skills (de Villiers, 2000). Students' active involvement in learning gives them the skills to integrate information into their own schema without relying on rote memorization (Slavin, 1994). They are therefore able to learn meaningfully. Meaningful learning help students to select relevant information (the student selects information from text and add that information to working memory); organize the information into a coherent whole, and integrate the information with appropriate existing knowledge (they connect the organized information to other familiar knowledge structures already in their memory) (Mayer, 1998). Consequently, students can acquire higher order thinking skills (HOTS) (Dunlap, 1999).

[5] DoE (2002a: 87) refers to 'core knowledge' and 'indigenous knowledge'. Core knowledge is the 'big ideas' or principles or main concepts around which the details of knowledge are built (e.g., the principle of 'continuity of life' represents core knowledge for the Life and Living knowledge strand); while Indigenous knowledge are produced by groups of people living in an area (province, country, etc.) for a long period of time…in some cases this knowledge and the wisdom that accompanies it have been lost.

The conceptual change theory places emphasis on the powerful role of students' own prior knowledge and experiences in the learning of science (Roth, 2002). Tytler and Prain (2009) emphasise the transient nature of conceptual development particularly through the strong influence of language. Indeed, students' language and its influence on learning is described later in the section on social constructivism (see page 18). Notwithstanding the importance of language in conceptual change, through meaningful teacher guidance, then students can question their own ideas through cognitive conflict, another avenue to acquire HOTS (Dunlap, 1999). Teachers are pivotal in applying the cognitive learning theory and the conceptual change theory to guide students toward cognitive conflict. The application of these theories to the classroom setting have proved to be challenging to teachers, especially, for instance, in large classrooms, in classrooms with a lack of resources, and for teachers who themselves lack the necessary skills to teach conceptually (see Chapter 1, page 6). In fact, teachers themselves need to have mastered the knowledge and processes that they are trying to teach. If not, then they might be unable to assist students in attaining deep conceptual understandings (Beeby, 1966; Fiske & Ladd, 2004, Meier, 2003 & Onwu & Stoffels, 2005). Thus, Hewson, Beeth & Thorley (1998) contend that teachers need guidance to teach for conceptual change, and therefore derived four significant steps of teaching for conceptual change, relating to: ideas, metacognition, status and justification. In a classroom where conceptual change guides the construction of knowledge, Gunstone (1994) claims that metacognition stands out as crucial to the conceptual change process. Teachers should specifically guide students to recognize their ideas, evaluate them, and to reconstruct the ideas based on their dissatisfaction or fruitfulness of the idea. In short, they should monitor, integrate and extend their own learning—part of good learning behaviours (Gunstone, 1994; Gunstone and Northfield, 1992). The development of the principle *Metacognition* used in the present study was developed in line with this idea, and will be discussed in more detail in light of the new instrument in Chapter 3.

The application of the concept of metacognition in teaching has been plagued with difficulties, as the definition in the literature still appears to be unclear (Larkin, 2006). The concept metacognition has generated interest since Flavell's (1976, 1979) seminal work. A lack of coherence in the literature has resulted in the concept having variable definitions (Anderson, Nashon & Thomas, 2009). Furthermore, other challenges in the literature include elucidating metacognition's nature and character (Wellman, 1985), as well as its measurement in practice (Scraw & Impara, 1990). However, many define metacognition as knowledge, control and awareness of learning processes (e.g., Baird & White, 1996; Thomas & McRobbie, 2001), while others define it as the ability to 'think about ones thinking' (Gilbert, 2005). As the present study draws on the conceptual change theory, which uses the definition of metacognition by Gilbert (2005), the use of the concept metacognition in the present study will be guided by this definition. Therefore, in this sense, metacognition is a construct considered to have a core focus on the improvement of students' learning processes and outcomes (Anderson *et al.*, 2009) thus giving student's opportunities to control their cognitive behaviour and self-instruct (Hughes & Agran, 1993). Self-instruction could guide students to monitor and evaluate their use of a strategy and allow them to self-correct as necessary (Pellegrino *et al.*, 2001).

Radical Constructivism

Radical constructivists argue that individuals can only really know their own private constructions of reality, making possible any number of "truths". If there are so many truths, it implies that there are many meanings. Ernst von Glasersfeld (Von Glasersfeld, 1989) questioned how we could unify them into some type of agreement where meaning is shared. Borrowing the expression from Paul Cobb, von Glasersfeld contends that shared meanings are really "taken-as-shared". According to von Glasersfeld, no grounds exist for believing the conceptual structures that constitute meanings or knowledge are held in common with different individuals (Howe & Berv, 2000). Rather, each individual builds up conceptual structures for him/herself, and one can never say whether or not people have produced the same construct. At best one may observe that in a given number of situations individual constructs seem to function in the same way, that is, they seem compatible.

In a school setting, the private worlds of the teacher and the student are "taken-as-shared" where the teacher "inputs" meaning into the students' constructions giving it more "viability" (Marshall, 1998, p. 451). The additional viability can be interpreted as the intersubjective, constituting the constructivist substitute for objectivity. The teacher then proceeds *as if* meaning were shared. Therefore, two individuals do not truly share meaning, we can only assume that they share the same knowledge, therefore knowledge is 'taken-as-shared' (Marshall, 1998, p. 451).

Social forms of constructivism

Social forms of constructivism emphasise the importance of the the social environment during learning. It specifically focuses on how individuals develop cognitively through social interactions largely influenced by their own cultural experiences. Teachers play an important role in guiding students toward social learning as they can use specialised teaching techniques to promote scaffolding. These views are expressed in the social forms of constructivism within the following groups, namely, social constructivism and socio-cultural constructivism.

Social Constructivism

The Russian social scientist, Vygotsky, played an important role in the development of the social aspects of constructivism. Vygotsky's theory rests on the fundamental premise that learning occurs on a social level within a cultural context (Slavin, 1994). Vygotsky's 'zone of proximal development' (ZPD) is defined as "the distance between the actual developmental level as determined by independent problem-solving, and the level of potential development as determined by problem-solving under adult guidance or in collaboration with capable peers" (Vygotsky, 1978, p. 86). The ZPD is that intangible area in which optimal learning takes place, and learners can extend beyond their current capabilities to the extent that "the (physical) development process lags behind the learning process" (Vygotsky, 1978, p. 86).

Teachers can help students reach the intended goal of learning a concept by scaffolding appropriate approaches (Wood, 1991; Woods, Bruner, Ross, 1976). Woods *et al.*, 1976 (p. 9) describes scaffolding to the ZPD as "…controlling those elements of the task that are initially beyond the learner's capability thus permitting them to concentrate and complete only those elements that are within their range of competence". Indeed, scaffolding is a form of additional support from the teacher. Skillful teachers can use scaffolding methods by balancing the provision of "just-in-time, just-enough assistance, and then the gradual fading of assistance…without slowing down advanced or more experienced students" (Dabbagh, 2003, p. 39). Scaffolding should thus provide support to novice students in order to gain the knowledge, skills and confidence to cope with their context (Young, 1993). However, once the scaffold is removed, then students should accept full control of the task, through gradual fading (Oliver & Herrington, 2001) of the support. Thus, the ZPD emphasizes the crucial role of mediation in learning.

There are many scaffolding approaches for teachers to draw on, but in a social constructivist context, guided by the ZPD, teachers should use scaffolding approaches supporting self-regulatory processes, including modeling thinking processes through the think-aloud-technique, providing resources and activities that present questions for critical thinking, providing scenarios or cases that emphasise multiple perspectives and require analytical thinking, and providing procedural guidance on how to complete tasks (McLoughlin & Oliver, 1999). In addition, they should also include methods like problem-solving activities and help students to become aware of generative or metacognitive thinking processes (Clark & Kazinou, 2001). Therefore, these scaffolding methods should support students to move beyond their current limitations.

One might argue that Vygotsky's ZPD might be more helpful than Piagetian theories as applied to the school setting. Vygotsky's ZPD allows teachers to consider time constraints and group interactions, which is seldom possible when applying Piaget's individual theories (Edwards & Mercer, 1987). Firstly, the ZPD considers time constraints by increasing the pace of the lesson when teachers use appropriate scaffolding strategies. Secondly, Vygotsky's ZDP allows teachers to formulate group interactions when planning lessons, another means of saving lesson time (support for these two points is shown later in Chapter 5, page 131). However, the strength in Vygotsky's work, and its appeal in Western countries, stems from the idea that knowledge is found in cultural contexts and is actively internalized by the individual who is strongly influenced by their social contexts (Vygotsky, 1978; Wertsch, 1985). Hence, the term socio-cultural constructivism, which is supported by the socio-cultural theory.

Socio-cultural Theory

Some social constructivists criticize the conceptual change theory. They claim that the theory is too focussed on the learning of particular concepts within the canon of Western science (Roth, 2002). These theorists argue that students should be learning about the nature of science and scientific ways of knowing. Moreover, students should learn to see science as a very human and social endeavour, with a cultural influence (Roth, 2002). In addition, many social constructivists emphasize the role teacher's play during "enculturation" of students into scientific discourse (Roth, 2002: 205). They further claim that teachers should pursue a cognitive apprenticeship—modeling and coaching students in how to think like scientists. Thus, the learning of science is a process of being enculturated into a special community with its own forms of reasoning and discourse (Rosebery, Warren & Conant, 1992).

On the other hand, a group of theorists who criticize "enculturation" into Western science traditions are those who adopt a socio-cultural perspective (Roth, 2002). They believe that science is only one subculture, one way of viewing the world. Moreover, Western science supports only those students who "harmonise" with the culture of Western science (Roth, 2002: 205). Brickhouse (1998) argues that schools should connect with science communities more in line with students' efforts to forge their own identity. Furthermore, he argues for a broader vision of science which is more inclusive. In addition, he advocates teaching that encourage students to be more critical of the Western scientific community, as well as exposure to other ways of knowing.

One way to support the socio-cultural perspective at the classroom level is for teachers to possibly use language to connect with students and their communities. Language is an important "cultural tool" (Resnick & Nelson-Le Gall, 1997, p. 148), and can foster active engagement of ideas between teachers and students (e.g., Thomas & McRobbie, 2001; Thomas, 2002). Teachers should accommodate students' ideas through creating a language of communication in order to communicate learning, yet some researchers have found that teachers do not generally possess a language of communication during learning (e.g., Macdonald, 1990; Thomas & McRobbie, 2001). Many authors (e.g., Mayer, 1998; Savery and Duffy, 2001) argue that teachers can develop a language of communication by making knowledge personally relevant to students' everyday life experiences. Indeed, language can create important inroads in promoting an environment with a social-constructivist focus, and should be incorporated regularly in teaching in order to develop a sense of familiarity with the teachers' and students' language of communication. Therefore, constructivist theory provides valuable ideas about how learning takes place. However, these ideas should be evaluated against the many criticism of constructivism, which will be discussed in the next section.

Criticisms of Constructivism

It is important to be aware that there are criticisms of constructivism in the literature. As constructivism is regarded as a theory of how human knowledge originated (Phillips, 1995), the criticisms have direct impact on the credibility of the theory and practice of constructivism as applied to teaching and learning. With regard to science education, Leach and Scott (2003) identified the challenges that have been devoted to constructivism and science education. First, they argue that the philosophical underpinnings of constructivism are fatally flawed (e.g., Matthews, 1992; Nola, 1997; Suchting, 1992); second, there is no evidence that so-called 'constructivist teaching' achieves better results in terms of students' learning (e.g., Matthews, 1997, p. 23); and third, the best advice that constructivism can offer about teaching is no more than common sense (e.g., Matthews, 1997).

First, with regard to the philosophical underpinnings of constructivism, Phillips (1995) contends that the theory of constructivism is complex, and they are not single-issue positions. They address a number of deep problems, most of which the authors have their own interpretations about issues, trying to advance their position. From an epistemological perspective, Millar (1989) contends that the writings of most constructivists are unanalyzed and unclear. Many of these epistemological issues centre around the notion of 'taking children's ideas seriously' (Millar, 1989, p. 590). This issue has been controversial because it could be argued that school science is almost an entirely consensually agreed upon body of knowledge (Matthews, 1997). Therefore, it is questionable as to what extent children's ideas can be taken seriously in the science classroom. Furthermore, from this perspective there is much debate with regard to the various terminologies used by researchers (e.g., Gauld, 1987), and how one interprets children's ideas depends on the constructivist position that one adopts (Gilbert, 1983).

Second, another critique of constructivism is that there is "no congruent constructivist model of teaching" (Millar, 1989, p. 589). As a result, teachers who are trying to create constructivist classroom environments could be faced with many dilemmas. Windschitl (2002) describes them as conceptual, pedagogical, cultural and political challenges in the classroom, because each classroom context poses different challenges. For instance, during teaching, the teachers' personal decision-making is strongly influenced by context (related to specific groups of students), content (related to particular academic material to be taught), and person (embedded in the teacher's unique belief system). Furthermore, as the teachers' professional knowledge becomes richer and more coherent they begin to form highly personalized pedagogy which are influenced by alternative ways to explain phenomena (Reynolds, 1989), personal value judgments (Leinhardt, 1988), as well as belief systems that influence their decisions (Kagan, 1992). As a result of the uniqueness of every classroom situation, every decision that teachers make during teaching is very likely influenced by conceptual, pedagogical, cultural and political issues, possibly making a constructivist model of teaching elusive.

Third, teachers also face the question of whether constructivist teaching should be used for the teaching of all science concepts. Millar (1989) suggests that rather than propose a constructivist model of teaching, it might equally be argued that science should be taught in whatever way is to engage the active involvement of students, as this is most likely to make them feel willing to take on the serious intellectual work of reconstructing meaning. Indeed, it could be argued that learning is internally driven, within the students' head, and that any successful learning can take place independent of teaching (Millar, 1989, p. 589). For instance, methods like group discussion (Cosgrove, Osborne & Carr, 1984), predict-observe-explain sequences (White, 1988) and concept mapping (Novak & Gowin, 1984) are methods supporting active learning, yet the empirical evidence available suggests that there has been very little value in any of the above approaches, and that more empirical evidence is necessary to justify the value of constructivist approaches to teaching and learning (Osborne, 1996).

The criticisms of the constructivist theory of learning are informative as these can act as predictors to potential problems in classroom practice. Moreover, the criticisms of the constructivist theory of learning might also pose a danger of weakening the rNCS's policies of teaching and learning in science. Importantly, this study neither criticizes nor supports the rNCS views on constructivism, but simply examines *whether* the Western Cape Province teachers are using key social constructivist features to transform their Natural Science classrooms as required by the rNCS. In light of the issues discussed above, in the next sections, it is argued, firstly, that the rNCS (Natural Science) (DoE, 2002) supports social constructivism, and secondly, that the rNCS supports key social constructivist classroom features from the literature.

Positioning the rNCS within constructivism

A social constructivist orientation holds that learning is a social as well as an individual process, and does not occur in a vacuum (Milne & Taylor, 1995). It might be argued that the rNCS in Natural Science emulates this view. Indeed, the rNCS uses an integrated approach to learning, combining the socio-cultural theory (social aspects of learning) and the conceptual change theory (individual aspects of learning). Such an approach has many advantages, which Milne and Taylor (1995) claim promotes the personal and mental construction of knowledge, allows students to subscribe to their conceptual structures, and enables them to engage with the construction of knowledge through a social and cultural emphasis mediated by language. Consequently, in the next two sections, it is shown that the rNCS supports a social constructivist orientation through quotations from the curriculum document. In the first section, the rNCS in Natural Science's view on learning outcomes, and its link to social constructivism is argued. In the second section, the rNCS's support of specific social constructivist key features is argued.

The rNCS's support of social constructivism

The rNCS envisages that Natural Science students should be scientifically literate, numerate and lifelong learners who should acquire academic and social skills to cope with the requirements of the 21st century (DoE, 2002). The vehicle to attain these skills is a flexible curriculum based on learning outcomes. The rNCS (DoE, 2002) defines outcomes as the promotion of knowledge at the end of the learning process in OBE. Furthermore, the outcomes should be framed within the rNCS's (DoE, 2002) 'critical outcomes' (broad competencies such as critical thinking and problem-solving) and 'developmental outcomes' (outcomes inspired by the constitution that enable learners to become responsible, sensitive and productive citizens) (DoE, 2002). Arising from these broad outcomes are three specific learning outcomes to be attained by all Natural Science students—promoting process skills (Learning Outcome 1), conceptual knowledge (Learning Outcome 2), as well as science, society and the environment (Learning Outcome 3) (DoE, 2002). The three outcomes promote skills related to the personal development of the student (affective and cognitive outcomes) and the social development of the student (social outcomes) (DoE, 2002), which very likely emulates Milne and Taylor's (1995) social constructivist orientation in the classroom.

The rNCS in Natural Science describes learning as a process with the goal of attaining outcomes. During the learning process the role of the student is to be "more actively involved" (DoE, 2002, p. 3) in the learning process, gaining knowledge and skills enabling them to "…participate in society as critical and active citizens" (DoE, 2002, p. 3). On the other hand, the role of the teacher in attaining these outcomes has been described as facilitators who do not simply transfer knowledge, but "mediate learning", through "active involvement in the organization and interpretation of the learning materials" (DoE, 2002, p. 3). Thus, the teacher's role extends further than the transfer of knowledge, but encompasses crucial decisions based on choosing the best teaching strategies to accomplish an outcome, decisions similarly taken by teachers using the ZPD and scaffolding (see pages 16-17) within a social constructivist orientation.

The rNCS in Natural Science promotes scientific knowledge as ever-changing because it is "under constant construction", and "changes over time as people acquire new information and change their ways of viewing the world" (DoE, 2002, p. 4). This view of scientific knowledge has implications for teaching. First, teachers should promote learning for understanding, as the type of learning envisaged should produce students who "will not only recall scientific knowledge and skills, but also apply it in different contexts" (DoE, 2002, p. 7). Second, knowledge should transform in a series of steps starting with applying "certain methods of inquiry" to "repeated investigations", after which, "results are carefully debated and examined before being accepted as valid" (DoE, 2002, p. 4). Thus, the transformation of knowledge from individual understanding to sharing knowledge for verification is a position very likely consistent with a social constructivist orientation.

The teachers' role in mediation can be guided by a set of key features transforming classrooms toward a social constructivist learning environment. Lebow (1993) argues that if constructivism is viewed as a philosophy, not a teaching method, then it offers an alternative set of values (or key features) for teachers to draw on during teaching. Indeed, if teachers accept the key features below, then they are very likely to transform their classrooms from traditional behaviourist teaching emphasizing teacher-centredness (Slavin, 1994), toward a learning environment with a social constructivist focus. Lebow (1993, p. 5) notes:

> ….traditional educational technology values replicability, reliability, communication and control; which contrasts sharply with the seven primary constructivist values of **collaboration, personal autonomy, generativity, reflectivity, active engagement, personal relevance, and pluralism** [emphasis added].

Thus, in the next section, I argue that the rNCS in Natural Science supports Lebow's (1993) key social constructivist features to develop a classroom environment with a social constructivist focus.

Key Features of a Social Constructivist-based Environment

In a learning environment encouraging the construction of knowledge, the student must have some stimulus or goal for being there. The goal is not only the stimulus for learning, but is the primary factor in determining what the student attends to, what prior experience they bring to bear in constructing an understanding, and what understanding is eventually constructed (Savery & Duffy, 2001). In Dewey's terms it is the "problematic" that leads to the organizer for learning (Dewey, 1998). For Piaget it is the need for accommodation when current experiences cannot be assimilated into existing schema (Piaget, 1977; von Glasersfeld, 1989), and for Savery and Duffy (2001) student "puzzlement" can be the stimulus and organizer for learning. Thus the goal for learning is central to what is to be learnt, leading to the student taking ownership of the problem. If the goal of the activity is clear and the student accepts the relevance of the topic in relation to the bigger picture (Savery & Duffy, 2001), they are more likely to incorporate the relevant knowledge to existing knowledge. To further personalize knowledge, it should be contextualized. Contextualising knowledge, as well as making learning meaningful (see page 14) is of particular importance to the rNCS (DoE, 2002). It could be argued that this enhances science learning because it makes sense of the students' everyday experiences. Therefore, the first key feature of a social constructivist orientated learning environment is ***personal relevance*.** The rNCS in Natural Science's description of, and its support of this key feature, is shown in Table 2.1. Other additional quotes from the document also support the key feature, for instance, "…*enables learners to demonstrate outcomes in issues which have relevance to their lives*." (p.7); and, "*learners should make learning meaningful by categorizing, interpreting and applying knowledge, so that they are able to understand, and not memorise knowledge*" (p.9)

Wittrock (1998) argues for learning with understanding. He claims that learning is a *generative process*, in which the student mentally and actively constructs explanations and understanding. He further claimed that students should generate relations between subject matter, knowledge and experience. As a result students should attempt to make sense of the subject matter through active learning (Mayer, 1998). In the cognitive sense, the term being *actively engaged* is related to meaningful learning, where students select, organize and integrate knowledge to create meaning (see page 14). Teachers play a pivotal role in this process. They should lead students to generate meaning by "engaging with the students' metacognitive processes to construct relations between personal knowledge and formal knowledge" (Mayer, 1998, p. 369). One might argue that the term metacognition succinctly encapsulates the meaning of "learning with understanding" (Wittrock, 1998, p. 44) thus combining Lebow's (1993) terms, namely, generativity and active engagement. Therefore, the second key feature of a social constructivist orientated learning environment is ***metacognition*.** The rNCS in Natural Science's description of, and its support of this key feature, is shown in Table 2.1. Other additional quotes from the document also support the key feature, for instance, "*reflect on and explore a variety of strategies to learn more effectively*" (p.1); "*…the conceptual progression from grade to grade are central to this curriculum*" (p.2); and, "*learners develop the ability to think objectively and use a variety of forms of reasoning while they use process skills to investigate, reflect, analyse, synthesise and communicate*" (p.5).

The notion of metacognition is complex and, judging from its multifaceted nature described in the literature (see page 15), teachers very likely need additional scaffolds to guide students toward metacognition. As described earlier in the section on constructivism (pages 14-16), metacognition is associated with the conceptual change theory. In this context, the term is associated with students' ability to 'self-correct' by 'thinking about their thinking' (Pellegrino *et al*., 2001). Indeed, two further scaffolds could guide students toward metacognition, namely, students' ability to re-assess their thoughts through questioning their ideas (i.e., *uncertainty in science*); and their ability to find answers through investigation (i.e., *scientific investigation*). Therefore, the third and fourth key features of a social constructivist orientated learning environment are ***uncertainty in science*** and ***scientific investigation*.**

Table 2.1 Description of each of the key features and its relevance to social constructivism in South Africa and the international literature.

Dimension	Relevance to Social Constructivism as per rNCS (DoE, 2002)	Relevance to Social Constructivism literature
Personal Relevance (Gives meaning to learning by placing knowledge in personally relevant contexts)	*This policy creates an opportunity…, and enables learners to demonstrate outcomes in issues which have relevance to their lives (p. 7)*	Access to contextualized science knowledge makes science interesting because standard science knowledge and skills are learnt in familiar contexts (Savery & Duffy, 2001).
Metacognition (The student is engaging cognitively with knowledge all the time)	*The revised National Curriculum Statement has chosen learning outcomes which stresses the learner's ability to use science knowledge, not just acquire it. Using knowledge refers to the learner's ability to operate and work with knowledge, to recognize when an idea is relevant to a problem, and to combine relevant ideas (p. 5)* *Learners have the ability to collect and extract informationfor various sources and then organize and analyse that information… and then apply the knowledge in a variety of situations (p. 9)*	Teachers should allow learners to build on knowledge generatively and to use metacognitive processes to reflect on the learning process (Mayer, 1998)
Investigation (Learners need to develop investigative skills to enable them to solve problems and think critically)	*…learner sets up a situation in which they measure data, record data, and interpret data in quantitative and qualitative terms…learners might evaluate an investigation designed to demonstrate their grasp of principles of investigations… and compare reports of investigations to show how well the results they reported in different ways (p. 6)*	Learning should always be engaged in the process of sense-making and asking questions (Mayer, 1998).
Uncertainty in Science (Places strong emphasis on the provisional nature of scientific knowledge)	*Knowledge production in science is an ongoing process that usually happens gradually, but occasionally knowledge leaps forward as a new theory replaces the dominant view (p. 4)*	Von Glasersfeld (1989) emphasises that knowledge is not fact – it is the most viable explanation of the experiential world (Resnick, 1987)
Critical Voice (Learners become critical and express it in the classroom)	*The learner and teacher should together consider work done…and assessment activities (p. 82)*	Learners should be critical when integrating new ideas into their own schema (Roth, 2002)
Collaboration (Describes how the learners should interact with others)	*Learners communicate their ideas or results, and choose an appropriate means to communicate with a specified audience…this skill helps the learner reflect their own learning and in building confidence as a person (p. 14)*	According to von Glaserfeld (1989) other people are the greatest source of alternative views to challenge our view.
Respect for Difference (Importance of expressing an opinion in a multicultural setting, and especially opinions related to the person–taking into account their personal background opinions, opinions related to their culture, etc)	*Natural Science learning area statement envisages a teaching and learning milieu which recognizes that the people of South Africa operate with a variety of learning styles as well as culturally influenced perspectives (p. 5)*	In a plural world, learners should respect each others opinions in a social setting like a classroom (Savery & Duffy, 2001)

Other additional quotes from the document also support the key features, for instance, for ***uncertainty in science***, "*As with all other knowledge, scientific knowledge changes over time as people acquire new information and change their ways of viewing the world*" (p.4); "…s*o while there are similarities in the ways scientists work, it is not possible to put all science knowledge and activities under a single heading*" (p.5). For the key feature ***scientific investigation***, "…*collect, analyse, organize and critically evaluate information*" (p. 1); and "*the learner should show initiative and solve problems, for instance, observing, surveying and measuring, comparing information, and determining the effects of certain factors on others*" (p. 8).

Students who have the *personal autonomy* (Lebow, 1993) to be guided by metacognition, are very likely empowered, together with their teacher, to make pedagogical decisions about teaching strategies to best accomplish an outcome (Rudduck, 1999). If students make their "thinking visible" (Pellegrino *et al.*, 2001: 90-91), then it is more likely that teachers can select instructional strategies to support their learning (Agran *et al.*, 2003). However, decisions have to be made regarding the degree of autonomy and control given to the student (Thomas, 2002). Teachers can empower students to make decisions regarding teaching strategies if they foster an environment where students might be allowed to critically voice their views. Indeed, Taylor *et al.* (1994, p. 5) claim that teachers should "willingly demonstrate to the class their pedagogical accountability by fostering students' critical attitudes toward teaching and learning activities". Therefore, the fifth key feature of a social constructivist orientated learning environment is ***critical voice*** which gives students opportunities to voice their opinions in choosing teaching strategies to best accomplish an outcome. The rNCS in Natural Science's description of, and its support of this key feature, is shown in Table 2.1. Other additional quotes from the document also support the key feature, for instance, "*Identify and solve problems and making decisions about learning using critical and creative thinking*" (p.1); and, "*learner and teacher can plan scientific investigations by rewording a vague question and evaluating someone elses plans during testing*" (p.15).

The students' ability to openly express their critical views about the teachers' pedagogical strategies can be accomplished painlessly if there is a good quality communicative atmosphere in the class. As discussed earlier (pages 16-18), in a social constructivist orientated environment, language is an important "cultural tool" (Resnick & Nelson-Le Gall, 1997: 148), and can foster active engagement of ideas between teachers and students (e.g., Thomas, 2002; Thomas & McRobbie, 2001). A language of communication is likely to bridge the gap between teachers' and students' exchange of ideas during teaching. If students are given the opportunities to explain and discuss their ideas, then they are more likely to generate cognitive words (Thomas, 2002). Discussion in this way, not only develops the students cognitively through language, but strengthens relationships between teachers and students. Moreover, debating and negotiation can serve as a source of "puzzlement" (Savery & Duffy, 2001, p. 5). In addition, communication with others through words is the primary mechanism for testing understanding. According to von Glasersfeld (1989), other people are the greatest source of alternative views to challenge our view. Hence, collaborative groups are a means of testing not only ones own understanding, but also the understanding of others. Therefore, the sixth key feature of a social constructivist orientated learning environment is ***collaboration***. The rNCS in Natural Science's description of, and its support of this key feature, is shown in Table 2.1. Other additional quotes from the document also support the key feature, for instance, "*work effectively with others as members of a team, group, organization, community…*" (p.1); and, "*competence in communicating involving when it is important to make extra effort to communicate ones ideas or results…*" (p.2).

Students are more likely to express their views in collaborative groups if they feel emotionally safe, away from "emotionally threatening situations" (Järvelä, 1998). Moreover, in a plural society like South Africa, where "learners in Natural Science think in terms of more than one world view" (DoE, 2002: 12), students should be tolerant by allowing the voices of all children and communities they come from to be heard in the classroom. It might be possible that students with diverse views and opinions about scientific and other phenomena could be trapped in contentious situations if teachers do not create a safe environment for them to openly and honestly express their views. Indeed, studies (e.g., Rudduck, 1999) suggest that students valued and sought respect from teachers, and "social support in relation to academic and emotional concerns" (p. 50). This suggests that student's value respect for different opinions as pivotal to their social development, especially in a social constructivist learning environment, and hence the inclusion of the key feature pluralism (Lebow, 1993) conceptualized as ***respect for difference*** for the purposes of the present study, is the seventh key feature of a social constructivist orientated learning environment. The rNCS in Natural Science's description of, and its support of this key feature, is shown in Table 2.1. Other additional quotes from the document also support the key feature, for instance, "*different world-views are usually present in the science classroom*" (p.1); "*…be culturally and aesthetically sensitive across a range of contexts*" (p.1); and, "*learners are encouraged to develop knowledge and understanding of the rich diversity of this country, including the cultural, religious and ethic components of this diversity*" (p.2).

In summary, Lebow's (1993) key features have guided the development of a social constructivist learning environment for the present study. Although it is acknowledged that seven key features might not assess every aspect, the selected dimensions are all considered particularly relevant to a social constructivist learning environment required by the rNCS. As was described in Chapter 1, this study assesses whether teachers are successful in creating a social constructivist learning environment, and uses a questionnaire to do so. It draws on the field of LER which uses the key features above to guide the development of a new questionnaire—the *Social Constructivist*

Learning Environment Survey (SCLES). In the next section the literature in the field of LER is reviewed.

The Field of Learning Environments (LER)

Fraser (1994; 1998; 2007), through his reviews of the literature in the field of LER, shows the growth and prominence of the field of LER over the past thirty-odd years, and highlights the development of numerous research methods, lines of research, and instruments. As will be shown in the sections that follow, many authors have successfully been guided by this field to produce a host of rigorous studies.

In the next section, through the review of LER, appropriate and essential research methods previously employed in similar studies will be identified and used to guide the development of the new instrument. But first, a short historical overview of LER is provided. Second, the literature related to past learning environment instruments are reviewed. Third, the key student outcomes of attitude toward science and gender equity are reviewed.

History of Learning Environment Research

The current field of LER has been shaped and developed by several influential figures over the years. Starting as early as the 1930s, Kurt Lewin (1936) recognized that human behaviour is a result of the interaction between the individual and his/her environment, and subsequently summarized this in a formula $B=f(P,E)$ where behaviour is considered to be a function of the person and environment. Following Lewin's work, Murray (1938) proposed that additional factors within a system affect behaviour. For instance, internal factors like personality characteristics (needs), and external factors in the environment itself (press) affect behaviour, later referred to as the needs-press model. Murray further elaborated on the needs-press model by introducing the terms alpha press (the perceptions of the environment as held by the detached observer) and beta press (the perceptions of the environment as held by a participant within the environment). Later Stern, Stein and Bloom (1956) expanded on this model when they recognized that there is a distinction between perceptions of an individual (private beta press) and a group (consensual beta press). Furthermore, Stern (1970) proposed that the more congruence there is between the personal needs and environmental press, the better the outcomes; therefore the fit between the person and the environment was later described as the person-environment fit model. The first group who related this model to the school setting, was Gertzel and Thelen (1960) cited in Aldridge & Fraser (2008), who suggested that within a class, the interaction of the personality needs and the environmental press, as well as expectations, predicts student outcomes. Hunt (1975) and Fraser and Fisher (1983) expanded on the model, while Walberg (1981) used the prediction of learning through student outcomes to propose a nine-factor or multifactor psychological theory of educational productivity. The theory holds that students' learning is a function of nine factors, namely, three aptitude variables (age, ability and motivation), two instructional variables (quantity and quality of instruction), and four psychological environments (the home, classroom, peer group and mass media environment). This theory suggests that adjusting one factor alone cannot bring about optimal learning as multiple factors affect learning.

A milestone for the development of the field of learning environment research occurred about 40 years ago when Herbert Walberg and Rudolf Moos began their seminal independent programs of research. Walberg developed the *Learning Environment Inventory* (LEI) as part of the research and evaluation activities of the Harvards Physics Project (Walberg & Anderson, 1968; Walberg, 1979), whereas Moos developed the social climates scale. Moos (1974) developed a scheme for classifying human environments (relationship, personal development and system maintenance and change) to enable the classification and sorting of various components of the environment (Wolf & Fraser, 2008). Using this idea, Moos developed the *Work Environment Scale* (WES) (Moos, 1974), which assessed dimensions in the workplace. Later he linked this work to the class settings to develop the *Classroom Environment Scale* (CES) (Moos, 1979; Moos & Trickett, 1974; Trickett & Moos, 1973). Both the LEI and CES were developed in the USA.

Following the work in the USA, two further programmes began in the Netherlands (e.g., Wubbels & Brekelmans, 1998) and Australia (e.g., Fraser, 1980, 1990; Dorman, 2003). In the Netherlands the development of the *Questionnaire on Teacher Interaction* (QTI; Fraser & Walberg, 2005; Wubbels & Brekelmans, 1998) was pioneered by Wubbels and his colleagues. Research using this questionnaire diversified to numerous countries, for instance, Korea (Kim, Fisher & Fraser, 1999), Brunei (Scott & Fisher, 2004, Singapore (Goh & Fraser, 1998) and Australia (Henderson, Fisher & Fraser, 2000).

In Australia, Fraser and his colleagues developed the *Individualised Classroom Environment Questionnaire* (ICEQ, Fraser, 1980, 1990). In addition, other questionnaires were developed in Australia, namely, the *Science Laboratory Environment Inventory* (SLEI, Fraser, Giddings & McRobbie, 1995; Henderson, Fisher & Fraser, 2000), *Constructivist Learning Environment Survey* (CLES, Kim *et al*., 1999; Nix, Fraser & Ledbetter, 2005; Taylor, Fraser & Fisher, 1986), and *What Is Happening in the Classroom*? (WIHIC, Aldridge, Fraser & Huang, 1999; Fraser & Chionh, 2000; Wolf & Fraser, 2008).

The field has grown, diversified and internationalized to Asian countries where several questionnaires were cross-validated, translated and back-translated into many languages, for instance, Chinese, Indonesian, Korean and Malay (e.g., Aldridge *et al*., 1999b; Lee, Fraser &

Fisher, 1986; Margianti, Aldridge & Fraser., 2004). Studies in Africa have progressed and made headway, particularly in South Africa. Learning environment research is in its infancy in South Africa (Fraser & Fisher, 1986), but growing steadily. Adams (1996, 1997) was the first South African to administer a LER questionnaire, the *Science Laboratory Environment Inventory* (SLEI), to 264 science and biology college students in sixteen Western Cape classes. The study aimed to investigate the effects of class membership on the perceptions of science laboratory classroom environments. The results of the study revealed that there were significant differences between the students' actual and preferred perceptions of the science laboratory environments. It also showed that students within the classes tended to perceive the science laboratory environment similarly. More recently, other studies emerged in South Africa, when Ntuli, Aldridge and Fraser (2003) investigated 1077 primary school students in rural Kwa-Zulu Natal using WIHIC (a primary school version) to determine assessment methods for improving primary school mathematics. Later, Aldridge, Fraser and Sebela (2004) used the CLES, which was administered to 1864 primary school students in 43 mathematics classes employing teacher action research. The most recent large-scale study was conducted by Aldridge, Laugksch, Seopa and Fraser (2006) who aimed to monitor the transformation of classrooms towards outcomes-based education (OBE) learning environments. In this study, a new instrument—the *Outcomes-Based Learning Environment Questionnaire* (OBLEQ)—was developed and validated. The instrument was administered to 2638 Grade 8 science students in one school in 50 classes in the Limpopo Province, South Africa. The study revealed that generally OBE is being implemented in the Limpopo Province, and that the OBE learning environment can be associated with the student outcomes, students' attitude toward science, achievement and gender equity, replicating similar studies in Western countries. In addition, this study was replicated to the wealthier Western Cape Province. Critien (2009) administered an adapted version of the questionnaire used by Aldridge *et al.* (2006), namely, the *Outcomes-Based Learning Environment Questionnaire-Western Cape* (OBLEQ-WC) to 927 Grade 8 students in 30 schools in the Western Cape Province. The findings similarly suggest that OBE is being implemented in Natural Science classes in the Western Cape but highlight important differences between the provinces. Therefore, LER studies have diversified and been expanded to various subjects, grades and countries.

Numerous lines of research have been identified in LER. Firstly, there has been remarkable progress in combining qualitative and quantitative methods (Fraser & Tobin, 1991; Tobin & Fraser, 1998). The mixed-method studies have been drawn from various areas, for instance, some include research on exemplary science (e.g., Fraser & Tobin, 1989), cross-cultural studies in Taiwanese and Australian classrooms (e.g., Aldridge & Fraser, 2000), and checking the trustworthiness of quantitative results (e.g., Fraser & Tobin, 1998). In a similar study to the present, Aldridge *et al.* (2006) conducted a South African study using qualitative data to check the trustworthiness of quantitative data, following the collection of data from a sample of 2638 Grade 8 science students in the Limpopo Province, South Africa. The results found that classroom observations, student and teacher interviews, as well as narrative stories, justified the validity of the quantitative data, making the results trustworthy. On the other hand, Fraser (2002) argued that in some Asian studies there is a lack of large-scale qualitative data collection strategies similar to that of Aldridge *et al.* (2006). He further claimed that quantitative studies tend to dominate and overshadow qualitative studies in Asian countries (e.g., Margianti, Fraser, & Aldridge, 2001; Khine, 2001). Therefore, this is an area that should be developed in those countries.

Second, another line of research involves determinants of classroom environments. There have been numerous studies involving differences between students' and teachers' perceptions of the actual and preferred classroom learning environment. A common trend emerged from these studies where students perceive a more positive classroom learning environment than the one they actually experienced. This result has been replicated using a variety of instruments (e.g., Aldridge *et al.*, 2006; Fraser & Chionh, 2000; Margianti *et al.*, 2001; Wong & Fraser, 1996). An advantage of this line of research is that teachers can use the results of the actual and preferred learning environment studies and then apply them to their own classroom situations through action research (e.g., Aldridge *et al.*, 2004). The action research studies give teachers opportunites to improve their own classroom learning environments through empirical evidence. In addition, other determinants of classroom environments are the differences in perceptions of males and females, where in most studies females tend to perceive the classroom learning environment more favourably than males (e.g., Teh & Fraser, 1995), and grade level as well as ethnic differences has been assessed (e.g., Castillo, Peiro and Fraser, 2006). Therefore, evaluating students' actual and preferred learning environments can provide a vast array of information, which teachers can test, and then apply in their own classroom teaching.

Third, a strong line of research which is relevant to the present study has been investigations into associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classroom environment (McRobbie & Fraser, 1993). Fraser's (1994) tabulation of 40 past studies in science education showed that the association between outcome measures and the classroom environment have been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments, and a variety of samples (ranging across numerous countries and grade levels). For example, the CLES has been utilized with the *Test of Science-Related Attitudes* (TOSRA) to examine associations between the learning environment and students' affective and cognitive outcomes with samples of 1083 Grade 10 and 11 science students in 24 classes in Korea (Kim *et al*., 1999); 1879 Grade 7 to 9 science students in Australia (Aldridge, Fraser, Taylor & Chen, 2000); 1843 Grade 4 to 9 mathematics classes in South Africa (Aldridge *et al*., 2004); and 1079 high school students in 59 classes in Texas, USA (Nix, Fraser & Ledbetter, 2005). Other recent studies involving the outcome *Attitude* *toward Science*, was used in combination with the instrument WIHIC [Fraser & Chionh (2000); Kim *et al*., (2000); Raabflaub & Fraser (2002); Zandvliet & Fraser (2005)]. Numerous studies used the key student outcomes, namely, *Attitude toward Science* and achievement. For instance, Power and Tisher (1979) used them on a sample of 315 junior high school students in 20 classes in Melbourne, Australia; Wierstar (1984) on a sample of 398 15-16 year olds in 9 classes in the Netherlands, as well as locally, Aldridge *et al.* (2006) conducted a study on a sample of 2638, 13-14 year old science students in the Limpopo Province, South Africa.

Other studies related to outcome-environment research are multilevel analysis, which uses statistical procedures like multiple regression analysis (which takes into account the hierachical nature of the classroom setting) (Bock, 1989; Bryk & Raudenbus, 1992), and meta-analysis studies (Haertel, Walberg & Haertel, 1981). Most of the significant results from these studies, especially the multiple regression analyses were replicated, and typically consistent in direction (Goh & Fraser, 1998; Goh, Young & Fraser 1995). In addition, some of the outcome-environment associations were obtained in countries where the questionnaires were translated into Asian languages (e.g., Goh & Fraser, 1998; Kim *et al.*, 1999; Lee *et al.*, 2003; Margianti *et al.*, 2001; Teh & Fraser, 1995; 2000). Thus, the outcome-environment studies can be applied in many contexts using a variety of techniques.

In summary, the historical development of the field of LER shows that the field has grown and diversified, developing into many important lines of research. This information has provided a context for the development of the new LER instrument, the *Social Constructivist Learning Environment Survey* (SCLES). Having identified the seven dimensions, the next step is to identify suitable scales and items, which would be adopted and adapted from already-existing and widely-used general classroom environment questionnaires. Though there are numerous questionnaires available in the field of LER, the questionnaires which contribute most significantly to the scales of SCLES are the *Constructivist Learning Environment Survey* (CLES) (Taylor, Fraser & Fisher, 1997), the *Individualized Classroom Learning Environment Questionnaire* (ICEQ) (Rentoul & Fraser, 1979), and the *Cultural Learning Environment Questionnaire* (CLEQ) (Fisher & Waldrip, 1997). Thus, these three instruments will be the focus of attention in the next section.

Learning Environment Instruments

Investigations in the area of LER commonly use survey instruments to assess student perceptions. The instruments provided a snapshot (Fraser, 1998) of the learning environment studied. The development of an instrument is influenced by many decisions. First, as discussed earlier, Stern, Stein and Blooms (1956) expansion of the needs-press model that identified differences existing between an individual's perceptions of the environment (private beta press) and a group's perception of the environment (consensual beta press) challenges the researcher to consider whether participants' reaction should be treated individually (private beta press) or as a whole (consensual beta press). Second, this, together with Moos' scheme for classifying the three dimensions of relationship, personal development, and systems maintenance and change have influenced the classification of various scales utilized in contemporary learning environment instruments. Third, the development of different forms, such as the 'long or short forms', 'class and personal forms' and 'actual and preferred forms' influence the format of the questionnaire, and these will be elaborated on in Chapter 2 (pages 31-32). Learning environment instruments are more accessible through the 'long and short' forms (Fraser, 1982; Fraser & Fisher, 1986). Teachers can administer, assess and score the shorter versions quicker than the full versions. The other form, the 'class and personal form', help to distinguish group or individual differences (Tobin, 1987). The personal form differs from the class form (Fraser, Fisher & McRobbie, 1996; Fraser, Giddings, & McRobbie, 1992), and rather than give general statements relating to the class, for example, "Students learn from collaboration in the class" it is related more to the personal experiences of the student, for example, "I learn from collaboration in this class". Furthermore, it allows for sensitivity to subgroups, for example, gender, when analyzing a classroom environment (Aldridge & Fraser, 2008).

Constructivist Learning Environment Survey (CLES)

The development of the *Constructivist Learning Environment Survey* (CLES) occurred because Taylor *et al.* (1997) argued that many instruments focused on the improvement of teaching and learning within the context of traditional epistemology. A radical constructivist stance was the conceptual frame for CLES, contrary to a social constructivist focus for SCLES, the instrument to be developed for the present study. The focus of CLES was to measure the extent to which teachers are giving students opportunities to experience a constructivist learning environment, whilst simultaneously broadening their pedagogical focus beyond the recall of knowledge, but to additionally take into account students' out-of-school experiences. Taylor *et al.* (1997) argued that a learning environment encouraging the construction of knowledge promotes an emancipatory ethos, giving both teachers and students the skills to become critically aware of the repressive myths of objectivism and control which govern schools and classrooms. The awareness promotes open discourse (Taylor & Campbell-Williams, 1993), consequently allowing students to (1) negotiate with the teacher about the nature of learning activities, (2) participate in the determination of assessment criteria and undertake self-assessment and peer-assessment, (3) engage in collaborative and open-inquiry with fellow students, and (4) participate in reconstructing the social norms of the classroom (Taylor *et al.*, 1997)—dimensions forming the scales CLES.

The CLES consists of five scales (*Personal Relevance*, *Uncertainty of Science*, *Shared Control*, *Critical Voice*, and *Student Negotiation*), and each scale comprises seven items to succinctly describe the scale. The final version of CLES consists of only positively-worded items with the items arranged in groups rather than cyclically. It has a response scale of *Almost Never, Seldom, Sometimes, Often and Almost Always*. The present study drew on three scales from the CLES, namely, *Personal Relevance*, *Critical Voice* and *Uncertainty in Science*, to include in the new instrument, SCLES (see Table 2.2 for the scale description, sample item and Moos' classification).

Table 2.2 Description and origin of each SCLES scale and its relevance to social constructivism in South Africa

Scale	Description	Sample Item	Moos' (1974) Category
	The extent to which…	*In my Natural Science class….*	
Investigation (ICEQ)	emphasis is placed on the skills and processes of inquiry and their use in problem-solving and investigation	I find out answers to questions by doing investigations.	System
Metacognition (Newly Developed)	learners are aware of how they think about their science ideas, i.e., by recognizing, evaluating and reconsidering their ideas	When I discuss my ideas about science to my classmates, I explain my reasoning.	Personal
Respect for Difference (Newly Developed)	learners are able to listen to and respect the views of others that is different from their own".	I listen to my classmates' opinions about science.	System & Relationship
Personal Relevance (CLES)	learning is relevant to students' lives	I learn about the world outside of school.	Personal
Collaboration (CLEQ)	students perceive they collaborate with others rather than act as individuals	I like working in groups.	Relationship
Critical Voice (CLES)	legitimacy of expressing a critical opinion	It's OK for me to question the way I am being taught.	Personal
Uncertainty in Science (CLES)	the status of scientific knowledge is provisional	I learn that science cannot provide perfect answers to problems.	System / Personal

ICEQ – Individualised Classroom Environment Questionnaire CLEQ – Cultural Learning Environment Questionnaire
CLES – Constructivist Learning Environment Survey

After meticulous conceptualization of CLES, the instrument was subsequently trialled in science classrooms in high schools. The CLES was validated internationally in numerous countries. For instance, in the United States of America (USA), with approximately 1600 students in 120 grade 9-12 science classrooms (Dryden & Fraser, 1996); in Thailand with 606 students in 17 classes (Puacharearn & Fisher, 2004); and in Korea with 1843 students in 42 classes (Kim, *et al.*, 1999). The CLES has also been validated in a cross-national study in Australia and Taiwan, with 710 students in 33 classes (Aldridge, Fraser, Taylor & Chen, 2000). A shortened version of CLES was used by Johnson & McClure (2004) with 290 students in upper primary, middle and high school. While locally, in South Africa, Sebela *et al.* (2003) administered CLES to 1864 learners in 43 mathematics classrooms, finding that the instrument is valid and reliable for use in South Africa.

The CLES has been modified for on-line use. Taylor and Maor (2000) designed the *Constructivist On-Line Learning Environment Survey* (COLLES), an online electronic questionnaire enabling one to readily monitor each students' preferred on-line learning environment and compare it with his/her actual experiences. Using social constructivism as its key pedagogical referent, the survey measures the students' and tutors' perceptions of the following scales: *Professional relevance*, *Reflective thinking*, *Interactivity*, *Cognitive demand*, *Affective support* and *Interpretation of meaning*. Thus, the fact that CLES was validated in different countries, in different classrooms, amongst different students, as well as used in a variety of settings, makes the questionnaire robust, and therefore can be used with confidence in the present study.

Individualized Classroom Learning Environment Questionnaire (ICEQ)

The ICEQ measures perceptions of the classroom environment along dimensions that differentiate conventional from open or individualized classrooms (Rentoul & Fraser, 1979). The dimensions were chosen to characterize the classroom environment described in the literature of individualized education (including open and inquiry-based classrooms). These dimensions were considered salient by a group of educational researchers, practicing teachers and high school teachers (Fraser & Fisher, 1982).

A distinguishing characteristic, as well as an advantage of the ICEQ, is that students or teachers can answer various forms of the questionnaire (Fraser & Fisher, 1982a). In fact, the ICEQ can measure the actual and preferred forms for both the students and the teachers, which allows for the investigation of differences between teachers and students in their perceptions of the actual and preferred classroom environment (see Rentoul & Fraser, 1980). Furthermore, these differences opens avenues to investigate ways in which classroom practice might be changed to align the actual classroom environment with the preferred classroom learning environment (Fraser & Fisher, 1982a, Fraser, 1981). In addition, the congruence between the actual and preferred learning environments can be assessed in relation to the scales in the final version of the ICEQ, namely, *Personalization*, *Participation*, *Investigation*, *Differentiation* and *Independence*, each assessed by ten items making up a total of 50 items in the questionnaire. Each item, with responses of *Almost Never*, *Seldom*, *Sometimes*, *Often and Very Often*, is scored on a 5-point scale. The scoring direction is reversed for approximately half the items. The present study drew on one scale from the ICEQ, namely, *Investigation*, to include in the new instrument, SCLES (see Table 2.2 for the scale description, sample item and Moos' classification).

Fraser (1981) validated the ICEQ using a sample of 766 students in Australia. The instrument was reliable and valid. McKavanagh & Stevenson (1992), however, found that the validity and reliability were not maintained through the five main scales and that some of the items needed restructuring. As a result, the factorial validity has not been properly established and replicated. The instrument, however, complements instruments like LEI (*Learning Environment Inventory*) and CES (*Classroom Environment Scale*) (Fraser & Fisher, 1982b) because it measures important individualized classroom dimensions that are often neglected in other instruments. Therefore, the ICEQ would not be useful on its own, but would be useful by using individual scales in combination with other instruments, as in the present study.

Cultural Learning Environment Questionnaire (CLEQ)

Fisher and Waldrip (1997) developed CLEQ to assess culturally sensitive factors in learning environments. The scales were chosen so that it could be classifiable into each of Moos' (1979) three general categories and Hofstede' (1984) cultural dimensions. The final version of the CLEQ contains seven scales, namely, *Equity*, *Collaboration*, *Risk involvement*, *Competition*, *Teacher authority*, *Modeling*, *Congruence* and *Communication*. Each of the seven scales is assessed by five items, making up a total of 35 items in the questionnaire. Each item is scored on a 5-point scale with responses of *Almost Never, Seldom, Sometimes, Often and Very Often*.

The CLEQ has been shown to be a valid and reliable instrument (Dhindsa, 2005; Fisher & Waldrip, 1999). It was validated in Brunei (Dhindsa, 2005) where the subjects were 831 upper secondary school students from a co-educational school. Factor analysis and reliability results showed that the instrument was suitable for evaluating the six scales and the results also suggested that students believed that both genders were treated equally in their class. Dhindsa (2005) modified the CLEQ for use in primary schools in this study. Part of this modification involved a reduction in the number of scales to three to alleviate workload for the students, namely, *Equity*, *Collaboration* and *Congruence*. These scales were selected because they were consistent predictors of students' attitudes and achievement in previous research using the questionnaire (Fisher & Waldrip, 1999). Therefore, the CLEQ (primary) contained 15 items which had been construct and content validated by teachers, students and fellow researchers. The present study drew on one scale from the CLEQ, namely, *Collaboration*, to include in the new instrument, SCLES (see Table 2.2 for the scale description, sample item and Moos' classification).

Fisher, Waldrip and den Brok (2005) used the primary version of CLEQ together with the *Questionnaire on Teacher Interaction* (QTI) on a sample of 2178 Australian in years 5, 6 and 7 in 103 primary classrooms. Results indicate that, after correction for covariates, *teacher proximity* (QTI) and *congruence* (CLEQ) are significantly associated with students' enjoyment in science. Also, strong associations were found between *teacher proximity* and all of the CLEQ scales. Thus, CLEQ has been found to be useful in combination with other questionnaires, and therefore only one scale was used to contribute toward SCLES for the present study.

Two Newly Developed Scales

As discussed earlier in this section, the dimensions were used as a basis for developing specific scales. Two of the dimensions, namely *Metacognition* and *Respect for Difference*, though strongly supported by the rNCS (DoE, 2002) and social constructivist literature, could not be matched by scales in the form described by the rNCS (DoE, 2002), and by literature currently available in the area of LER. Therefore, these two scales were specifically developed for the purposes of the present study. Firstly, in the case of the scale *Metacognition*, though there have been instruments in the field of LER which have developed scales to measure the dimension *Metacognition*, the definitions have not matched those of the rNCS (DoE, 2002). For instance, the fields of LER and metacognition merged through the development of the instrument the *Metacognitive Orientation Learning Environment Scale* (MOLES-S) (Thomas, 2003). In this instrument, metacognition was defined as the extent to which psychosocial conditions enhance students' metacognition. Moreover, Thomas (2002a) proposed that the beliefs and practices of the communities within which students learn and reason strongly influence their metacognition, in which language plays an important role, and therefore he framed the development of the instrument on social constructivist views, similar to the present study. Furthermore, the scales in the instrument, namely, *Metacognitive Demands*, *Teacher Modelling*, *Student-student Discourse*, *Student-teacher Discourse*, *Student Voice*, *Distributed Control*, *Teacher Encouragement* and *Support and Emotional Support* acknowledge that students should not be passive players in determining their roles in the classroom. Therefore, the development of MOLES-S pioneered an instrument that gave a quantitative snapshot of the metacognitive orientation of a classroom learning environment.

With MOLE-S as a foundation, Thomas and Au Kin Mee (2005) later conceptualized a new instrument, the *General Studies Metacognitive Orientation Scale* (GSMOS) to be used in primary schools in Hong Kong. This mixed-method study combined the use of the questionnaire with student interviews and classroom observations. The results showed that students developed metacognitive knowledge of teacher-selected thinking and learning strategies, as well as some awareness and limited control of their use of such strategies in their classroom. Other studies that took on a more qualitative approach to metacognition, yet still incorporated learning environments research, assessed how students' metacognitive functions are linked to posing questions in computerized learning environments (Kaberman & Dori, 2009), and more recently probed metacognition and reflective inquiry through a collaborative study—the *Metacognition and Reflective Inquiry* (MRI) (Anderson, Nashnon & Thomas, 2009).

In the context of the present study, as described earlier in this chapter (page 15), the dimension *Metacognition* was described as students 'thinking about their thinking' (Gilbert, 2005). Moreover, though the development of MOLES-S provided an instrument that gave a quantitative snapshot of the metacognitive orientation of a classroom learning environment, it did not frame metacognition in the context of the conceptual change theory, as was required for the present study by the rNCS (DoE, 2002). Furthermore, the development of the scale contextualized the study, and as described earlier (see page 15), the scale definition was derived from Hewson *et al.* (1998), who developed a set of guidelines that characterize the significant steps of teaching for conceptual change from the literature, namely: ideas, metacognition, status and justification. Of the four, the importance of *metacognition* was recognized by Gunstone (1994) who pointed out that a learner needs to be metacognitive in order to go through the conceptual change process. Gunstone and Northfield (1992) formulated the conceptual change process in three steps, namely, the students recognizing their ideas; evaluating them, and deciding to reconstruct them on the basis of their dissatisfaction or fruitfulness of the idea. Hence, students are able to monitor, integrate and extend their own learning, and are therefore likely to use good learning behaviours (Gunstone, 1994) (i.e., 'thinking about their thinking'). The items that defined the *Metacognition* scale in the present study were reflected in these three main steps. In other words, the aim of the scale was to determine whether learners were actually 'thinking about their thinking'. Hence, the definition of the scale is '*the extent to which students are aware of how they think about their science idea* (*i.e., by recognising, evaluating and reconsidering their ideas*') (see Table 2.2 for a sample item and Moos' classification).

Secondly, with regard to the scale *Respect for Difference*, having created a learning environment where students are able to monitor, integrate and extend their own learning through metacognition, with their reasoning being strongly influenced by their socio-cultural background, voicing their opinions in class might create many contentious situations. Moreover, as discussed in the last section, in a plural society like South Africa, where "learners in the Natural Science Learning Area think in terms of more than one world view" (DoE, 2002: 12), students should be tolerant—by allowing the voices of all children and the communities they come from to be heard in the classroom. Therefore, all opinions need to be respected in light of the fact that contentious situations might influence the classroom learning environment resulting in a need for teachers to monitor learning situations with regard to students respecting each other's opinions. Though the MOLE-S takes into account contentious situations through the affective scales *Teacher*

Encouragement, and *Support and Emotional Support*, these or other learning environment scales do not adequately encapsulate the scale *Respect for Difference* in the way that the rNCS (DoE, 2002) requires. Consequently, this necessitated the development of a new scale for the present study.

The new scale *Respect for Difference* is a measure of the degree to which teachers and students in the class support each other's ideas considering the multicultural contexts that exist within a single classroom in South Africa. Being multicultural implies that most students and teachers have different worldviews, and each view should be respected (DoE, 2002) during social interactions. The items that make up the new scale determined whether the teacher—the main authority figure in the class—encouraged the students to feel comfortable enough to express their own opinions about science (and themselves) in an open classroom setting that encourages respect for difference. In other words, that the teacher was creating a social constructivist learning environment that encouraged social interactions based on respect. The scale is important because research has shown that Western Science has been dominating science education and has created the expectation that students should accept Western Science and reject Indigenous Knowledge Systems (IKS) (Aikenhead, 2006). Students who learn in a class encouraging social interactions might feel distanced from the learning process if not given opportunities to participate; consequently science becomes less meaningful and therefore detrimental to achievement (Aikenhead, 2006: 85). Hence, the definition for this new *Respect for Difference* scale is: '*students are able to listen to and respect the views of others that are different from their own*' (see Table 2.2 for a sample item and Moos' classification).

In the next section, the literature on the learning outcomes, namely, attitude toward science and gender equity is reviewed, followed by a short review of the literature on socio-economic status in the final section.

Student Attitude Toward Science

Students spend many hours in their science classrooms. The concept students' attitude toward science is important in schooling, yet the concept is bedeviled by lack of clarity in the literature (Osborne, 2003). Indeed, Germann (1988) claims that definitions of the concept are vague, inconsistent and ambiguous. Thus the credibility of the concept is highly influenced by a clear and focused definition of the term.

The concept attitude toward science has long been used in the field of LER. The perspective adopted in many studies has been an affective one, related to the favourable or unfavourable feelings about people, places, events or ideas (Freedman, 1997). For instance, statements such as "I like science" or "I enjoy science" have been used to define attitude toward science (Papanastasiou

& Papanastasiou, 2004) in the LER studies. Indeed, in the past, the development of attitude toward science was built from a set of affective behaviours in science education (Klopfer, 1971). The affective behaviours were categorized, and then related to the development of different aspects of attitudes. Initially, three categories succinctly described attitude toward science within an affective framework, namely, the acceptance of science inquiry, the adoption of 'scientific attitudes', and the enjoyment of science learning experiences. Later, Klopfer (1976) expanded on the categories by adding specific characteristics, namely, '*Manifestation of favourable attitudes toward science and scientists'*; '*Acceptance of scientific inquiry as a way of thought'*; '*Adoption of scientific attitudes'*; '*Enjoyment of science learning experiences'*; *Development of interest in science and science-related activities'*, and '*Development of interest in pursuing a career in science'*. The current study relates the learning environment to how students feel about their science class, and therefore draws on one category described by (Klopfer, 1976), namely, the '*Enjoyment of science learning experiences'*, which best assesses students' overall enjoyment of their science classroom experience.

Attitude toward science has been measured in different ways. Examples of attitude toward science measures have been varied, for instance, subject preference studies where students are asked to rank their liking of school subjects (Osborne & Collins, 2000), interest inventories listing items and asking students what interests them and subject enrolment (Osborne, 2003) and qualitative methods (Baker & Leary, 1995, Osborne & Collins, 2000). It has generally been found that attitudinal scales are more statistically reliable and valid than other measures of student attitude toward science (e.g., Osborne & Collins, 2000). Indeed, Fraser (1977a & b; 1978a & b) developed the attitudinal scale the *Test of Science-Related Attitudes* (TOSRA) based on Klopfer's (1971) affective classification of science objects. The scale was developed to overcome three major problems related to measuring attitudes toward science in past studies, namely, low statistical reliability, lack of economy of items and lack of unidimensionality (Gardner, 1995). The development of TOSRA was an important milestone, not only in LER, but also in the area of attitudes toward science. It avoided the mistakes made in the study of Moore and Sutman (1970), who was highly criticized by Munby (1983) for the inconsistent results and the lack of reliability in their results. Furthermore, the study of Moore and Sutman (1970), being one of the first and well-known attitude scales assessing the emotional and intellectual attitudes toward science amongst science secondary school students, was furthermore criticized because the attitude objects measured were related to science and society, and not to attitude toward science as a school subject (Osborne, 2003). In addition, there was no single construct underlying a given scale, which goes against the internal consistency and unidimensionality (Gardner, 1995) required of a reliable instrument. Hence, the misjudgments from Moore and Sutman's (1970) study informed the development of TOSRA resulting in it being more statistically reliable and valid.

TOSRA can be considered a strong attitude scale, as its past development took into account issues raised by the guidelines recently developed by Kind, Jones and Barmby's (2007), which suggest four guidelines for the development of a valid and reliable attitude scale. In fact, of the four guidelines suggested by Kind *et al*. (2007), the first three, namely, taking into account clear descriptions of the constructs, justifying the combined constructs, and the reliability of the measures (internal consistency by Cronbach Alpha and unidimensionality through factor analysis), have largely been implemented during the development of TOSRA. The scales for TOSRA were developed to match Klopfer's (1971) categories described above. Fraser's (1981) scale names for TOSRA were *Social implications 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*. Following the conceptual development of the scales for TOSRA, the items were developed. Consequently, the initial version of TOSRA consisted of seven scales and fourteen items, based on a choice of options from a five-point Likert scale (1932) consisting of *Strongly Agree/Agree/Undecided/Disagree and Strongly Disagree*. The items were derived from free responses generated by science teachers and experts, which is a major justification for the validity of TOSRA. These items were then reduced to a set of reliable and usable items informed by the pilot study. The initial version of the TOSRA was field-tested and, after statistical item analysis, was reduced to ten items of seven scales (Fraser, 1977b).

The TOSRA was validated in numerous studies, in numerous grades, subjects and even cross-nationally. The current study has drawn on a modified version of the *Enjoyment of Science Lessons* scale, with negatively and positively worded items, challenging students to pause and think about each statement rather than choosing similar answers for all items. The *Enjoyment of Science* lessons scale has been used in many other studies to assess students' overall attitude toward science (Aldridge *et al.*, 2006; Fisher *et al*., 1997a; Henderson & Reid, 2000; Kim *et al.*, 1999, 2000). The TOSRA have been used variously, where in some studies, TOSRA was modified to use one or a few scales; cross-national studies have used TOSRA in Australia and Indonesia involving 1161 students in 36 countries (Adolphe, Fraser & Aldridge, 2003); and furthermore, other studies occurred in different contexts, like in Singapore amongst 1592 Grade 10 chemistry students (Wong & Fraser, 1996) and amongst 1346 students in Australia (Dettrick, 1990).

Gender Equity

The importance of equity in science classrooms has been acknowledged by the rNCS (DoE, 2002). Many have argued that the legacy of Apartheid have left unequal contexts (see Chapter 1) and, consequently, equity has been elusive (see Fiske & Ladd, 2004, 2005), primarily because it is such a multifaceted societal issue out of teachers' control. However, one form of equity which teachers are more likely to manage in classroom teaching is that of the equal treatment of males and females, described as gender equity.

Indeed, Bailey (1993) reviewed the literature on gender equity and found that there are different ways of describing the term. In general, gender equity has been described as teachers creating an environment encouraging the equal treatment of males and females in their classes. Thus, teachers through their teaching, are able to do so in numerous ways, for instance, through their interaction patterns with the students (Hall & Sandler, 1982; Jones, 1989), student-student interactions (Lockheed, 1984; Wilkerson & Marrett, 1985), content of curricula materials (Huff & Cooper, 1987), school organisation factors (Oakes, 1990) and extracurricula activities (Berrien, 1990; Isaac & Shafer, 1989). Indeed, a typical example of the equal treatment of males and females can be achieved through teacher-student interactions. Studies in this area reflect the imbalances in the amount of attention teachers pay to boys compared to girls (Jones & Wheatly, 1990; Morse & Handley, 1985). Baker (1986) found that teachers in science lecture classes questioned boys on subject matter 80% more often than they did girls. Furthermore, Tobin & Garnett (1987) found that 79% of classroom science demonstrations were conducted by boys. Therefore, if teachers are not aware of the consequences of gender imbalances in their classroom, then boys might dominate science classes, which might have negative effects on the confidence of girls in science classrooms.

Teachers also play an important role in creating gender equity in their classrooms through making males and females students aware that they have opportunities to engage with teaching methods which best support them (Bailey, 1993). Indeed, teachers can identify specific tasks viewed positively by males or females, and then possibly find the reasons why this is so. Thus, by actively searching for factors and reasons behind males and females preferring specific ways of teaching in particular contexts, teachers might avoid the potential flight of any of the sexes from science—a phenomenon currently experienced in many countries (e.g., Osborne & Dillion, 2008). More importantly, teachers might also avoid the image of science as a masculine subject. Indeed, an analysis of two nearly identical Australian and American studies (Kahle, Parker, Rennie & Riley, 1993) showed a relationship between gender and the subject Science. The findings strongly suggested that teachers play an important role in communicating gender equity in their classes through gender fair teaching, and if gender fair teaching is ignored, then they might negetively influence the student outcomes, achievement and attitude toward science. The study suggested that teacher training in gender equity is pivotal to eradicate negative images of science often perpetuated by society. For instance, it has been found that the masculine image of science is promoted by society, and that if teachers are not trained in gender equity, then it is very likely that teachers in the classroom setting might inadvertently construct the same image during lessons (Bailey, 1993). Moreover, in an environment where gender equity is ignored, then males are likely to achieve higher academically than females, and thus it might influence females' attitude toward science. Therefore, the pervasive and persistent effect of the masculine image of science on both teacher and student beliefs and attitudes, suggests that teachers should be aware of gender equity through gender fair teaching methods in their classes.

Recent research has shown that young females tend to show more interest in environmental and biological sciences, while young males tend to lean toward physical sciences (Farenga & Joyce, 1997ab). Moreover, international literature has shown that at the age of 14, interest in pursuing a further involvement in science has already been formed (Osborne & Dillon, 2008). For instance, in a recent analysis of data collected by the US National Educational Longitudinal Study, Tai, Qi Lui, Maltese & Fan (2006) showed that by age 14, students with expectations of science-related careers were 3.4 times more likely to gain physical science and engineering degree than students without similar expectations. Further evidence suggests that children's life-world experiences are a major determinant of any decision to pursue the study of science (UK Royal Society, 2006). And even more importantly, children younger than 14 are influenced by what happened outside their classroom, in other words, what happens outside the classroom is as important as what happens inside the classroom (Osborne & Dillon, 2008). The above evidence therefore suggests that engaging students (especially girls) with interactive pedagogy—like social constructivist teaching approaches—before the age of 14 is critical, that is at or before Grade 9 level. After this time, however, student interest in science declines, especially during middle and high school (Alexakos & Antoine, 2003) and this coincides with a decrease in performance, even in cases where students who scored well in middle school did not perform as well in high school (NCLB, 2001).

Thus, for teachers to create gender equity through gender fair teaching practices in their learning environments, it is pivotal that they introduce gender-fair teaching at the appropriate time in the students' development and those teachers become skilled through appropriate training to sensitize them to the methods that would best promote gender equity.

Socio-economic Status (SES)

Socio-economic status (SES) is a measure of an individual's or group's standing in the community, usually related to the income, occupation, educational attainment and wealth of either an individual or a group (Demarest, Reisner & Anderson., 1993). It is a set of 'contextual givens' that dictate neighbourhood, housing, and access to resources that affect enrichment or deprivation as well as the acquisition of specific value systems (Crnic & Lamberty, 1994).

A family's SES is based on family income, parent education, and social status in the community (Damarest *et al.*, 1993). These variables are often summarized in a single figure or socio-economic index. As there is no general agreement on the definition of socio-economic status (Majoribanks, 1979; Teddlie & Reynolds, 2000; Van der Berg & Burger, 2003), different socio-economic indexes are constructed for different uses. Therefore, various studies have operationalised SES as, for example, poverty level (Crouch & Mabogoane, 2001), parental education and/or occupation and household income (Anderson, Case & Lam, 2001; Case & Deaton, 1999; Coleman *et al*., 1966) and family income (Demarest *et al.*, 1993).

The choice of schools that students attend is very likely influenced by their family income, particularly the amount parents are willing to pay for school fees (see Chapter 1, page 7). By definition, educational status and material resources increase with SES (Lareau, 1987). Parents of higher SES groups experience more autonomy, intellectual complexity, self-direction, and freedom in their lives and thus their children value self-direction and intellectual curiosity (Ramey & Ramey, 1994). For instance, in the middle-class community, parents generally perceive education as a shared enterprise and scrutinize, monitor, and supplement the school experience of their children (Lareau, 1987). Furthermore, these parents would very likely become intensely involved in their children's lives because they have the economic resources, for example, to hire tutors, arrange time to meet with the teachers, and so forth. Thus, middle-calss parents are more likely to be involved in their childrens' schooling at many levels.

On the other hand, working-class parents generally have poor educational skills, lower occupational prestige with the teachers, limited time at their disposal, as well as limited disposable income to supplement and intervene in their children's schooling (Ramey & Ramey, 1994). These parents' lives are generally characterized by routinisation and lack of autonomy leading to restrictive parenting, placing more emphasis on conformity rather than independent thinking (Flanagan, 1993). Although interpretations vary, some literature further suggests that lower-class and working-class families do not value education as highly as middle-class families (Lareau, 1987), with further claims that middle-class family's feel more welcome at schools than lower and working-class families (Lightfoot, 1978f; Ogbu, 1974). Thus, the experience of middle-class and working-class childrens' schooling differ.

As was evident in Chapter 1 (page 5-7), middle-class parents' ability to pay higher school fees, generally give middle-class students better schooling experiences because of the better quality peers, better quality teachers and better contexts they exerience. First, middle-class students typically arrive in classrooms with fairly broad experiences and a foundation for making the leap from personal experiences to formal knowledge, while the limited knowledge of disadvantaged students probably lets them struggle to do this (Bernstein, 1996). Furthermore, Bernstein contends that students are influenced by two codes of meaning, that is, the informal community code and the formal school code. In order to progress in subjects like Mathematics and Natural Science, with 'vertical demarcation requirements' (Chisholm *et al*., 2000) (i.e., they have long, interconnected conceptual chains of increasing abstraction [Taylor *et al.*, 2003: 133]), students are expected to progressively master the school code and to appropriately switch between the two codes. Consequently, students from higher SES backgrounds are probably of a better quality when entering school because they are generally better prepared at home to transition to the formal codes of schooling than poorer working-class students.

Second, teachers who teach in middle-class schools are generally better quality teachers because they are often better qualified (see Chapter 1). Spillane (2002) argues that the teachers' interpretation of the curriculum, which is referred to as recontextualisation, is influenced by two inter-related factors, namely, their cognitive processes, and the contexts that they work in. The first factor, their cognitive processes, is important in the teachers' interpretation of policy as teachers "make sense" of what policy requires of them before they respond to policy requirements (Spillane, 2002). Beeby (1966: 84) observes that:

> The effect of inadequate general education on teacher's acceptance of new practices operates at two levels, the intellectual and emotional. For example, a teacher with no more knowledge of science than snippets he picked up at primary school may not simply have enough familiarity with his subject matter to let go of his few memorized 'laws' and disconnected facts and launch himself on to the deep stream of teaching by problem-solving, where heaven knows what new questions might arise.

Thus, teachers who are better prepared in terms of their cognitive processes, influenced by their background, training and level of confidence (Rogan, 2000), are more likely to interpret the curriculum to the needs of the students.

Third, teachers are also influenced by the contexts they work in, that is the schools they teaching at. Beeby (1966) presented a model to categorise schools into four stages of development, from 'lower' to 'higher' stages, the model was later expanded into a more comprehensive one by Verspoor and Wu (1990) and later de Freiter, Vonk and van den Akker (1995), similarly proposing four stages, namely, Unskilled, Mechanical, Routine and Professional. These two models are significant because, given the lack of evidence about how teachers in South Africa are influenced by their context during teaching (see Chapter 1), these can be used as guides to help teachers develop in various contexts. Furthermore, the usefulness of Beeby's (1966) model lies not so much in the stages (which are a continuum), but in the elements that span these stages. The model can act as a guide, suggesting types of interventions that are likely to be successful depending on the level at which the school is at. The model suggests that the implementation strategy followed need to be guided by factors associated with the teacher (such as their professional background) as well as the differing realities of the school. For example, a teacher with a high level of professionalism—as described by the Verspoor model—is well trained, has good subject mastery, is interested in improving student performance, and will therefore have the confidence to master and adapt an innovation to fit the needs of the student. On the other hand, shortage of physical resources is certainly one factor that could impede implementation. Beeby (1966: 76) notes:

> A teacher with fifty to eighty children in a small bare room, with no equipment but a blackboard, a piece of chalk, and a few miserable dog-eared textbooks, with not enough pencils and pieces of paper to go around,…, can scarcely be expected to encourage the unfolding of personalities and the emergence of creative minds.

Fourth, context can also influence how teachers recontextualise. Teachers are considered to be students who are engaging in "sense making", a learning process situated in their community of practice (Spillane, Reiser & Reimer, 2002). The institutional contexts, also referred to as "communities of practices", are considered critical in teachers' interpretation of policies because these contexts promote or constrain interpretation and practice (Spillane *et al*., 2002). In combination, recontextualisation (Spillane, 2002) and the developmental readiness of the school as described by the Verspoor model, influences the teachers' teaching strategies. Moreover, most teachers know more teaching strategies than they can actually use, which can be encapsulated in the term 'pedagogical content knowledge' (Shulman, 1987), which is a combination of the subject knowledge, pedagogic skills and viewpoints of what it is to be a better teacher. Johnson, Monk and Hodges (2000) intimate that the classroom practice that the teacher use for a particular group of students on a particular day with a particular topic can only be selected from the teacher's stock of pedagogical content knowledge. Particularly, science teachers who should be at anything less than the professional stage are more so influenced by the environment that they teach in. Furthermore, the environment exerts a selection pressure on which a teacher's pedagogic strategies are successful. In other words, success lies in the 'fit' between the teaching strategy and the environment, where 'unfit' ones are not repeated unless the environment changes (Johnson *et al.*, 2000). Thus, the classroom shapes the teachers' behaviour. If this is so, then classrooms with better resources and better qualified teachers, very likely middle-class schools (see Chapter 1, pages 1-2 & pages 6-7), have a better chance of success in implementing an innovation, like the implementation of a new curriculum, which supports Bernstein (1996) argument that SES influences classroom practice.

Chapter Summary

In this chapter, the literature of the conceptual basis for the current study is reviewed. The literature on constructivism, LER, students' attitude toward science, gender equity and SES is thus reviewed, while a detailed analysis of the rNCS is given.

First, the review of the literature on constructivism showed that individual and social constructivism is central concepts in the rNCS's interpretation of the construction of knowledge. The rNCS uses an integrated approach combining elements of the two forms of constructivism, with more emphasis on social constructivism. However, though constructivism is advocated internationally and locally, it has many criticisms. These criticisms are discussed in the context of classroom teaching.

Second, the rNCS's support of outcomes and its relation to social constructivism is shown. In an environment with a social constructivist orientation, the key features highlighting its social constructivist emphasis are shown to be supported by the rNCS through quotes from the actual curriculum. Once identified, these key features would form the foundation of the new questionnaire, developed to assess whether Grade 9 Natural Science teachers in the Western Cape Province, are implementing social constructivist learning environments.

Third, through the review of the LER literature, the key features identified to form the basis of the new instrument, the SCLES, is operationalised to scales. The scales are drawn from numerous valid and reliable instruments developed in past LER studies. To put these instruments in context, the history of LER is reviewed. Then, numerous lines of research are reviewed to identify appropriate and essential research methods previously employed in similar studies in LER. Some of the lines of research include associations between student outcomes and the environment, evaluation of educational innovations, differences between student and teacher perceptions of the actual and preferred environment, determinants of the classroom environment, use of qualitative methods and cross-national studies and past South African learning environment research is reviewed. Finally, selected scales are drawn from primary questionnaires, as well as the development of two new scales, to form the SCLES.

In the next part of the chapter, the key student outcome of students' *Attitude toward Science* is reviewed. Here, it is shown that the development of attitude toward science for the present study is historically used in the affective sense, as in many LER studies. Furthermore, the scale attitude toward science is drawn from a modified questionnaire, the TOSRA, and the development of this questionnaire is reviewed.

The second student outcome, gender equity, is shown to be developed from a definition of males and females being treated equally in classrooms. In this sense, teachers should use gender fair teaching techniques in their classroom in order to give both sexes equal opportunities in learning, and thus to improve the student outcomes students' attitude toward science and achievement.

In the final part of the chapter, the literature on SES is reviewed. It is shown that a major definition of SES is in line with family income. It is further shown that family income strongly influences the school fees parents are willing to pay, and thus the type of school students attend. Parents, who are willing to pay higher school fees, most likely send their children to middle-class schools. Consequently, these students experience better quality peers, better quality teachers, and better contexts. Thus students have different experiences in their schooling and teachers have varied opportunities to interpret the curriculum to the needs of the students they teach. In the next chapter, the research methodology is described.

Chapter 3
RESEARCH METHODOLOGY

Introduction

Before describing the research methodology, a detailed account of the research design is given in order to put it in context with the present study, and then ethical issues are considered before the collection of the data. The research methodology is carefully described in eight stages. In the first six stages, the collection of the quantitative data is discussed with regard to the development of the instrument, pilot study, sample used, administration of the new instrument, the capturing and cleaning of the data, and the analysis of the quantitative data. In the next two stages, the qualitative data is discussed with regard to its collection, and then the analysis of the qualitative data. Finally, a summary of the chapter is given.

Research Design

The study used a contemporary research design involving mixed-methods (e.g., Tashakorri & Teddlie, 2003), which took place in two phases, namely, a large-scale quantitative data collection phase, and then a small-scale qualitative data collection phase. Using the mixed-method approach was anticipated to provide credible and trustworthy answers to the research questions posed in Chapter 1.

Mixed-Method Approach

The purpose of using mixed-methods is to make sense of complex social phenomena that cannot be fully understood using either quantitative or qualitative techniques on their own. Mixed-methods have developed only in the past thirty years (Tashakorrie & Teddlie, 2003). Prior to this, there was much debate regarding the mixing of methods. Most researchers were reluctant to mix quantitative and qualitative methods because the incompatibility thesis stated that it is inappropriate to do so (Tashakorrie & Teddlie, 2003, Greene, Caracelli & Graham, 1989). A change in this view occurred only recently, when authors (e.g., Tashakorrie & Teddlie, 2003; Howe, 1988) confirmed that quantitative and qualitative methods are compatible, and has resulted in many more investigators using this approach in their research.

Mixed-methods have many more advantages above the exclusive quantitative and qualitative methods. Tashakorri and Teddlie (2003) suggest three important advantages. First, mixed-methods can provide answers to research questions that the other methods cannot. Qualitative research questions tend to be exploratory which are typically concerned with theory generation, while quantitative research questions tend to be confirmatory, which are typically more concerned with theory verification. Mixed-methods enable the researcher to answer confirmatory and exploratory questions, and therefore to verify and generate theory in the same study.

Second, mixed-methods can offset the disadvantages that certain of the quantitative and qualitative methods have by themselves, mixing the complementary strengths and non-overlapping weaknesses of the two methods. Greene *et al.* (1989) proposed five functions of this approach, namely, triangulation, complementarity, development, initiation and expansion. In the case of the first two functions of mixed-methods (i.e., triangulation and complementarity), triangulation can help overcome the weakness and/or intrinsic biases and problems that come from a single method, while complementarity can lead to multiple inferences, confirming or complementing each other (Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 2003). The other three functions (i.e., development, initiation and expansion) are more related to mixed-methods studies in which inferences are made at the end of one phase (e.g., quantitative), leading to questions and/or design of the second phase (e.g., qualitative). Thus, by offsetting the disadvantages that the methods have by themselves, the validity of the results can be maximised.

Third, different inferences from mixed-methods can often reflect different voices and perspectives, which is welcome because it can lead to the re-examination of the conceptual frameworks and assumptions underlying each of the components (qualitative and quantitative) (Tashakkori and Teddlie, 2003). Thus, mixed-methods is largely an investigative process where the researcher gradually makes sense of social phenomena by shaping the way the researcher perceives the world through contrasting, comparing and classifying the objective of the study.

On the other hand, there are some disadvantages associated with mixed-methods, some of which are outlined next. Firstly, it might be very time-consuming collecting both quantitative and qualitative data, and even more so when collected separately. Secondly, it might be very cumbersome to ensure that data be analysed before proceeding to the next stage in research, which adds to the time-consuming nature of the approach. Finally, in order to do meaningful research, it is necessary that the researcher be familiar with both quantitative and qualitative forms of research. Thus, in light of these challenges, the mixing of methods requires careful planning. A strategy that guides the planning process, and sequences the methods, is the sequential mixed-method strategy, which will be described in the next section.

Sequential Mixed-Method Strategy

The sequential mixed-method strategy enables one to plan the research process by setting the order of the data collection strategy. As a first step, the researcher has to decide whether to collect the quantitative or qualitative data first. In the present study, priority was given to the quantitative data so that data could be collected to determine students' perceptions of their actual and preferred learning environment through a newly developed questionnaire. This was followed by the collection and analysis of the qualitative data, primarily to obtain explanations for the trends observed and thus maximizes the trustworthiness of the results.

Sequentially seperating the quantitative and qualitative data collection phases ensured that steps could be taken within each of the phases to maximize the validity of the results. First, by applying the idea of 'grain sizes,' that is, the use of different-sized samples for different research questions varying in extensiveness and intensiveness (Fraser & Tobin, 1991; Tobin & Fraser, 1998), a more in-depth picture and understanding of the issues related to constructivism, especially the socio-cultural influences on the classroom learning environment, was created. This concept have been successfully used in reputable learning environment studies (e.g., Aldridge *et al*., 1999ab), hence its use in the present study. Second, to maximize the validity of the SCLES questionnaire and the *Attitude toward Science* scale, factor analysis and scale reliability was performed on the data (see Chapter 4). The achievement test was checked by experts to ensure that the questionnaire was at the level appropriate for Grade 9 students. Third, the validity of the qualitative data was guided by Lincoln & Guba's (1989) criteria of *prolonged engagement* (i.e., the amount of time spent building a rapport and trust with participants in order to understand the context more fully); *persistent observation* (i.e., the duration and number of observations—which should be sufficient to enable the researcher to identify crucial characteristics of the case); and *member checks* (i.e., sharing of ideas and emerging hypotheses with participants to establish credibility and to ensure that a realistic picture is presented). Thus, the rigour practiced maximized the validity of the results.

Trust was an important issue to consider during the qualitative data collection phase. Lincoln and Guba (1985) suggest that trust is pivotal to the validity and trustworthiness of data supplied by the participants. Their research also suggests that respondents are more likely to be both candid and forthcoming if they respected the inquirer and believed in his or her integrity. The integrity of the researcher was boosted when teachers were aware that the researcher came from a teaching background, allowing the teachers to feel supported and therefore to confidently communicate about many aspects of teaching as was evident during teacher interviews. Moreover, similarly, the students claimed during interviews that they trusted the researcher. First, they claimed that the researcher communicated the goals of the research to them, which made them understand why they were being interviewed. Second, they were allowed to ask questions about the research, enabling them to understand the researcher's questions, and thus they communicated in an open and honest manner. Third, the fact that they could voluntarily participate, whilst the researcher kept the information confidential, made them feel confident, and thus they communicated in an open and honest manner. Thus, these factors contributed significantly toward teachers and students trusting the researcher and her research, and thus influencing their candid and forthcoming responses during interviews.

Application of the Sequential Mixed-Method Strategy

The sequence for the data collection and analysis for the present study is illustrated in Figure 3.1. It shows how the methods were combined sequentially by following up the main quantitative data collection phase of the study with a smaller qualitative data collection phase in order to compare the classroom learning environment of Grade 9 classrooms. Phase 1 involved the collection of quantitative data through a newly developed learning environment questionnaire (SCLES) (see Chapter 2). As this phase formed the major part of the study, it was referenced 'QUAN' (Figure 3.1), in line with conventions used by Tashakkori and Teddlie (2003). The QUAN data collection involved two steps: firstly, administering the questionnaire to 200 students in five schools, and then 1955 students in 52 schools, during the pilot and large-scale studies respectively. Following the large-scale study, the QUAN data were analysed. Here, once again, the validity of the data was maximised through a number of steps, namely, refining and validating the questionnaire (factor analysis), obtaining further evidence of validity (scale reliability) (see Chapter 4), finding significant associations (correlations and multiple regressions), and looking at the patterns of the actual and preferred responses by producing graphic profiles of the trends (of the six scales) for each of the 52 schools (these steps are described later in Chapter 4). The QUAN data were used as a springboard for further data collection. The graphic profiles of the 52 schools generated during the QUAN phase were scrutinized, after which five schools were chosen for further analysis through classroom observations, as well as and teacher and student interviews during Phase 2, the qual phase. These data were combined to produce narrative stories, which comprised the interpretative phase of the study (Figure 3.1). Before, during and after the QUAN and qual data collection phases, ethical issues were always considered. These are discussed in the next section.

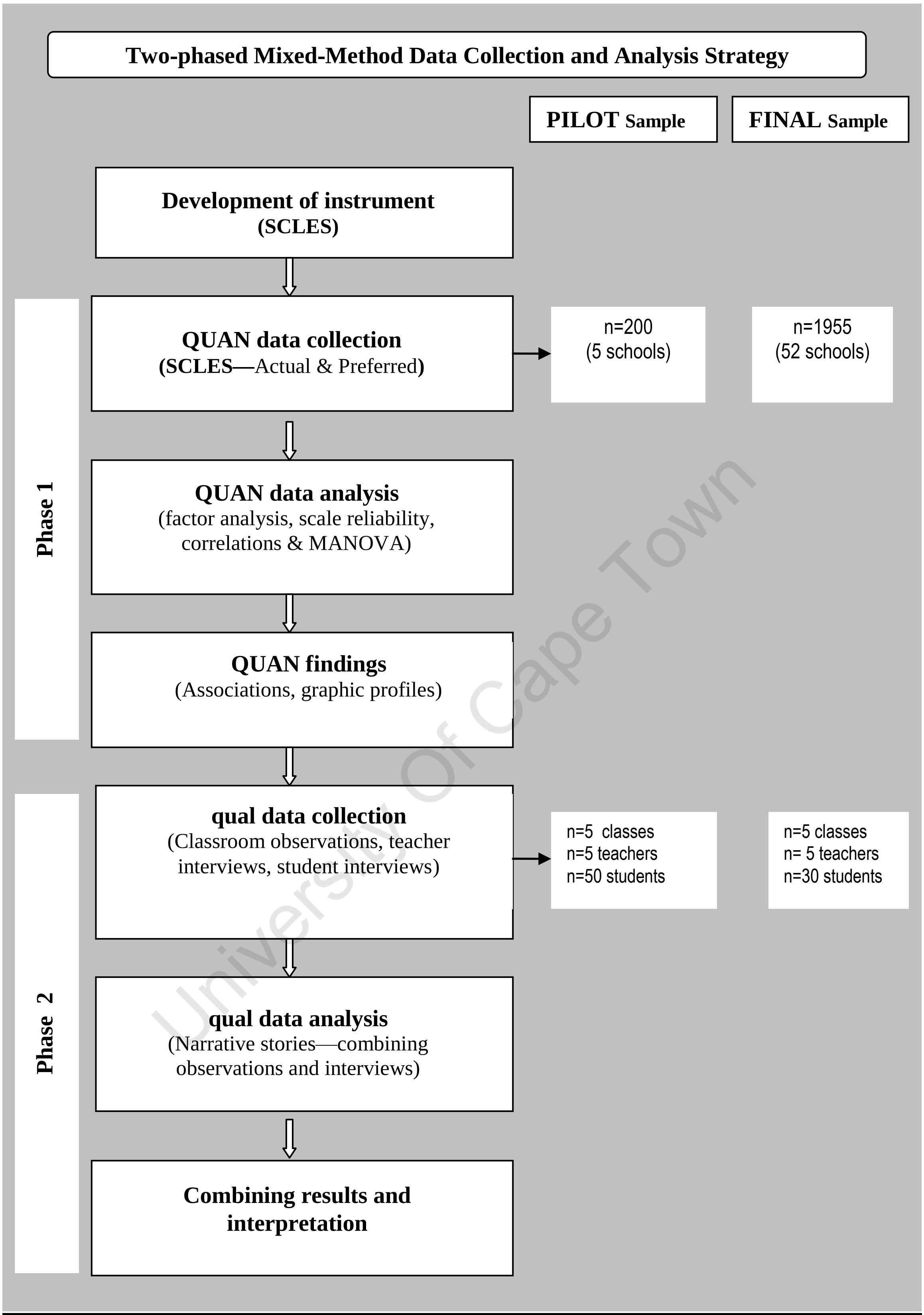

Figure 3.1 Diagrammatic representation of the two-phased mixed method data collection and analysis strategy.

Ethical Issues

The researcher has an obligation to respect the rights, needs, values and desires of the informants (Cresswell, 2003). Entering a teacher's classroom was obtrusive, especially, in the present study, where prolonged periods of time are spent in the classroom through administering the questionnaire, observing the class, interviewing the participants and taking detailed notes. At any stage during the course of the study, it might have been possible that sensitive information were revealed. Therefore, out of concern for the school, teachers' and students' positions, the following safeguards were employed:

1) The researcher applied for permission to conduct research at public schools in the Western Cape through the Western Cape Education Department (WCED). The WCED subsequently addressed a letter to principals and teachers stating that the researcher could conduct research at their school (see Appendix 1).

2) Before administering the questionnaire, detailed instructions were explained to the students. Students were also informed that the completion of the questionnaire was confidential and voluntary, which gave them the option to withdraw from completing the questionnaire.

3) The names of the students and schools were kept confidential. During the capturing process, teachers' and students' names were encoded, and could only be de-coded by the researcher, who also used these codes to track specific questionnaires if queries arose.

After considering the ethical issues, the methods involved in the research were conducted.

Research Methods

In this section, a detailed account of all the stages the researcher followed to develop the instrument, collect data and analyse the data is provided. This account comprises seven stages, starting with the development of an instrument to be used for the collection of quantitative data. The second stage involved describing the pilot study, where the instrument was piloted with a few schools. The third stage involved the administration of SCLES, where the newly developed instrument was administered in one classroom from 52 sample schools. The fourth stage involved capturing and cleaning the data collected during the quantitative collection. Once captured, the fifth stage involved analyzing the quantitative data. In the sixth stage, preliminary findings from the quantitative data were used to choose a sub-sample of the classrooms for the qualitative data collection phase. Finally, the analysis of the qualitative data is described in order to arrive at informed inferences, and to provide credible and trustworthy answers to the research questions.

The Quantitative Data

During the quantitative data collection phase a newly developed instrument captured the Grade 9 Natural Science students' perceptions of important dimensions (see Chapter 2) describing their social constructivist learning environment. Grade 9 students were chosen for the present study as these students are at the end of the junior secondary phase of schooling, and have attained nine years of experience in social constructivist learning environments. After piloting the questionnaire, it was administered to a random sample representing all urban and public schools in the Western Cape Province. The data was collected from a meticulously selected sample in order to reflect the heterogeneous nature of schools in the province. Profiles of all 52 classrooms reflected the students' perceptions of their social constructivist learning environment, and these data were used to select schools for the qualitative data collection and analysis. Thus, the large-scale quantitative phase spans six stages, starting with the development of a new instrument, and ending with the analysis of the quantitative data. Each stage is discussed below.

Stage 1: Development of a New Instrument

Development of SCLES

A major contribution of the present study is the development and validation of a widely-applicable and distinctive questionnaire for assessing students' perceptions of their actual and preferred classroom learning environment in a social constructivist setting. The development and validation of the questionnaire involved a number of steps to ensure that the questionnaire was development in line with past LER instruments (see Chapter 2, pages 31-36). Therefore, when developing SCLES, the following were considered.

Firstly, the choice of the dimensions in the questionnaire needed to be consistent with Moos's (1974) three general psychosocial dimensions, namely relationship dimensions, personal development dimensions and system maintenance and system change dimensions. How Moos's scheme was used to classify the seven dimensions of the SCLES is shown in Table 2.2. The *Relationship Dimensions* identifies 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. The *Personal Development Dimensions* assesses basic directions along which personal growth and self-enhancement tend to occur. The *System Maintenance and System Change Dimensions* considers the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change.

Secondly, historically, in studies in which both the actual and preferred classroom environment are assessed, researchers have administered separate actual and preferred versions of questionnaires (Aldridge & Fraser, 2008). However, to provide a more economical format in this research, the inclusion of two adjacent responses, that is, the actual learning environment response (i.e., to record what students perceived as actually happening in their class), and the preferred learning environment response (i.e., to record what students would prefer to happen in their class), was to be included on one page (see Appendix 3). Therefore, a parallel actual and prefer form of the questionnaire was developed, which influenced the wording of the items for each dimension.

Thirdly, in developing the new questionnaire, dimensions were developed in order to encapsulate a social constructivist focus required of the new curriculum. As was described in considerable detail in the conceptual framework in Chapter 2, using a review of the South African national Department of Education policy documents (e.g., DoE, 2002), as well as the national (e.g., De Villiers, 2000) and international literature (e.g., Driver & Oldham, 1986; Driver *et al*., 1994; Matthews, 1992) on social constructivism, dimensions were identified that were central to the educational philosophy of social constructivism. The review of the literature in Chapter 2 (pages 22-26) emphasised the following seven dimensions, which form the scales of the SCLES: *personal relevance* (teachers making knowledge personally relevant to students' everyday life experiences), *metacognition* (giving students opportunities to 'think about their thinking'), *uncertainty in science* (giving students opportunities to re-assess their thoughts), *scientific investigations* (giving students opportunities to further develop their thinking through investigations), *collaboration* (giving students opportunities to test their ideas with one another), *critical voice* (giving students opportunities to question the teachers' pedagogical goals) and *respect for difference* (giving students opportunities to express their personal opinions).

The scales were drawn from three internationally validated and reliable questionnaires in the field of LER, namely: three scales from the *Constructivist Learning Environment Survey* (CLES) (Taylor, Fraser & Fisher, 1997), one scale each from the *Individualised Classroom Environment Questionnaire* (ICEQ) (Rentoul & Fraser, 1979) and one scale from the *Cultural Learning Environment Questionnaire* (CLEQ) (Fisher & Waldrip, 1997) (Table 2.1). Furthermore, two newly developed scales (i.e., *Respect for Difference* and *Metacognition*) were included in the SCLES, as these scales were not available in current LER questionnaires, and importantly, contextualized the questionnaire to the local educational setting.

The process of developing the new scales involved two main steps. Firstly, a wide search of the broader literature was conducted in an attempt to find appropriate descriptions for the two new scales (see Chapter 2, page 36). Secondly, once found, individual items were refined with the guidance of experts in the field of science education. The items were first formulated when the researcher and an expert in the field of cognition in science education brainstormed many ideas, and then developed a large selection of items to appropriately describe the scales. Subsequently, items appropriately describing the scales were selected upon consultation with two other experts, who were both experts in the field of science education, as well as former Grade 9 teachers. Thereafter, the panel participated in refining the wording of the items appropriate for Grade 9 level students, and finally they agreed upon a final list of items. However, in the case of the scale *Metacognition*, the panel further suggested that the scale were more appropriately described using nine items, relative to the five items, on average, describing the other scales.

Each item on the questionnaire included a version in English, Afrikaans and isiXhosa—the local vernacular. Beneath each English item were the Afrikaans and isiXhosa translations (in a different font), as illustrated below (see Appendix 3):

> I enjoy lessons in Natural Science
> *Ek geniet Natuurwetenskaplesse*
> **Ndiyazonwabela izifundo zezeNzululwazi**

This format was chosen in order to accommodate the multilingual classrooms in the Western Cape Province. Moreover, the simultaneous available translations gave those students who were not English first language speakers the confidence to engage with each item in their own language, thus maximising the likelihood that students supplied reliable and valid responses to the items.

The translation process involved four main steps. Firstly, the English version was produced, by drawing on various scales from past questionnaires (see Chapter 2, pages 31-36), and then developing two new scales described above. Secondly, two highly experienced language specialists in Afrikaans and isiXhosa, each translated the questionnaires into Afrikaans and isiXhosa respectively. Thirdly, another set of independent Afrikaans and isiXhosa translators conducted an independent back-translation as recommended by Brislin (1970) of Afrikaans and isiXhosa versions into English. The back-translations were verified by three independent translators who checked the translations against the original English versions. Any further queries or comments generated were conveyed to the original translators, who refined their translations in order to capture the original English version meaning of the questionnaire.

To provide contextual cues and minimise confusion to students, it was considered appropriate to group together in blocks all the items that belong to the same scale instead of arranging them randomly or cyclically (Aldridge & Fraser, 2008). To give the students confidence to complete the questionnaire, scales were sequenced so that familiar issues (e.g., *Investigation*) were sequenced earlier and the potentially more difficult issues (*Uncertainty in Science*) was sequenced later in the questionnaire. The response format was a five-point frequency scale of *Always, Often, Sometimes, Seldom* and *Never*. The actual and preferred versions of SCLES were placed next to one another on a single form of the questionnaire so that it was more economical to administer and easier to complete by Grade 9 students. Each item, then, required a response on the same line to 'How it is' and 'How I want it' (Appendix 3 & 4).

The new instrument, called the *Social Constructivist Learning Environment Survey* (SCLES), consists of seven scales with 5-10 items per scale, and a total of 53 items. The SCLES includes scales from existing instruments that are considered relevant to social constructivist teaching adopted by South African teachers (i.e., *Investigation*, *Personal Relevance*, *Collaboration*, *Critical Voice* and *Uncertainty in Science*), as well as two newly developed scales called *Metacognition* and *Respect for Difference* (Table 2.1).

Assessment of attitude toward science

Another focus of this study was to monitor the attitudes developed by students experiencing a social constructivist-based learning environment. Therefore, as described in Chapter 2, a student attitude scale was included in the SCLES. The attitude scale, based on the *Test of Science Related Attitudes* (TOSRA, Fraser, 1981) was developed and integrated into the questionnaire in order to assess students' attitudes toward science. As was mentioned in Chapter 2 (page 40), the strength of TOSRA lies in the fact that much of the criticisms of previous measures were accounted for during its development (see Kind *et al*., 2007). As discussed in Chapter 2 (page 38), the scale was adopted and adapted from the original 10-item *Enjoyment of Science* scale from the original TOSRA. The original scale was modified to an eight item scale (with some reversed-scored items) to shorten and contextualize it for Grade 9 students. The students responded to items using the same response format as the SCLES. The same procedures of translation and back-translation, as described earlier, were used to generate an Afrikaans and isiXhosa equivalent for each item from the English version.

Assessment of achievement

In line with other past LER studies (e.g., Aldridge *et al.*, 2006), this study monitored the achievement of students experiencing a social constructivist-based learning environment. A science test was developed to examine students' understanding of scientific principles related to scientific investigations. Of the three learning outcomes emphasized by the rNCS (DoE, 2002), Learning Outcome 1 focuses on the skills gained during scientific investigations (DoE, 2002), thus the skills related to this learning outcome was tested. Out of a wide range of topics which could be linked to investigative tasks, the skills related to graphs, namely, drawing a line graph, predicting from the line graph and interpreting information from a line graph was tested. Moreover, the choice of graphs as a topic was evaluated together with three factors considered important when setting the test. Firstly, whether all students were exposed to the content covered; secondly, that the test was set within the framework of the rNCS Learning Outcome 1 (DOE, 2002); and thirdly, that the test be learner-centred. These three factors will be discussed in turn.

Firstly, for the sake of fairness, the researcher needed to be certain that all students covered the same content featured in the test, as teachers were not required to complete all topics at the same time during the year. Consequently, a variety of experts in the subject Natural Science, namely, the Head of Natural Science in the WCED, two subject advisors for the Metropole Central and Metropole East, and highly experienced Grade 9 Natural Science teachers, were consulted, and unanimously agreed on two factors. Firstly, that the teachers at all 52 schools should have covered the content and skills related to the topic line graphs, by the planned administration date (May 2007). Secondly, at this stage in the academic year, students should know their teachers well enough to critically comment on their classroom learning environment through the SCLES. Thus, it was decided that the test would cover the topic line graphs and should be administered during the planned administration date in May 2007.

Secondly, the achievement test needed to be confined to criteria related to Learning Outcome 1. As the test was developed to examine students' understanding of scientific investigations as stipulated in Learning Outcome 1 (DoE, 2002), the skills acquired for this learning outcome was located in competency 3 (DoE, 2002)—the evaluation of data and communication of findings (Figure 3.1). The level at which Grade 9 students should function for this competency should be located within the assessment standard for Grade 9 students (Figure 3.1) (DoE, 2002: 69). These criteria were encapsulated in the science test which was selected, adapted and modified from a pilot test of possible Common Assessment Tasks (DoE, 1997b.).

Evaluate data and communicate findings		
Grade 7	**Grade 8**	**Grade 9**
Learner generalizes in terms of a relevant aspect and describes the data to support generalization.	Learner considers the extent to which the conclusions reached are reasonable answers to the focus questions of the investigation.	Learner seeks patterns and trends in the data collected and generalizes in terms of simple principles.

Figure 3.2 Assessment standards for Grades 7, 8 and 9 (DoE, 2002: 69)

Finally, another factor to consider was the type of test to be set, namely, a practical test or a paper-and-pencil test. It might be argued that a practical test is more conducive to a social constructivist classroom learning environment. However, considering the heterogeneity of the schools in the Western Cape Province (see Chapter 1, page 7), most low SES category schools are seldom or not at all exposed to science laboratories or science equipment (Botha, 2002; Meier, 2003). Therefore, considering these circumstances, a paper-and-pencil test was more likely a better option for the present study. In addition, research evidence both nationally and internationally suggest that students struggle with performance tasks comprising 'hands-on', practical and creative tasks

(Meier, 2003). Available evidence in South Africa (Ensor *et al.*, 2002; Joint Education Trust, 2001; Reeves & Long, 1998ab) suggests that performance tasks tend to work against measures of student performance as students struggle to read and understand complex information. Furthermore, in the USA, Darling-Hammond (1994) casts doubts on the fairness of using performance tasks in high stake national testing. Similarly, Meier (1997) contends that the extra cost (time and materials required) and complexity (ensuring that administration and assessment procedures are standardized) in this mode of assessment might be a disadvantage. Therefore, a paper-and-pencil-test appears to be more appropriate for the present study, with additional advantages of further data analysis through variances and correlations, and one can make comparisons by SES. As a consequence, a paper-and-pencil-test was the logical choice for the purposes of this study.

Stage 2: Pilot Testing

The survey questionnaire was piloted in five Grade 9 classes, each at a different school. A total of 200 students were involved in the pilot study. This sample size represented 10% of the final sample, by SES (one class in the 'high' SES category, three classes in the 'medium' SES category and one class in the 'low' SES school category) (discussed in detail in the next stage, Stage 3).

Major purposes of the pilot study were to establish whether the items of the Afrikaans and isiXhosa versions of the questionnaire, the actual and preferred response format, and the instructions of SCLES were well-understood. Before commencing with the pilot study, the researcher explained the instructions to the students, and the students were encouraged to underline words that they found difficult to understand. Here the researcher took the opportunity to note the time taken to deliver the instructions and for the students to complete the questionnaire. Thereafter the researcher collected the questionnaires, and then randomly selected five students per class (two boys and three girls, as in all classes there were more girls than boys) to share their opinions about the response format, instructions and the translation of the questionnaire. The interviews were tape-recorded with the students' permission. The selected students were given their questionnaires at the beginning of the interviews. Each of them had a chance to share his/her answers with the other students in order for the researcher to establish whether they understood the response format.

Following the student interviews during the pilot study, it was concluded that the items, instructions, and response format were well-understood. The students further verified that the Afrikaans and isiXhosa versions alongside the English version in each item helped them understand the item, implying that the translations maximized the likelihood that students supplied reliable and valid responses. In addition, from the interviews, as well as examination of the questionnaires answered by the students during the pilot study, it was evident that two important changes needed to be made to the SCLES in order maximise the Grade 9 Natural Science students' understanding of the questionnaire.

First, the word 'seldom' (in English) and 'selde' (in Afrikaans), used on the response scale, caused confusion in the all the classes piloted. The students were told that the word seldom meant 'hardly ever' or 'not often', and the students immediately understood it. Replacing the terms 'seldom/selde' on the response format of the questionnaire proved difficult, because of the difficulty to fit any of these terms into the response format on the questionnaire. Therefore, it was decided to add a special section in the instructions on the first page of the questionnaire so that the term could be clarified and explained before the students started the questionnaire (Appendix 3).

Second, two format changes were made to the questionnaire for clarity in presentation. On the personal background information page (i.e., the first page of the questionnaire), the age response was expanded, as there were many students above the age of 17 in the sample who were given the opportunity to write their age in the space provided. Furthermore, the numbering in the instructions was changed to bold and large, to emphasise the different instructions (Appendix. 3). Therefore, from the pilot study it was concluded that the students fully understood the items, instructions and the response format of the SCLES.

Stage 3: Administration of SCLES

Stratified sampling, as recommended by Creswell (2003) identified the sample of schools. This strategy ensured a total random sample of 1955 Grade 9 Natural Science students, one class in 52 schools, represented by urban and public schools in the Western Cape Province, South Africa. The sample was used in investigating the validity and reliability of the new instrument (Tables 4.1 & 4.2), and for investigating social constructivist-based associations (Chapter 4, pages 75-88).

Sample selection

The selection of the sample was restricted to public (i.e., government-funded) and urban schools. Furthermore, as the WCED manages all public schools in the Western Cape Province. Access to statistics and other information (e.g., a list of all public schools or the school fees for public schools) would be readily available. In addition, the WCED manages schools in groups, called Education, Management and Development Centres (EMDCs). There are seven EMDCs in this province, namely Metropole Central (MC), Metropole East (ME), Metropole North (MN) and Metropole South (MS), Overberg, South Cape/Karoo and West Coast/Winelands. Of the seven EMDCs, the four EMDCs, namely, the MC, ME, MN and MS comprise approximately 50% of all urban and public schools (DoE, 2003). The other three EMDCs consist of rural schools. Therefore, schools in this sample were selected from four EMDCs, namely, MC, ME, MN and MS, which consist of urban and public schools.

As was shown in Chapter 1 (page 7), schools vary in composition of students, very likely explained by SES (Fiske & Ladd, 2004; Van der Berg, 2007; Van den Berg & Burger, 2003). The SES of the parents was defined by family income (see Chapter 2, pages 42-45). In order to compare schools, SES needed to be controlled for, which meant that, as was evident in Chapter 1 (page 7), schools were stratified by parents' ability to pay high, medium and low school fees, which is the sample design which will be explained below.

The number of schools within each of the four metropoles varied. Out of a total of 201 schools, the distribution of schools is shown in Table 3.1 in the total column, showing the Grade 9, urban and public schools in the Western Cape Province.

Table 3.1 Summary of the stratified proportional sampling by EMDC and SES, with the values representing the number of schools and their percentage, while the numbers in the parenthesis represent the proportional sample and sample percentage.

Metropole / SES	South	North	Central	East	Total
Low	13 (4)	12 (4)	12 (3)	11 (3)	48 (14)
%	24 (29)	24 (31)	24 (21)	24 (27)	24 (27)
Medium	25 (6)	24 (5)	24 (8)	22 (5)	95 (24)
%	46 (42)	48 (38)	47 (57)	46 (46)	47 (46)
High	16 (4)	14 (4)	15 (3)	14 (3)	58 (14)
%	30 (29)	28 (31)	29 (22)	30 (27)	29 (27)
Total	**54 (14)**	**50 (13)**	**51 (14)**	**46 (11)**	**201 (52)**
%	**100 (100)**	**100 (100)**	**100 (100)**	**100 (100)**	**100 (100)**

The distribution of schools per metropole was as follows: MS (54), MN (50), MC (51) and ME (46) (DoE, 2003). In order for each of the metropoles to be representative in the final sample of 52 schools (see Table 3.1), the schools were proportionally scaled down so that the distribution of schools in the final sample were: MS (14), MN (13), MC (12+2) and ME (11) (Table 3.1). The two extra schools in MC were the back-up schools, to maintain the sample of 50 schools if any school were unable to participate. However, as all the schools agreed to participate, it was decided to include the two extra schools as they provided rich insights into the final sample of 52 schools. Furthermore, the overall representation of the H/M/L school fees based on all four metropoles showed a distribution of High (24%), Medium (47%) and Low (29%), therefore, to represent the H/M/L schools per metropole, the schools were represented by this ratio (Table 3.1).

The samples of schools within each of the metropoles were identified by stratified sampling as recommended by Creswell (2003). Schools were stratified by three school fee categories, namely, the high, medium and low school fee categories. The low school fee category formed the baseline category as the school fees in this category were identified in line with the Departments of Education's choice of "no fee" schools. "No fee" schools were identified as part of a national policy to scrap fees in poor schools through the Education Laws Amendment Act 24 of 2005. The choice of schools was based on a formula relating school fees to the students' family income. As part of the reparation for Apartheid, the Department of Education funded schools in accordance with an index based on the relative poverty of the communities surrounding the schools—categories identified by Statistics South Africa (DoE, 2003). They grouped the schools according to quintiles. Schools in quintile one, for instance, housed those schools in the poorest communities, whilst those in quintile five, housed the least poor communities. Therefore, in the present study, the the low [L] SES category schools consisted of "no fee" schools, with fees of R300 and below (C. Soudien, personal communication, 22 August 2007).

The data of all schools and its distribution was further examined through descriptive statistical analyses using box-and-whisker plots (Field, 2009). The distribution showed that the lower quartile was R250 and less, which closely corresponded with the "low SES" school categorisation of R300 and less. Inspection of the list of schools showed that there was a difference of less than 10 schools, which suggests that the latter categorization was close to the statistical distribution. Further inspection of the data's distribution through the box-and-whisker plot showed that the upper quartile was from R2100 and above. However, careful inspection of schools, taking into the researchers' contextual familiarity of the schools, suggested that three schools should not be included in the high SES categorisation, and should therefore be moved to the medium SES category, implying that the first school fee in this category changed to R2251 and above. Consequently, schools in the medium SES category ranged from between R301 and R2250, closely corresponding with the interquartile range of between R250 and R2100. Therefore, the categories of school fees representing the metropoles in the present study were as follows: below R300 (representing the low [L] school fees), between R301-R2250 (representing the middle [M] school fees) and R2251 and above (representing the high [H] school fees), appropriately described the school fee distribution of the four metropoles used in the present study. Thus, this sample selection ensured a total random sample of 1955 Grade 9 Natural Science students from one class in 52 schools, represented by urban and public schools in the Western Cape province, South Africa.

Prior to administration of the survey in the sample schools, permission to involve teachers and students at the selected schools were sought from the Head of Department of Education in the Western Cape Province (Appendix 1). After the written permission was granted, the questionnaires were ready to be administered in all the selected secondary schools. In February/March of 2007, letters were faxed to the chosen schools in the sample, requesting permission for the school to participate in the study. The letters were addressed to the school principal (Appendix 2). The initial response rate was low (10 schools out of 55 responded), but after telephonically contacting the principals, a much better response rate was received. Initially fifty-five schools were contacted, which included the intended sample of fifty schools in addition to back-up schools. The back-up schools acted as a safety net to keep the number of schools at fifty, in case any school withdrew last minute. Out of the fifty-five schools invited to participate in the study, three schools declined. Therefore, the sample consisted of fifty-two schools, who all participated in the study (the two additional schools were still back-up schools). By the end of the first school term (March), the same 52 schools were contacted telephonically and continued to express willingness to participate. At the beginning of the second school term (mid-April), the data collection times and dates were finalized and confirmed with the head of Natural Science at the school, and then the class teacher. At the beginning of May the questionnaires were administered, over a period of five weeks.

Before the researcher administered the questionnaire to the class, the students were told that completing the questionnaire was voluntary and confidential. Fortunately all the students who were invited to participate responded, and took on average between 35-45 minutes to complete the questionnaire. The teachers were given the option to stay in the class or leave—most teachers offered to help with administration at the beginning of the lesson, but left afterwards. The teachers of the isiXhosa first language classes were asked, and agreed, to stay during administration in case there were any questions from the students.

Before students could start answering the questionnaire in class, instructions, stapled to the front of the questionnaire (Appendix 3) were read. While reading, the researcher stopped, on occasion, to further explain instructions, sometimes in both English and Afrikaans (as explained in the pilot study above). The isiXhosa versions were read by the class teacher, as the researcher could was not able to speak the language. The researcher started by explaining the requested general information and its importance for the survey, for instance, *Student Name* and *Surname*, *School Name*, *Class*, *Age*, and so forth. The researcher then explained the response format for every item of the survey and how the response was to be indicated both under the actual and preferred columns. This was done to make sure that the students understood the SCLES structure and in particular the ACTUAL and PREFERRED columns. An example was used to explain the difference (e.g., *John eats ice-cream every Sunday* [ACTUAL]; *but John would like to eat ice-cream every day* [PREFERRED]).

Stage 4: Capturing and Cleaning of the Quantitative data

All students invited to participate in the study responded to the questionnaire. Data was gathered from Grade 9 Natural Science students in 52 schools within four EMDCs in the Western Cape Province, which made up a total of 1955 students. This total was obtained by careful and meticulous inspection of the data. Any questionnaires considered invalid were withdrawn from the sample. The questionnaires were considered invalid, if: first, they were considered 'suspicious' cases, which were identified based on three criteria, namely, if the student completed the whole questionnaire in less than 15 minutes, gave the same response for all the items (e.g., chose *seldom* for all responses), and there was an obvious pattern in the responses (e.g., every second item in a scale had the same response). These questionnaires were withdrawn from the sample and marked 'suspicious', which comprised 20 cases from the entire sample. As a result, this meant that of the original 2019 responses, the withdrawal of 20 cases resulted in 1999 cases being left in the dataset. These cases were given a unique school and teacher identity (ID), which was recorded with other information related to the class, for instance the class size, date collected, time collected, and so forth, in order to track the questionnaires if queries arose.

Second, in cases where the whole achievement test was left out (23 cases), or where students left out more than one response page blank (21 cases); these cases (i.e., 44 in total) were left out of the data analysis. The sample was thus reduced to 1955 students, which was the total final sample used in the study.

These data were captured, first, in the electronic package, *Microsoft Excel* 2003 by a data capturer with 20 years experience. Acknowledging the probability of mistakes during the manual capture, the data were checked through a verification process by transferring the data to the electronic programme *Falcon*. Thus, the data were entered twice in order to ensure that mistakes were avoided when data was entered, and thus to maximise the validity of the captured data.

The dataset was cleaned once the verification process was completed. The data cleaning process consisted of carrying out validation or consistency checks to remove or control errors and missing information in the dataset (Miller, Acton, Fullerton & Maltby, 2002). Subsequent data cleaning entailed the inspection of the frequencies of responses for each category per item. Furthermore, the data cleaning process involved checking the logic in the captured data by determining the frequency analysis per variable, as well as checking for apparent irregularities when compared to the responses on SCLES. For those responses that were found to be outside the expected range, the original was checked and corrections were made in the data file.

Stage 5: Analysis of Quantitative Data

A number of steps were taken during the analysis of the quantitative data, which will be discussed in turn. A factor analysis was conducted to determine whether the 53 items of the SCLES measured seven independent dimensions of the social constructivist learning environment. Principal component factor analysis with varimax rotation was considered to be the most appropriate type of factor analysis. To determine whether the items in the six scales of SCLES and one scale of TOSRA assessed a similar construct, the internal consistency reliability was examined using the Cronbach alpha co-efficient. The mean correlation of a scale with other scales was used as an estimate of each of the SCLES scale's discriminant validity. An ANOVA, with class membership as the independent variable, was used to examine the ability of each SCLES scale to differentiate between classrooms.

To acquire an overview of the average scores for the actual and preferred learning environment scores for all the scales, a MANOVA for repeated measures was performed with the six SCLES scales as the dependent variables, and the form (actual or preferred) as the independent variable. Only statistically significant results were interpreted in terms of Wilks' lambda criterion, a one-way ANOVA, and effect sizes (magnitudes of the differences between countries expressed in standard deviation units) (Thompson, 1998). The mean scores from this analysis were used to generate graphic profiles for each of the 52 classrooms in the sample.

To examine associations between the learning environment (SCLES), and the two student outcomes, attitude toward science and achievement scores, data were analysed with a one-way MANOVA using the class mean as the unit of analysis. A multivariate test using the Wilks' lambda criterion and the univariate ANOVA was interpreted for each scale, with the individual as the unit of analysis, to investigate whether students in the three in SES category schools had different perceptions of their classrooms, attitudes toward science and achievement scores. Then, in order to interpret the statistically significant results at each SES level, ANOVA's and Tukey's HSD multiple comparison procedure was performed. The magnitude of the differences between each pair of SES was determined through effect sizes (Thompson, 1998).

Simple correlation and multiple regression analysis, at the individual and class mean levels of analysis, were used to examine the relationships between the students' perceptions of the classroom and the student outcomes of attitude toward Science and achievement. Simple correlation was used to examine the bivariate relationship between each student outcome with the learning environment scale of SCLES. Multiple regression analysis was used to examine the joint influence of the whole set of the environment scales on each outcome, as well as which environment scales contributed to variance in learners' attitudes or achievement when the other environment scales were mutually controlled for.

Gender equity in the classroom learning environment, attitudes toward science and achievement scores were examined through a one-way MANOVA for repeated measures and using the within—class gender subgroup mean as the unit of analysis. Gender was the repeated measure factor and the SCLES, attitude and achievement scales formed the set of dependent variables. As males and females are not found to be in equal numbers in every class, the within gender mean was chosen as the unit of analysis to provide a matched pair of means, one within—class mean for males and one within—class mean for females. This reduces confounding in that, for each group of males within a particular classroom, there is a corresponding group of females in the same classroom. Because the multivariate test produced statistically significant results using Wilks' lambda criterion, the univariate ANOVA for repeated measures was interpreted for each individual scale to investigate whether males and females had different perceptions of their classrooms, different attitudes and different achievement scores.

The Qualitative Data

The qualitative data collection phase was conducted in order to validate the trends obtained from the quantitative data results. The schools selected for this phase were chosen using the actual and preferred classroom learning environment profiles generated during the quantitative data analysis. Five schools were chosen and one class per school (five classes) was observed a minimum of five lessons. The qualitative data collection involved interviews the class teacher and students, as well as classroom observations. Stages six and seven below describe the qualitative data collection and analysis.

Stage 6: Qualitative Data Collection

The questionnaire data provided a basis for measuring students' perceptions of the learning environment in the different contexts, but the "trustworthiness" of the data was provided through the qualitative data. In order to validate the quantitative results, classroom observations as well as student and teacher interviews were used. Selection of the schools to be observed and interviewed involved scrutiny of the 52 classroom profiles generated during the quantitative data collection. Five schools were chosen on the basis of (1) the absolute high/low score for actual perceptions, and (2) discrepancies between the students' actual and preferred perceptions of their classroom learning environment for selected scales. Before the classroom observations, prior consultations, negotiations and arrangements were made with the Natural Science teachers of the selected schools in order to provide a common understanding about the purpose and importance of lesson observations for the study. During the negotiations, the teacher was shown his/her classroom profile based on the students' actual and preferred perceptions of the SCLES dimensions and discussions ensued. Part of the discussion entailed emphasising the need for the classroom observations, as well as conducting the interviews with the teacher and students. In the end, all five teachers showed willingness to be observed and subsequently interviewed. At this point, the teachers made timetables available to the researcher.

During the classroom observations, a minimum of five consecutive lessons per teacher were observed because this would give the researcher opportunities to identify occurrences of events and instances relevant to the SCLES dimensions. Lesson observations were important in the present study because it gave the researcher an opportunity to observe the teacher and students in their natural classroom setting (Turner & Meyer, 2000). In order to ensure minimal classroom interference with the normal classroom practice, non-participant observation method (Borg & Gall, 1989) was use, where the researcher remained apart from the people observed. The advantages of this approach were that it was less obtrusive, and less likely to be distorted by the emotional involvement of the observer. Furthermore, it gave the researcher opportunities to observe and note events and practices that were related to the SCLES dimensions.

Interviews provide in-depth understanding of the participants in their natural setting, which leads to deeper levels of meaning (Lincoln & Guba, 1985; Tobin & Fraser, 1998). These levels of meaning might not have been provided by classroom observations alone. In regard to the interviews with the teacher, the Natural Science teacher was interviewed immediately after the lesson. The researcher applied an unstructured interview approach because the events and instances observed during the lessons differed from classroom to classroom. The discussions with each of the teachers, both formal and informal, were often based on their successes or failures when implementing strategies related to SCLES in their teaching. On the other hand, a focus group interview with six randomly selected students (three boys and three girls) was held once per class. Interviews with the students were done in order to clarify and verify the observations. The proceedings for the student interviews as recommended by Kvale (1996) were tape-recorded and transcribed for later analysis. Interestingly, the students agreed to be tape-recorded during interviews, but the teachers did not. As a consequence, detailed notes were taken during interviews with the teacher. Thus, the interviews played a very important role in providing insights into the classroom observations.

Stage 7: Analysis of Qualitative Data

In analyzing the qualitative data, the researcher used the thematic approach—guided by the SCLES dimensions, which were used as themes (Aronson, 1994) to guide the search for common patterns of classroom practices. The researcher applied narrative stories (Hatch & Wisniewski, 1995; Lincoln & Guba, 1985; Polkinghorne, 1995), where the observation data were used in the form of stories which was used to provide models of typical Natural Science lessons in that class. The narrative stories were used to combine the data from the classroom observations and the student and teacher interviews in an attempt to piece together an understanding of the learning environment of Grade 9 Natural Science students in the Western Cape Province in a variety of socio-economic settings during the data analysis. The stories were followed by interpretive commentary based on the interviews with the different students and teachers (Aldridge & Fraser, 2000; Aldridge *et al.*, 2006).

Chapter Summary

The present study took place in two main sequential data collection phases, namely, the quantitative data collection phase (QUAN) and the qualitative data collection phase (qual). This contemporary mixed-method approach was employed to triangulate the quantitative data with the qualitative data so that the study could provide credible and trustworthy answers to the research questions.

For the QUAN phase, a newly developed instrument, the *Social Constructivist Learning Environment Survey* (SCLES) was used to assess students' perceptions of six aspects of the learning environment. Four of the aspects were assessed using scales that were adopted and adapted from past learning environment questionnaires (namely, *Scientific Investigations*, *Personal Relevance*, *Collaboration*, *Critical Voice* and *Uncertainty in Science*). The other two scales were developed specifically for the present study in order to contextualize the questionnaire even further (namely, *Metacognition* and *Respect for Difference*). Another scale, *Attitude toward Science*, was taken directly from one of the scales from the *Test of Science-Related Attitudes* (TOSRA) which was used to test students' attitude toward science. The achievement test was developed by the researcher to assess the skills related to the drawing of straight line graphs, as well as predicting from and interpreting information from a straight line graph.

After the pilot study and modification to the questionnaire, data were collected from 1955 students in urban and public Grade 9 Natural Science classrooms in the Western Cape Province, South Africa. Due to the heterogeneity of the sample, it was stratified according to EMDC and SES (into high SES, medium SES and low SES). This method of choosing the sample—as recommended by Creswell (2003)—ensured a total random sample of 1955 Grade 9 Natural Science students in one class in 52 schools, represented by urban and public schools in the Western Cape Province, South Africa. Furthermore, to ensure the one class chosen was randomly selected, the selection process involved the researcher selecting a class from a random list of numbers representing all the Grade 9 Natural Science classes in the school.

After the data collection, the data were analysed. Firstly, the quantitative data were analysed through a principal component factor analysis, which was used to refine and validate the SCLES scales. Cronbach alpha reliability, disctiminant validity and ANOVA for class membership differences were used to provide further evidence of scale reliability and validity for the SCLES. Secondly, associations between the learning environment and the student outcomes attitude toward science and achievement scores were examined with the sample of 1955 students using simple correlation and multiple regression analyses for two units of analysis (individual and class mean). Differences in gender perceptions of their classroom learning environment, attitudes toward science and achievement scores was analysed using a one-way MANOVA for repeated measures with the within-class subgroup as the unit of analysis. Thirdly, a one-way MANOVA was used to examine associations between SES and the classroom learning environment, attitudes toward science and achievement scores. While pairwise comparisons of the significant SES groups was examined using Tukey's HSD multiple comparison procedure—the magnitude of the sizes of the pairwise comparisons was examined by calculating the effect sizes as recommended by Thompson (1998). Finally, to determine whether there was congruence between the actual and preferred responses of the six learning environment scales, a MANOVA for repeated measures was performed. To estimate the magnitudes of the differences, effect sizes were calculated as recommended by Thompson (1998). Details of these analyses appear in Chapter 4.

The mean scores for each of the scales were used to generate graphic profiles of the 52 classrooms, and of them 5 classrooms were chosen for the qualitative data collection phase. The schools were chosen based on high/low mean scores for both the actual and preferred learner perceptions (hence a narrow/wide gap between actual and preferred learner perceptions), as well as large or small discrepancies between the SCLES scales. Chapter 4 describes the results and follows next.

Chapter 4
RESULTS

Introduction

In the previous chapter details of the development and administration of the survey instrument was described. The instrument was used to collect quantitative data from 1955 students in one classroom in 52 schools. The information from the quantitative data analysis was used as a point of departure for the collection of qualitative data from five classrooms using classroom observations as well as teacher and student interviews. In the present chapter, the findings of the quantitative and qualitative data are described. This chapter reports the findings under two headings. First, the results from the analysis of the quantitative data collected using the SCLES are reported, and then the findings from the analysis of the qualitative data collected through classroom observation and interviews are described.

Findings from the Quantitative Data

The quantitative data were analysed statistically by, first, examining whether the instrument was reliable and valid. In order to do so, the factorial validity of the scales and the ability of the scales to differentiate between the perceptions of students in different classrooms were examined. Second, associations between the SCLES scales and the three student outcomes, namely, attitude toward science, achievement and gender equity, were examined in three different SES groups (i.e., high, medium and low SES). The first two student outcomes were examined using simple correlation and multiple regression analyses, while gender equity was examined using one-way MANOVA for repeated measures. Third, the three SES groups were further examined in order to compare the three categories, using a one-way MANOVA as well as a Tukey HSD *post hoc* test.

Reliability and validity of SCLES

A major objective of the present study was to develop and validate a questionnaire for monitoring the social constructivist learning environments in the Western Cape Province, South Africa. The data collected from 1955 students in 52 schools were used to examine the reliability and validity of SCLES. As a first step, the data were used to perform a principal component factor analysis followed by a varimax rotation (Table 4.1).

Items from various scales, that is, the *Respect for Difference* scale (item 15), the *Investigation / Metacognition* scale (items 24, 26, 27, 28 and 29), the *Personal Relevance scale* (items 34 and 35), the *Critical Voice* scale (items 43 and 44), and the *Uncertainty in Science* scale (item 48) were omitted from the factor analysis (Table 4.1) and from further analyses because they had factor loadings of less than 0.30. The revised instrument (Appendix 4) therefore consisted of 34 items. In addition, the *Investigation* and *Metacognition* scales came together during the factor analysis, suggesting that students regarded *Investigation* and *Metacognition* in similar ways. This scale was subsequently re-named *Working with Ideas*.

Table 4.1 Factor loadings for a modified version of actual form of the SCLES in South Africa.

	Factor Loading					
Item No.	Working with Ideas	Respect for Difference	Personal Relevance	Collaboration	Critical Voice	Uncertainty in Science
9	0.68					
10	0.51					
11	0.63					
12	0.53					
13	0.70					
14	0.58					
21	0.54					
22	0.65					
23	0.60					
25	0.60					
16		0.46				
17		0.63				
18		0.57				
19		0.63				
20		0.62				
30			0.67			
31			0.56			
32			0.77			
33			0.73			
36				0.79		
37				0.72		
38				0.66		
39				0.41		
39				0.70		
41					0.66	
42					0.71	
45					0.51	
46					0.58	
47					0.63	
49						0.60
50						0.63
51						0.56
52						0.65
53						0.63
% Variance	17.48	4.99	3.72	8.16	4.25	6.13
Eigenvalue	5.94	1.70	1.27	2.78	1.45	2.09

Factor loadings smaller than 0.30 have been omitted.

The sample consisted of 1955 students in 52 classes in South Africa.

Overall, the percentage of variance accounted for by the different scales ranged between 3.7% and 17.5%, with the total variance accounted for being 44.7%. The eigenvalues ranged between 1.2 to 5.9 for the scales (Table 4.1).

For the revised 34-item SCLES instrument (Appendix 4), three further indices of scale reliability and validity were generated for the actual and preferred versions of the instrument (Table 4.2). The Cronbach alpha reliability co-efficient was used as an index of scale internal consistency of the actual and preferred versions. A discriminant validity index (i.e., the mean correlation of a scale with the other five scales) was used as evidence that each scale in the actual and preferred versions of the SCLES measures a separate dimension that is distinct from the other scales within the questionnaire. Analysis of variance (ANOVA) results were used as evidence of the ability of the actual form of each scale to differentiate between the perceptions of students in different classrooms.

Table 4.2 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 SCLES.

Scale	Unit of Analysis	No. of Items	Alpha Reliability		Mean Correlation with other Scales		ANOVA Eta^2
			Actual	Preferred	Actual	Preferred	Actual
Working with Ideas	Individual	10	0.82	0.85	0.24	0.38	0.19***
	Class Mean		0.94	0.92	0.28	0.26	
Respect for Difference	Individual	5	0.62	0.70	0.27	0.39	0.09***
	Class Mean		0.77	0.91	0.37	0.33	
Personal Relevance	Individual	5	0.67	0.69	0.23	0.34	0.11***
	Class Mean		0.86	0.88	0.37	0.38	
Collaboration	Individual	5	0.72	0.76	0.24	0.32	0.06***
	Class Mean		0.77	0.84	0.06	0.30	
Critical Voice	Individual	5	0.66	0.59	0.28	0.32	0.06***
	Class Mean		0.63	0.59	0.24	0.27	
Uncertainty in Science	Individual	5	0.69	0.71	0.31	0.39	0.05***
	Class Mean		0.58	0.84	0.32	0.49	
Attitude	Individual	8	0.82				
	Class Mean		0.96				

*** $p<0.001$
The sample consisted of 1955 students in 52 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.

Table 4.2 shows that the internal reliability (Cronbach alpha co-efficient) for the actual version of the SCLES scales ranged between 0.62 and 0.82 with the individual as the unit of analysis, and between 0.58 and 0.94 using the class mean as the unit of analysis. For the preferred version of SCLES, the internal consistency reliability of scales ranged between 0.59 and 0.85 for the individual as the unit of analysis, and between 0.59 and 0.92 using the class mean as the unit of analysis. Overall, these results indicate that the internal consistency for both the actual and preferred versions of the SCLES is satisfactory.

For the actual version of SCLES, the discriminant validity (mean correlation of a scale with other scales) ranged between 0.23 and 0.31 with the individual as the unit of analysis, and between 0.06 and 0.37 with the class mean as the unit of analysis (Table 4.2). For the preferred version of SCLES, the discriminant validity ranged between 0.32 and 0.39 with the individual as the unit of analysis, and between 0.26 and 0.49 for the class mean as the unit of analysis (Table 4.2). These results suggest that the scales in the actual version of SCLES assess distinct constructs, although there is a degree of overlap. However, the factor analysis (Table 4.1) attests to the independence of factor scores on the actual form of the SCLES. The results for the preferred version of the SCLES suggest that the raw scores assess somewhat overlapping aspects of the learning environment.

An Analysis of Variance (ANOVA) with class membership as the independent variable was used to determine whether the actual form for each SCLES scale was able to distinguish between the perceptions of students in different classes. The eta^2 statistic for each scale (Table 4.2) indicates that each SCLES scale differentiated in a statistically significant manner ($p<0.001$) between classes.

Taken together, the results from the factor analysis, as well as the indices of scale reliability and validity (the Cronbach alpha reliability index, the discriminant validity index and ANOVA), suggest that the *Social Constructivist Learning Environment Survey* is reliable and valid for use in high school Natural Science classes in South Africa and therefore can be used with confidence by teachers and researchers in the future.

Reliability of Attitude toward Science Scale

A scale from the *Test of Science Related Attitudes* (TOSRA) (Fraser, 1981), called the *Enjoyment of Science Lessons* scale, was adopted and adapted to assess the overall attitude of the students toward science (Chapter 2, page 38). Similar to the original ten-item *Enjoyment of Science Lessons* scale (TOSRA) (Fraser, 1981), the new scale contained positively and negatively worded items. However, in order to shorten and contextualize the scale for the Grade 9 students, it was modified to an eight-item scale.

Data collected from 1955 students in 52 schools were analysed to examine the internal consistency of the *Attitude toward Science* scale (see Tables 4.2). The internal consistency reliability (Cronbach alpha co-efficient) for the *Attitude toward Science* scale is 0.82 with the individual as the unit of analysis and, 0.96 with the class mean as the unit of analysis. These results indicate that the

Attitude toward Science scale is reliable for use in high school Natural Science classes in South Africa and can therefore be used with confidence by teachers and researchers in the future.

Using SCLES to Describe Science Classrooms in the Western Cape Province

Using descriptive statistics, the learning environment of Natural Science classes was analysed based on students' responses to the SCLES. The scales of SCLES were used to describe a typical Natural Science classroom environment in the Western Cape Province. Because the number of items in each scale ranges between 4 and 10, the average item mean (i.e., the scale mean divided by the number of items in the scale) was calculated and used as the basis for describing the different classrooms. Table 4.3 reports the results in terms of the average item means for the class as unit of analysis for both the actual and preferred scores for the scales *Working with Ideas*, *Respect for Difference*, *Personal Relevance*, *Collaboration*, *Critical Voice* and *Uncertainty in Science*.

Table 4.3 Average item mean, average item standard deviation for differences between the scores of the actual and preferred perceptions on the SCLES (effect size and MANOVA results) for the class mean as the unit of analysis

Scale	Average Item Mean		Average Item Standard Deviation		Differences	
	Actual	Preferred	Actual	Preferred	Effect Size	*F*
Working with Ideas	3.15	3.95	0.32	0.21	3.01	226.09***
Respect for Difference	3.82	4.20	0.21	0.25	1.65	67.81***
Personal Relevance	3.38	3.92	0.28	0.29	1.89	97.37***
Collaboration	3.75	4.12	0.20	0.21	1.80	86.38***
Critical Voice	3.62	4.00	0.20	0.19	1.95	101.32***
Uncertainty in Science	3.50	3.95	0.17	0.21	2.37	144.51***

***$p<0.001$
The sample consisted of 1955 students in 52 classes in South Africa.

The results in Table 4.3 show that the students' perceptions of the actual learning environment ranged between 3.15 and 3.82 for different scales. The average item mean for the learning environment that students would prefer ranged between 3.92 and 4.20 for different scales. A one-way MANOVA was performed with the six SCLES scales as the dependent variables and the form (actual or preferred) as the independent variable. The multivariate test yielded statistically significant results ($p<0.001$) in terms of Wilks' lambda criterion, indicating that there were differences in the set of criteria as a whole. Therefore, the one-way ANOVA was interpreted for each of the six individual SCLES scales. The results of the *F* tests are shown in Table 4.3 along with descriptive statistics. In order to estimate the magnitudes of the differences (i.e., in addition to their statistical significance), effect sizes (i.e., magnitudes of the differences expressed in standard deviation units) were calculated as recommended by Thompson (1998, 2002).

A graphic profile of the scores depicted in Table 4.3 was generated, showing the discrepancies between the actual and preferred scores (Figure 4.1). The level of each SCLES dimension in Figure 4.1 was perceived to be lower for the actual score of every scale than students' preferred score. Likewise, individual class profiles of all 52 classes revealed that students' preferred scores were higher than the actual perceptions of their Grade 9 Natural Science classrooms.

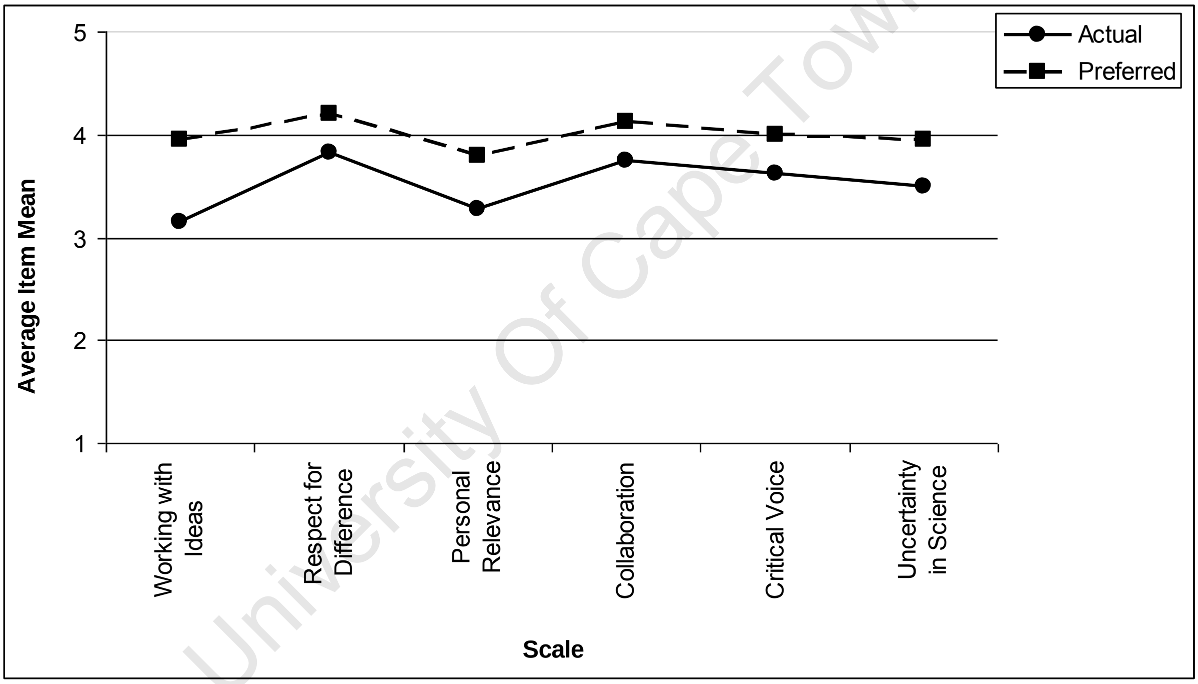

Figure 4.1 Differences in students' perceptions of the actual and preferred learning environment for SCLES for all 1955 students in 52 classes.

Overall, the results reported in Table 4.3 and Figure 4.1 indicate statistically significant differences ($p<0.001$) between the actual and preferred scores for all six learning environment scales for the class mean as the unit of analysis. The effect size for each of the SCLES scales ranged between approximately 1.5 and 3 standard deviations for the class mean as the unit of analysis (Table 4.3). These results suggest that there are large differences between students' perceptions of their actual and preferred environment, as is also evident from Figure 4.1.

Associations between Social Constructivist Learning Environment Survey and Attitude toward Science and Achievement

In order to determine associations between the SCLES scales and the student outcomes of students' attitudes toward science and achievement, simple correlation and multiple regression analyses were used. As SES plays a significant role in describing the learning environments of science classrooms in the Western Cape Province, it was necessary that the results be reported by SES group. The SES group is determined by the annual school fees, as school fees are an important indicator of SES (described in Chapter 3, page 61). Thus, the results for each of the two student outcomes in this section were described and reported by SES group (i.e., stratified into high, medium and low SES).

Simple correlation analysis was used to provide information about the bivariate relationship between *Attitude toward Science* and each individual environment scale. Multiple regression analysis was used to describe the joint relationship between the attitude measure and the entire set of six environment scales. Using standardised regression coefficients (β), the environment scales which contributed uniquely and significantly to the explanation of the variance in each dependent variable were identified. For example, in the case of achievement, the standardised regression coefficients identify the specific environment scales that make a significant contribution to explaining the variance in achievement when the other environment scales are mutually controlled for.

In the next section the results of the simple correlation and multiple regression analyses is described for students in each high, medium and low SES category schools by describing the associations of the scales, first, with student attitude toward Natural Science and then, with achievement.

Associations for the High SES group

Student Attitude Toward Science

Table 4.4 shows the associations between the SCLES scales and students' attitudes toward science for the high SES group. When using the individual as the unit of analysis, the results of the simple correlation analyses indicate statistically significant (p<0.01) associations between students' attitudes toward science and five of the six learning environment scales (i.e., *Working with Ideas*, *Respect for Difference*, *Personal Relevance*, *Critical Voice* and *Uncertainty in Science*). With the class mean as the unit of analysis, three of the six learning environment scales were statistically significantly related to students' attitude toward science, namely, *Personal Relevance*, *Critical Voice*, and *Uncertainty in Science*. All statistically significant associations were positive.

Table 4.4 Simple correlation and multiple regression analyses for associations between student attitude toward science and achievement and the dimensions of the SCLES in South Africa for students in the high SES group.

Scale	Unit of Analysis	Student Attitude toward Science		Achievement	
		r	*β*	*r*	*β*
Working with Ideas	Individual	0.50**	0.40**	-0.06	-0.09
	Class Mean	0.47	0.15	-0.26	-0.49
Respect for Difference	Individual	0.27**	0.05	0.05	0.08
	Class Mean	0.50	-0.01	0.49	0.48
Personal Relevance	Individual	0.29**	0.08	0.04	0.06
	Class Mean	0.83**	0.58	0.41	0.37
Collaboration	Individual	-0.02	0.07	-0.05	-0.06
	Class Mean	-0.52	0.18	-0.01	-0.13
Critical Voice	Individual	0.17**	0.01	0.01	-0.04
	Class Mean	0.57*	0.34	0.28	-0.10
Uncertainty in Science	Individual	0.36**	0.18**	-0.03	-0.06
	Class Mean	0.66*	0.01	0.27	-0.05
Multiple Correlation (R)	Individual		0.30**		0.02
	Class Mean		0.84*		0.68

* $p<0.05$
**$p<0.01$
The sample consisted of 491 students in 14 classes in South Africa.

The multiple correlation between students' perceptions of the learning environment and students' attitudes is 0.30 with the individual as the unit of analysis, and 0.84 with the class mean as the unit of analysis (Table 4.4). At both levels, the multiple correlation is statistically significant. The significant standardised regression coefficients in Table 4.4 show that, with the individual as the unit of analysis, two of the six scales were significant ($p<0.01$) independent predictors of student attitudes, namely, *Working with Ideas* and *Uncertainty in Science*. With the class mean as the unit of analysis, no scales were significant independent predictors of student attitudes in Table 4.4.

Achievement

Analyses were conducted to explore associations between the six dimensions of the social constructivist learning environment and student achievement for the high SES group (Table 4.4). The results of the simple correlation analysis with the individual as the unit of analyses indicated no statistically significant ($p>0.05$) relationship exists between achievement and any of the six scales. Similarly, using the class mean as the unit of analysis, there were no statistically significant ($p>0.05$) relationships existing between the achievement scores and any of the six SCLES scales.

The multiple regression (*R*) for achievement showing the association of students' achievement to the whole set of six environment scales is not statistically significant ($p>0.05$) for both the individual and the class mean as the unit of analysis (Table 4.4). The magnitude of the multiple correlation is 0.02 for the individual and 0.68 for the class mean as the unit of analysis. The standardised regression coefficient (β) is statistically non-significant ($p>0.05$) for both the individual and the class mean as the unit of analyses (Table 4.4).

Associations for the Medium SES group

Student Attitude Toward Science

Table 4.5 shows the results of the associations between the SCLES scales and students' attitude toward science for the medium SES group. When using the individual as the unit of analysis, the results of the simple correlation analyses indicate statistically significant ($p<0.01$) associations between students' attitude toward science and all six learning environment scales.

Table 4.5 Simple correlation and multiple regression analyses for associations between student attitude toward science and achievement and the dimensions of the SCLES in South Africa for students in the medium SES group.

Scale	Unit of Analysis	Student Attitude toward Science		Achievement	
		r	β	r	β
Working with Ideas	Individual	0.44**	0.42**	-0.07**	-0.12**
	Class Mean	0.53**	0.75	0.37	-0.05
Respect for Difference	Individual	0.17**	0.06*	0.09**	0.09*
	Class Mean	0.28	0.12	0.59	-0.01
Personal Relevance	Individual	0.10**	-0.01	0.07*	0.07
	Class Mean	0.06	0.17	0.06	0.38
Collaboration	Individual	-0.16**	-0.02	0.02	0.01
	Class Mean	0.33	-0.18	0.79	-0.04
Critical Voice	Individual	0.49**	0.02	0.06	0.06
	Class Mean	0.52**	0.01	0.57	0.10
Uncertainty in Science	Individual	0.21**	0.07	-0.01	-0.30
	Class Mean	0.53**	0.51*	0.73	-0.09
Multiple Correlation (R)	Individual		0.22**		0.02**
	Class Mean		0.66**		0.17

* $p<0.05$
**$p<0.01$
The sample consisted of 888 students in 24 classes in South Africa.

Five of the six statistically significant associations were positive, except for *Collaboration*. With the class mean as the unit of analysis, three of the six learning environment scales were statistically significantly related to students' attitude toward science, namely, *Working with Ideas*, *Critical*

Voice and *Uncertainty in Science* ($p<0.01$) (Table 4.5). All statistically significant associations here were positive.

The multiple correlation between students' perceptions of the learning environment and students' attitude toward science is 0.22 with the individual as the unit of analysis and 0.66 with the class mean as the unit of analysis. At both levels, the multiple correlation is statistically significant ($p<0.01$). The significant standardised regression coefficients in Table 4.5 show that, with the individual as the unit of analysis, two of the six scales were significant independent predictors of student attitude toward science, namely, *Working with Ideas* and *Respect for Difference*. With the class mean as the unit of analysis, only *Uncertainty in Science* was a significant independent predictor of students' attitude toward science (Table 4.5).

Achievement

Analyses were conducted to explore associations between the six dimensions of the learning environment and student achievement for the medium SES group. The results of the simple correlation analysis with the individual as the unit of analyses indicated statistically significant associations between the achievement scores and three of the six scales, namely, *Working with Ideas*, *Respect for Difference* and *Personal Relevance* (Table 4.5). With the class mean as the unit of analysis, there were no statistically significant ($p>0.05$) relationships that existed between the achievement scores and any of the six SCLES scales.

The multiple regression (R) for achievement suggest that the association of students' achievement to the whole set of six environment scales is statistically significant with the individual as the unit of analysis and non-significant ($p>0.05$) with the class mean as the unit of analysis. The magnitude of the multiple correlation is 0.02 for the individual and 0.17 for the class mean as the unit of analysis (Table 4.5). The standardised regression coefficient (β) is statistically significant for two of the six scales, namely, *Working with Ideas* and *Respect for Difference* with the individual as the unit of analysis.

Associations for the Low SES group

Student Attitude Toward Science

Table 4.6 shows the results of the associations between the SCLES scales and students' attitude toward science for the low SES group. When using the individual as the unit of analysis, the results of the simple correlation analyses indicate statistically significant ($p<0.01$) associations between students' attitude toward science and all six learning environment scales. All associations are positive. With the class mean as the unit of analysis, none of the associations are statistically significant at the 0.05 level in Table 4.6.

The multiple correlation between students' perceptions of the learning environment and students' attitude toward science is 0.18 with the individual as the unit of analysis, and 0.54 with the class mean as the unit of analysis (Table 4.6). However, statistically significant ($p<0.01$) results exist only at the individual level. The significant standardised regression coefficients in Table 4.6 show that, with the individual as the unit of analysis, two of the six scales were significant independent predictors of student attitudes toward Science, namely, *Working with Ideas* and *Respect for Difference*. With the class mean as the unit of analysis, none of the scales are statistically significant ($p>0.05$) independent predictors of student attitudes (Table 4.6).

Table 4.6 Simple correlation and multiple regression analyses for associations between student attitude toward science and achievement and the dimensions of the SCLES in South Africa for students in the low SES group.

Scale	Unit of Analysis	Student Attitude		Achievement	
		r	*β*	*r*	*β*
Working with Ideas	Individual	0.38**	0.29**	-0.04	-0.10
	Class Mean	0.58	-0.17	0.32	-0.21
Respect for Difference	Individual	0.31**	0.18**	0.07	0.08
	Class Mean	0.01	-0.17	0.56*	0.68*
Personal Relevance	Individual	0.17**	0.67	0.03	0.03
	Class Mean	0.50	0.81	0.49	-0.08
Collaboration	Individual	0.13**	-0.05	0.04	0.56
	Class Mean	-0.17	-0.53	0.32	-0.07
Critical Voice	Individual	0.19**	0.04	0.03	-0.02
	Class Mean	-0.04	0.22	-0.17	-0.72*
Uncertainty in Science	Individual	0.18**	-0.03	0.04	0.78
	Class Mean	0.39	0.16	0.49	0.60*
Multiple Correlation (R)	Individual		0.18**		0.01
	Class Mean		0.54		0.81*

* $p<0.05$
**$p<0.01$
The sample consisted of 576 students in 14 classes in South Africa.

Achievement

Analyses were conducted to explore associations between the six dimensions of the learning environment and student achievement for the low SES group (Table 4.6). The results of the simple correlation analysis with the individual as the unit of analysis indicated that no statistically significant relationships ($p>0.05$) existed between the achievement scores and any of the six SCLES scales. With the class mean as the unit of analysis, there were statistically significant associations between the achievement and only one scale, namely, *Respect for Difference* (Table 4.6).

The multiple regression (*R*) for achievement (Table 4.6) suggest that the association of students' achievement to the whole set of six environment scales is not statistically significant ($p>0.05$) with the individual as the unit of analysis, but statistically significant with the class mean as the unit of analysis ($p<0.05$). The magnitude of the multiple correlation is 0.01 for the individual and 0.81 ($p<0.05$) for the class mean as the unit of analysis. The standardised regression co-efficient (β) is statistically significant for none of the six scales for the individual as the unit of analysis, but statistically significant for three of the six scales, namely, *Respect for Difference*, *Critical Voice* and *Uncertainty in Science* for the class mean as the unit of analysis (Table 4.6).

Social Constructivist Learning Environment Survey and Gender Equity

Gender equity was defined in terms of the differences in perceptions of male and female students (see Chapter 2, pages 40-42). Possible differences between males and females on all SCLES scales (actual and preferred) were determined by using a one-way MANOVA for repeated measures with the within-class gender subgroup mean as the unit of analysis. Gender was the repeated measure factor and the SCLES, the scale *Attitude toward Science* and achievement formed the set of dependent variables. As males and females are not found to be in equal numbers in every class, the within-class gender mean was chosen as the unit of analysis to provide a matched pair of means—one within-class mean for males and one within-class mean for females. This reduces confounding, in that, for each group of males within a particular classroom, there is a corresponding group of females in the same classroom. Because the multivariate test produced statistically significant results using Wilks' lambda criterion, the univariate ANOVA for repeated measures was interpreted for each individual scale to investigate whether males and females had different perceptions of their classrooms, attitude toward science and achievement.

The results were reported using the average item mean and average item standard deviation for the male and female students for each actual SCLES scale, each preferred SCLES scale, the *Attitude toward Science* scale and student achievement. The effect sizes and ANOVAs were also reported. These results were reported in Table 4.7, showing the overall results for all 52 classrooms. These results suggest that male and female perceptions were statistically significantly different for the scales *Respect for Difference* and *Critical Voice* (Table 4.7).

For both scales, females perceive a more positive classroom learning environment than males do. The effect size for each actual scale of the SCLES (calculated to provide an estimation of the magnitude of the difference) ranged between 0.03 and 0.45 standard deviations, and between 0.12 and 0.53 standard deviations for the different preferred scales. Judging from the effect sizes, the magnitude of the differences between male and female students' perceptions of the actual and preferred learning environments are generally small. However, the importance of *Respect for*

Difference is emphasized for the preferred scale. Females would generally prefer more respect with regard to others' beliefs and views in their learning environment than males do, judging from the statistically significant (p<0.05) results, as well as an effect size of 0.53 standard deviations, a relatively larger effect size than that of the other scales.

Table 4.7 Average item mean, average item standard deviation and difference between males and females and (effect size and MANOVA for repeated measures) on the actual and preferred versions of the SCLES and attitude toward science and achievement using the within-class gender mean and the individual as the unit of analysis

Scale		Scale Mean		Standard Deviation		Difference	
		Male	Female	Male	Female	Effect Size	*F*
Working with Ideas	Actual	3.19	3.14	0.36	0.33	0.14	0.68
	Preferred	3.93	3.97	0.22	0.26	0.13	0.87
Respect for Difference	Actual	3.75	3.86	0.22	0.24	0.24	5.91*
	Preferred	4.10	4.24	0.25	0.28	0.53	6.68*
Personal Relevance	Actual	3.37	3.38	0.30	0.31	0.03	0.04
	Preferred	3.89	3.94	0.27	0.34	0.16	0.59
Collaboration	Actual	3.73	3.77	0.22	0.25	0.17	0.67
	Preferred	4.11	4.14	0.22	0.28	0.12	0.19
Critical Voice	Actual	3.54	3.66	0.24	0.29	0.45	4.91*
	Preferred	3.97	4.03	0.20	0.24	0.27	1.79
Uncertainty in Science	Actual	3.50	3.49	0.24	0.22	0.04	0.01
	Preferred	3.93	3.96	0.26	0.22	0.13	0.33
Attitude toward Science	Actual	3.63	3.53	0.33	0.45	0.27	1.40
Achievement	Actual	6.71	6.64	0.76	0.96	0.08	0.18

* p<0.05
The sample consisted of 1955 students in 52 classes in South Africa.

The results for the student outcomes, namely, attitude toward science and achievement, showed similar trends to that of the SCLES scales. In both cases there were no statistically significant (p>0.05) results between the scores of the males and females, with very small effect sizes (Table 4.7). These results suggest that overall males and females have similar attitudes toward science and achievement scores.

Thus overall, the results in Table 4.7 suggest that while the perceptions of the actual and preferred learning environments are similar for both the males and females, there were statistically significant differences in the views of males and females for the scales *Respect for Difference* and *Critical Voice*. This result is supported by Figure 4.2. The results further suggest that females perceived a learning environment more favourable than males.

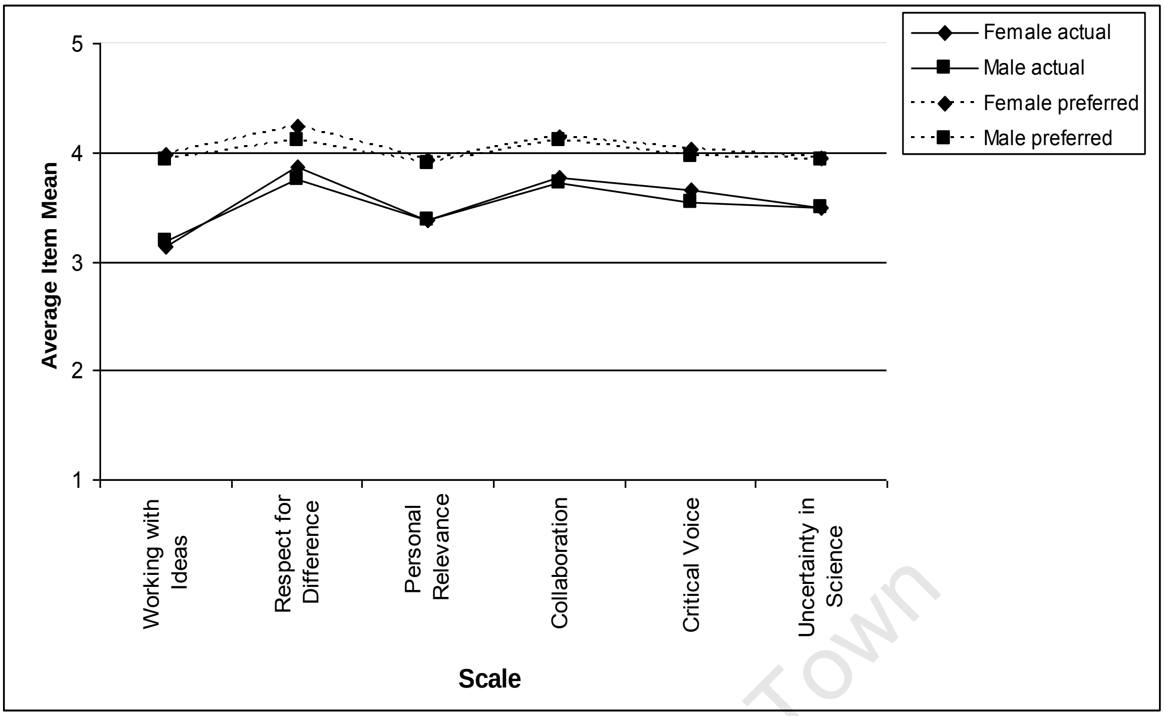

Figure 4.2 Differences between male and female students' scores on the actual and preferred versions of SCLES.

As discussed earlier in Chapter 1 (pages 1-2), SES plays an important role in the classroom learning environment of Grade 9 Natural Science students in the Western Cape Province. Therefore, in the next section, the results regarding gender equity will be examined further by SES (categorized into high, medium and low SES school categories), and as a consequence these results might give an indication of whether teachers are teaching to promote gender fair learning environments.

Gender equity in high SES context

The results reported in Table 4.8 show that for the actual classroom learning environment, the perceptions of males and females in the high SES category schools are statistically significantly different ($p<0.05$) for the scale *Respect for Difference*. For the preferred classroom learning environment, the perceptions of males and females are statistically significantly different ($p<0.05$) for the scales *Working with Ideas, Collaboration* and *Uncertainty in Science*, as well as *Respect for Difference* and *Personal Relevance* ($p<0.001$).

The effect sizes were calculated to give an estimation of the magnitude of the difference between the male and female scores. Generally the results indicate that the magnitudes of the differences between male and female students' perceptions for *Respect for Difference* (actual and preferred) and *Personal Relevance* (preferred) were large, that is between 1 and 2 standard deviations units.

Table 4.8 Average item mean, average item standard deviation and difference between males and females and (effect size and MANOVA for repeated measures) on the actual and preferred versions of the SCLES, *Attitude toward Science* and achievement of the high SES group using the within-class gender mean and the individual as the unit of analysis

Scale		Scale Mean		Standard Deviation		Difference	
		Male	Female	Male	Female	Effect Size	*F*
Working with Ideas	Actual	3.08	2.89	0.27	0.25	0.73	3.14
	Preferred	3.70	3.89	0.25	0.26	0.74	13.39*
Respect for Difference	Actual	3.79	4.13	0.34	0.24	1.17	17.03*
	Preferred	4.05	4.58	0.40	0.12	2.03	27.77**
Personal Relevance	Actual	3.62	3.71	0.30	0.31	0.29	2.07
	Preferred	3.93	4.30	0.36	0.13	1.51	17.63**
Collaboration	Actual	3.68	3.76	0.22	0.25	0.34	0.93
	Preferred	3.92	4.19	0.35	0.26	0.88	5.96*
Critical Voice	Actual	3.51	3.54	0.24	0.29	0.11	0.18
	Preferred	3.89	4.10	0.30	0.19	0.26	4.52
Uncertainty in Science	Actual	3.64	3.58	0.24	0.22	0.26	0.97
	Preferred	3.87	4.10	0.35	0.16	0.90	5.10*
Attitude	Actual	3.42	3.26	0.27	0.34	0.52	6.95*
Achievement	Actual	6.23	6.11	0.44	0.40	0.28	2.08

* $p<0.05$
** $p<0.01$
The sample consisted of 491 students in 14 classes in South Africa.

For the scale *Attitude toward Science*, the results in Table 4.8 show that there is a significant difference ($p<0.05$) between the perceptions of males and females in the actual classroom learning environment. The size of the difference is just over a half a standard deviation unit, with females generally having a less favourable attitude toward science than males do. With regard to the achievement scores, there were no significant differences between males and females ($p>0.05$).

Overall, while perceptions of the actual learning environment were similar between males and females in the high SES group, there are statistically significant differences in perceptions of the preferred learning environment. Here, females generally prefer a more favourable learning environment than males. For the scale *Attitude toward Science*, males have a more positive attitude toward their Natural Science class than females do.

Gender equity in medium SES context

The results reported in Table 4.9 for the medium SES context show that the perceptions of males and females were statistically significant ($p<0.05$) only for the scale *Respect for Difference* associated with the actual and preferred learning environments. Here females perceive a more favourable learning environment than males. The effect sizes on the scale *Respect for Difference* were about 0.5 standard deviation units for both learning environments.

As shown in Table 4.9, the male and female students had similar scores for the scale *Attitude toward Science*, and no statistically significant differences existed. Likewise, males and females scored similarly in their achievement scores (Table 4.9).

Table 4.9 Average item mean, average item standard deviation and difference between males and females and (effect size and MANOVA for repeated measures) on the actual and preferred versions of the SCLES, *Attitude toward Science* and achievement of the medium SES group using the within-class gender mean and the individual as the unit of analysis

Scale		Scale Mean		Standard Deviation		Difference	
		Male	Female	Male	Female	Effect Size	*F*
Working with Ideas	Actual	3.13	3.07	0.31	0.27	0.20	0.68
	Preferred	3.89	3.96	0.23	0.27	0.28	1.07
Respect for Difference	Actual	3.66	3.76	0.21	0.19	0.50	7.33*
	Preferred	4.02	4.13	0.30	0.21	0.43	5.76*
Personal Relevance	Actual	3.38	3.32	0.18	0.22	0.30	1.24
	Preferred	3.86	3.91	0.25	0.27	0.19	0.98
Collaboration	Actual	3.73	3.76	0.19	0.28	0.12	0.28
	Preferred	4.07	4.13	0.28	0.27	0.21	0.75
Critical Voice	Actual	3.49	3.58	0.20	0.26	0.39	1.43
	Preferred	3.87	3.92	0.17	0.23	0.25	0.84
Uncertainty in Science	Actual	3.42	3.39	0.21	0.23	0.13	0.51
	Preferred	3.84	3.89	0.25	0.23	0.20	1.29
Attitude	Actual	3.47	3.56	0.28	0.43	0.25	2.40
Achievement	Actual	5.13	5.07	0.31	0.28	0.20	0.69

* $p<0.05$
** $p<0.01$
The sample consisted of 888 students in 24 classes in South Africa.

Overall, while the perceptions of the actual and preferred learning environment were similar between males and females in the medium SES group, there were statistically significant perceptions only on the scale *Respect for Difference*.

Gender equity in low SES context

The results reported in Table 4.10 show that males and females in the low SES group perceive the actual and preferred learning environments similarly in regard to each of the SCLES scales. All the differences are statistically non-significant ($p>0.05$). For the scale *Attitude toward Science*, and achievement scores, the results are also statistically non-significant ($p>0.05$) (Table 4.10).

Table 4.10 Average item mean, average item standard deviation and difference between males and females and (effect size and MANOVA for repeated measures) on the actual and preferred versions of the SCLES, *Attitude toward Science* and achievement of the low SES group using the within-class gender mean and the individual as the unit of analysis

Scale		Scale Mean		Standard Deviation		Difference	
		Male	Female	Male	Female	Effect Size	*F*
Working with Ideas	Actual	3.53	3.50	0.24	0.18	0.14	0.27
	Preferred	4.02	4.08	0.20	0.21	0.29	0.65
Respect for Difference	Actual	3.75	3.77	0.22	0.17	0.10	0.05
	Preferred	4.04	4.08	0.21	0.17	0.21	0.18
Personal Relevance	Actual	3.16	3.18	0.31	0.28	0.06	0.05
	Preferred	3.73	3.63	0.23	0.27	0.40	2.46
Collaboration	Actual	3.67	3.79	0.27	0.24	0.47	1.74
	Preferred	4.11	4.10	0.18	0.31	0.04	0.03
Critical Voice	Actual	3.64	3.92	0.30	0.23	1.05	3.08
	Preferred	4.01	4.14	0.26	0.21	0.55	1.79
Uncertainty in Science	Actual	3.53	3.53	0.23	0.16	0.00	0.00
	Preferred	3.94	3.91	0.26	0.19	0.13	0.25
Attitude toward Science	Actual	3.89	3.92	0.18	0.18	0.16	0.22
Achievement	Actual	2.71	2.64	0.76	0.96	0.09	0.18

The sample consisted of 576 students in 14 classes in South Africa.

Overall, the results suggest that males and females in the low SES category schools have similar perceptions about their classroom learning environment in the Western Cape Province.

Between-SES analysis: SCLES Scales, Attitude toward Science and Achievement

The classroom learning environment (SCLES scales), students' attitude toward science and achievement were compared based on their SES categories. As a first step, a one-way MANOVA was used to examine the means and standard deviations of the individual SCLES scales, attitude toward science and achievement in the different SES contexts (i.e., high, medium and low). Secondly, pairwise differences between the SES contexts were examined using the Tukey Honestly Significantly Different (HSD) *post hoc* procedure (Tukey, 1971). The size of the differences was examined by calculating the effect sizes as recommended by Thompson (1998, 2002).

Perceptions of the learning environment

To examine the learning environment by SES, data were analysed with a one-way MANOVA using the class mean as the unit of analysis. Socio-economic status (reviewed in Chapter 2, page 42) was the independent variable, and the SCLES scales, *Attitude toward Science* scale and achievement were the dependent variables. As multivariate tests produced statistically significant results using the Wilks' lambda criterion, the univariate ANOVA was interpreted for each individual scale in order to investigate whether students in the high, medium and low SES contexts had varying perceptions about their classroom learning environment, attitude toward science and achievement. The results are reported in Table 4.11 and the means were generated using the SES scores on each actual and SCLES scale, *Attitude toward Science* scale and achievement.

Table 4.11 Average item mean, average item standard deviation and difference between SES high (H), medium (M) and low (L) on the actual and preferred versions (effect size and MANOVA) of the SCLES using the class mean and the class as the unit of analysis.

Scale		Scale Mean			Standard Deviation			Difference
		SES H	SES M	SES L	SES H	SES M	SES L	*F*
Working with Ideas	Actual	2.89	3.09	3.50	0.23	0.25	0.16	27.67*
	Preferred	3.86	3.94	4.04	0.23	0.19	0.17	2.84
Respect for Difference	Actual	4.07	3.73	3.74	0.15	0.18	0.09	24.14*
	Preferred	4.49	4.11	4.05	0.14	0.21	0.12	28.14*
Personal Relevance	Actual	3.68	3.34	3.16	0.23	0.13	0.26	24.71*
	Preferred	4.23	3.90	3.68	0.14	0.22	0.22	27.26*
Collaboration	Actual	3.75	3.76	3.73	0.21	0.20	0.20	0.15
	Preferred	4.14	4.13	4.09	0.22	0.21	0.23	0.23
Critical Voice	Actual	3.57	3.55	3.79	0.18	0.15	0.22	8.52*
	Preferred	4.09	3.91	4.08	0.15	0.16	0.19	7.02*
Uncertainty in Science	Actual	3.63	3.41	3.52	0.17	0.16	0.12	9.48**
	Preferred	4.08	3.89	3.92	0.16	0.21	0.19	4.56*
Attitude	Actual	3.30	3.51	3.91	0.33	0.33	0.19	2.63**
Achievement	Actual	10.95	7.35	5.60	2.04	1.99	1.30	30.92*

* $p<0.05$
** $p<0.01$
The sample consisted of 1955 students in 52 classes in South Africa.

The overall results reported in Table 4.11 show that the perceptions of the students in the three SES categories on the actual version of the various SCLES scales are statistically significantly different ($p<0.05$) for the scales *Working with Ideas*, *Respect for Difference*, *Personal Relevance*, *Critical Voice* and *Uncertainty in Science*. For the preferred version of the various SCLES scales, there are statistically significant differences ($p<0.05$) for the scales *Respect for Difference*, *Personal Relevance*, *Critical Voice* and *Uncertainty in Science*. On the *Collaboration* scale, the results were statistically non-significant ($p>0.05$).

Attitude toward Science

For the *Attitude toward Science* scale there is a statistically significant difference between the high, medium and low SES groups ($p<0.01$). Table 4.11 shows that the mean scores (out of a total of 5) range between 3.30 (for the high SES category) and 3.91 (for the low SES category).

Achievement

Table 4.11 shows a statistically significant difference (*p*<0.05) between the mean achievement scores of the three SES groups. The mean scores (out of a total of 15) range from the highest score of 10.95 (for the high SES category) to the lowest score of 5.60 (for the low SES category), with the medium SES group scoring 7.35. This shows that the students of the high SES group have been scoring higher marks in the achievement test relative to the other two groups.

Identifying Differences in SES

In order to identify the pairs of SES groups that were statistically significantly different (*p*<0.05), a HSD *post hoc* procedure (Tukey, 1971) was used. The magnitude of the differences in the pairs of SES groups (i.e., High and Medium, High and Low, Medium and Low) were identified on the basis of their mean scores and effect sizes (calculated as recommended by Thompson [1998, 2002]) (Table 4.12).

Table 4.12 The Tukey HSD multiple comparison showing statistical differences between each pair of SES category High/Medium (H/M), High/Low (H/L) and Medium/Low (M/L)

Scale	Unit of Analysis	Mean Difference			Effect sizes		
		SES H/M	SES H/L	SES M/L	SES H/M	SES H/L	SES M/L
Working with Ideas	Actual	0.21*	0.62*	0.41*	0.83	3.12	2.00
Respect for Difference	Actual	0.33*	0.32*	0.01	2.06	2.75	0.07
Personal Relevance	Actual	0.34*	0.52*	0.18*	1.88	2.12	0.92
Collaboration	Actual	0.01	0.03	0.04	0.05	0.20	0.09
Critical Voice	Actual	0.01	0.22*	0.23*	0.12	1.10	1.29
Uncertainty in Science	Actual	0.22*	0.11	0.11	1.33	0.76	0.79
Attitude toward Science	Actual	0.20	0.60*	0.40*	0.00	2.35	1.54
Achievement	Actual	3.60*	5.35*	1.74*	1.79	3.20	1.06

* *p*<0.05 The sample consisted of 1955 students in 52 classes in South Africa.

An overall interpretation of differences in students' perceptions for the different SES groups can be made by examining the profile in Figure 4.3.

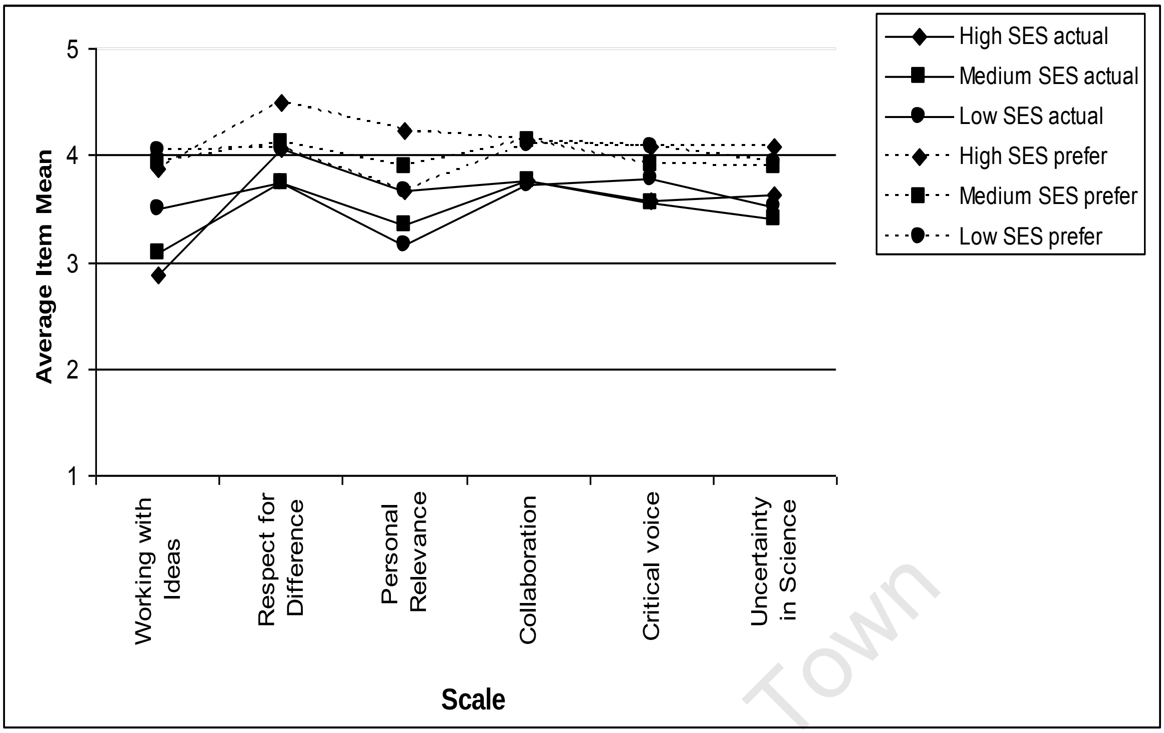

Figure 4.3 Differences between High, Medium and Low SES means on the actual and preferred SCLES.

The effect sizes and the results of the Tukey's multiple comparison procedure are given in Table 4.12. The most salient patterns in the results are summarized below.

The pairwise *post hoc* comparisons in Table 4.12 reveal the following trends:

1) For the comparison between the high SES group and the medium SES group, the scales *Working with Ideas*, *Respect for Difference*, *Personal Relevance* and *Uncertainty in Science* were statistically significant (p<0.05), with effect sizes ranging between 0.05 and 2.06 standard deviation units. In addition, similar results were found for achievement, which showed a fairly large effect size of 1.79.
2) For the comparison between the high SES group and the low SES group, the scales *Working with Ideas*, *Respect for Difference*, *Personal Relevance* and *Critical Voice* were statistically significant (p<0.05), with effect sizes ranging between 0.20 and 3.12 standard deviation units. Likewise, similar results were found for the scale *Attitude toward Science*, as well as for achievement, with effect sizes of 2.35 and 3.20 standard deviation units respectively.
3) For the comparison between the medium SES group and the low SES group, the scales *Working with Ideas*, *Personal Relevance* and *Critical Voice* were statistically significant (p<0.05), with effect sizes ranging between 0.07 and 2.00 standard deviation units. Likewise, for the scale *Attitude to Science* and the achievement scores, similar results were found, with effect sizes of 1.54 and 1.06 respectively.

Findings from the Qualitative data

The qualitative data collection phase was conducted in order to validate the trends obtained from the quantitative data results. The schools selected for this phase were chosen using the actual and preferred learning environment classroom profiles generated during the quantitative data analysis. Selection of the schools involved two steps. Firstly, the 52 classroom profiles were scrutinized for patterns and trends. Secondly, five schools were chosen on the basis of two characteristics (Table 4.13): (1) the absolute high/low value for the perceptions of the actual learning environment, and (2) discrepancies between the students' perceptions of the actual and preferred classroom learning environments.

Table 4.13 The criteria for the choice of schools for the qualitative data collection phase—based on the discrepancy of perceptions of students in their actual and preferred learning environment, and the absolute score (out of a total of 5) for each scale.

Class	**SES**	**Scale**	**Actual and Preferred Learning Environment Score**			
			Discrepancy		Absolute value	
			small	large	low	high
A	H	*Working with Ideas*		×	×	
		Respect for Difference	×			×
		Uncertainty in Science		×		×
B	M	*Personal Relevance*	×			×
		Critical Voice	×			×
		Uncertainty in Science	×			×
C	H	*Working with Ideas*		×	×	
		Respect for Difference		×		×
		Collaboration		×		×
		Critical Voice		×	×	
D	L	*Critical Voice*		×		×
		Uncertainty in Science		×		
E	M	*Working with Ideas*	×			×
		Personal Relevance		×	×	

Each of the five classes was observed a minimum of five lessons. The average length of the lessons was 40 minutes long. Interviews were conducted with the class teacher and the students in order to clarify and verify the observations. The student interviews involved focus groups, where six students per class were randomly chosen to be interviewed at the end of the classroom observation period.

The analysis of the qualitative data involved the use of narrative stories. This method has been successfully used in previous studies of LER (e.g., Aldridge *et al.*, 1999a; Fraser & Tobin, 1985) and has provided unique insights into the different classrooms studied. Through the narrative stories, a model of a typical Natural Science lesson in each class was created by combining the data from the classroom observations, as well as those from the teacher and student interviews (see Chapter 3, page 66). In order to create the narrative stories, the interviews were condensed and rephrased, as suggested by Kvale (1996), and the classroom observations were recorded as field notes and transcribed (Creswell, 2003) (Chapter 3, page 66).

In the next section, a general impression of each of the five classrooms (Classrooms A-E) is given. First, a brief description of the school and teacher is given to provide background information about the class. Second, the SCLES scale trends are presented in a graphic profile in order to give a visual representation of the actual and preferred learning environment discrepancies. Thirdly, the narrative story is presented. Finally, various data (observations and interviews) are analysed in relation to selected scales (see Table 4.13, page 92) so that relevant classroom features may be identified that impact on students' perceptions of these scales.

Class A

This class is a girls-only school in an affluent area in Cape Town, South Africa. Given the annual school fee of R11 980 per year, the school was categorized as high SES (see Chapter 3, page 61). The school is well-resourced in terms of its infrastructure with regard to four important matters. First, facilities such as water and electricity are available in all the classrooms. Second, the school is secured with a variety of measures, namely, a security guard who patrols during the day; a night security guard; fencing surrounding the perimeter of the school; and intercoms at various gates. Third, there are five science classrooms and one large computer room, both with functional equipment. The science classrooms house laboratory desks and chairs, microscopes, a variety of chemicals and many science teaching aids. The computer room is equipped with thirty computers and is run by a computer science teacher. Each computer has internet access and software related to science learning. Finally, other important facilities include a school library, with many science books for use during projects and research, as well as a staffroom where teachers meet.

This comparatively large school (853 learners) is staffed by well-qualified teachers, all of whom have university degrees. Fifty percent of the teachers are employed by the government (i.e., the provincial education department) and the rest by the school (i.e., School Governing Body [SGB]) (Chapter 1, page 7). The SGB is able to employ enough teachers to limit the maximum class size to 35 students.

The teacher of *Class A* is a female in her mid-twenties. She has a science degree and four years teaching experience. She confirmed that during her teacher training she was exposed to the term social constructivism on numerous occasions and was therefore familiar with the concept. She claimed that she tried to practice social constructivism in her class. The teacher's teaching approach generally incorporated active involvement of all students, with the main thrust focusing on approaches like class discussions and debates, as will be evident from the classroom narrative provided later. Focus group interviews with the students suggested that they enjoyed being actively involved in lessons. Furthermore, they were eager to be involved in lessons as the teacher encouraged them to participate in lessons because of her approachable, warm and non-threatening disposition. They said, for example, "Miss allows us to ask any question. We never feel stupid when talking to her". The students were also aware that the teacher encouraged debate by creating opposition in science lessons through her strong religious viewpoints. They said, "Sometimes Miss will say something about religion that goes against science evidence. Some students will agree while others might disagree". One student added, "Sometimes when she challenges us with the religious views, it makes the lesson more interesting". When interviewing the teacher, it was evident that her religious viewpoint featured frequently in her teaching of science. She stated: "My religious viewpoint makes me more objective about science; as a consequence, I often prepare lessons that polarize opinions, leading to class debate". The teacher added: "My light workload gives me time to do research for lesson preparation. I tend to focus on class discussion and debate as I know this class enjoys it".

In order to give an overall impression of the students' actual and preferred learning environment scores, Figure 4.4 represents a graphic classroom profile for *Class A*. It represents the average item means for the students' scores on the actual and preferred SCLES learning environment scales. The scales *Working with Ideas*, *Respect for Difference* and *Uncertainty in Science* were chosen to investigate further for the qualitative data collection phase (Table 4.13). The scales, shown graphically in Figure 4.4 below, are discussed in more detail in relation to the teacher and student interviews and classroom observations.

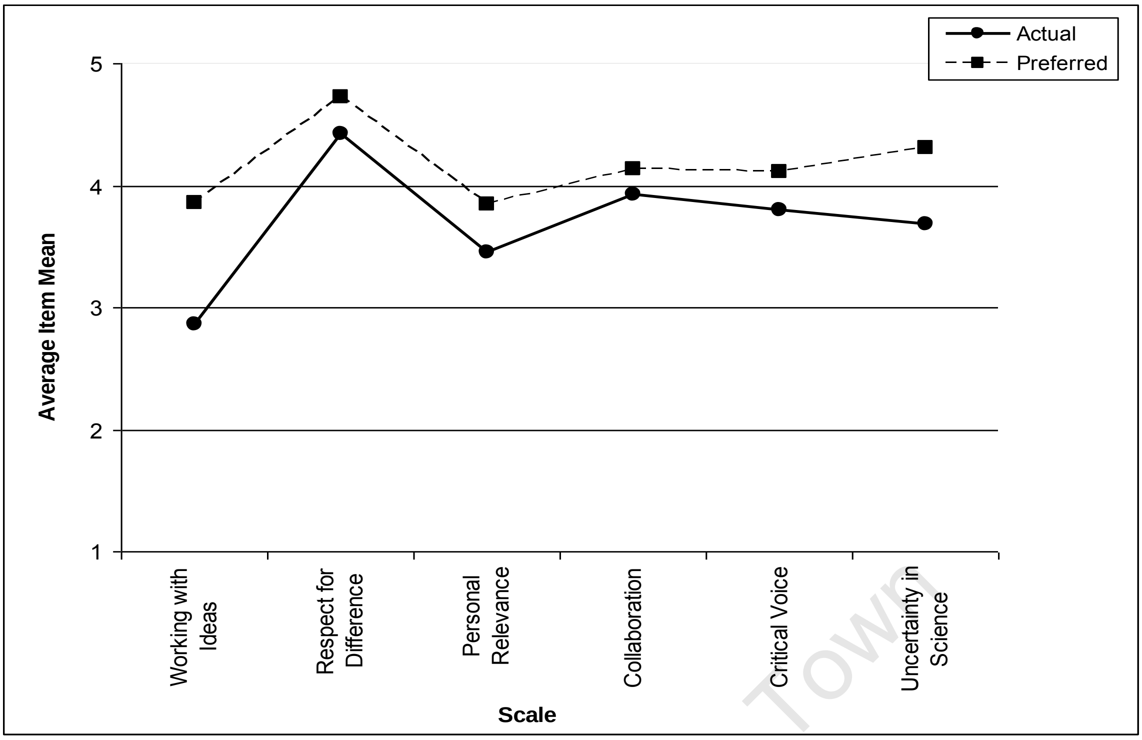

Figure 4.4 Average item mean for students' scores on the actual/preferred learning environment scales of the SCLES for the case study of Class A.

The observations are encapsulated in a typical Natural Science lesson for *Class A*. This is described below:

> I am warmly greeted by the teacher in the staffroom, and we proceed toward the classroom. The classroom door is locked, and the teacher explains that each class in the school has a Smartboard—a large whiteboard projecting images from a computer. Classrooms must thus be locked in the absence of adult supervision. Each teacher in the school has a dedicated classroom. The students change from one class to another between periods. As we walk toward the classroom door, we pass a row of girls waiting in line to enter the class.
>
> The teacher and I enter the classroom first, followed by 34 chatting and laughing girls. The teacher, clearly irritated by the noise, shouts "Please be quiet, I'm sure that you must be aware that we have a guest in our midst". The noise level decreases dramatically. A minute later, there is complete silence. The teacher then prompts the students to greet her by saying "Good morning, girls", and the students reply, "Good morning, Miss". The teacher then instructs them to sit, and they listen attentively. As I look around me, I notice that the classroom is neat, with many colourful pictures related to Biology on the walls. The students sit in groups of four, each student facing one another within the group. If the teacher is busy on the board, they have to turn their chairs and face her. They noisily turn their chairs to mark the beginning of the lesson.
>
> The lesson starts with the teacher asking a group to complete their Powerpoint presentation on the planet *Mars*. This group could not complete their presentation in the last lesson as they ran

> out of time. Four girls move to the front of the class, one inserting the flashdrive into the computer connection point, and the first slide is reflected on the interactive whiteboard screen. The rest of the students listen attentively. During the question session, the students put up their hand, waiting in turn for their question to be addressed. About 20 minutes into the 50-minute lesson, the teacher completes the question-and-answer session.
>
> She starts the next part of the lesson by saying "Now that we have been looking at the characteristics of the planets beyond our Earth, we are now ready to study our own planet—the Earth—in more detail". She starts off with a brainstorming session and writes the word *Lithosphere* on the interactive whiteboard. She uses a model as well as internet pictures to illustrate her point. A few seconds later she says "Now I will call up my friend" and a stopwatch pops up on the screen. She sets it to three minutes. She then instructs the students "I will give you three minutes to brainstorm this word—you have come across it before". The clock ticks and the students work frantically in their groups of four, while the teacher walks around the class.
>
> After three minutes the groups report back. The teacher takes one fact from each group to form a concept map summary on the interactive whiteboard. The students copy this from the interactive whiteboard while they listen to the teacher talking. The teacher encourages the girls to express their own opinions and "theories" based on what they have learnt about the *Lithosphere* already. One of the girls, perplexed, puts up her hand and passionately questions the teacher "How can we give our own opinions if there are facts about this topic in our textbook already". The teacher answers by saying "In science it is good to theorise". She continues by saying: "For example, if Tracy (fictitious name) gives her theory about continental drift… She will then do some Googling to check her ideas". She then bases what she believes is true on the best theory she has at the time, but maybe in ten years time that might change. I know that sometimes you students want to think—give me the right answers—but in some ways it is good to know all the things that do not work so that we can work toward what could work best at the time".
>
> This explanation interests all the girls, and one changes the topic and shouts out: "Is a theory an idea based on thought?" and the teacher replies "A theory is an idea based on evidence". The rest of the class sits listening attentively as the teacher patiently listens to their questions and attempts to answer them in the best way possible. A few minutes later, the siren wails and signals the end of the lesson.

The narrative suggests that the teacher gave students opportunities to engage meaningfully with knowledge and to develop concepts through respectfully listening to each other's opinions. For instance, during the classroom presentation on *Mars* at the beginning of the narrative, students were given the opportunity to listen and subsequently question the group who presented, in order to develop their understanding of the concept. Similarly, during the lesson on the *Lithosphere*, the teacher allowed the students to listen to one another's ideas through discussion, and then to listen to one another through the group report-back. By adopting this approach, it is evident that the teacher was encouraging the development of knowledge in a social setting. This, coupled with the teachers' Natural Science training skills that promote meaningful Natural Science learning, and the technological support from the well-resourced school, suggests that by and large, a social constructivist learning environment existed in this Natural Science class.

As shown in Figure 4.4, the very large discrepancy, as well as the low score on the actual and preferred learning environment scores for the scale *Working with Ideas* (Table 4.13) surprised the teacher. Her surprise was made evident when she said, "This could imply that I fail to make students understand work in class, especially when I thought that they responded positively to my structured approach to teaching! I take on this structured approach in order to economise on my class time". Through interviewing the teacher, it was apparent that she taught the class only four lessons a week and thus economized on her time by modifying her teaching through a two-part teaching approach. In the first part of the approach, she spent at least two lessons guiding the students in the development of a concept. In the second part, the students, themselves, developed the concept independently, particularly through independent or group-related research projects. She claimed that through independent work, the students were able to "think about their thinking", which she termed "metacognition". But more importantly she found that it allowed her to complete the content requirements in the syllabus. She said:

> With the time restrictions imposed by the Department of Education, and the whole of the last term being devoted to tests and examinations, as well as marking them, I have to adopt teaching approaches that help save time during lessons—for instance, I do many investigations.

Evidence of a two-phased teaching approach was apparent in the classroom narrative. The first phase was evident during the lesson on the *Lithosphere*. For instance, the teacher started this lesson by explaining, then illustrating (i.e., using tools such as the internet and models), followed by engaging the students with an activity (for instance, the groupwork exercise in the narrative), students then reported back by building a concept map, and finally a question session allowed students to ask the teacher questions. If time permitted, a general question session would end the lesson (evident in the classroom narrative where students asked questions on theorizing). Evidence of the second phase of the teaching approach was apparent on the lesson about the planet *Mars*. Though the two lessons involving the theory about *Mars* was completed prior to the classroom observations, the teacher used investigative approaches in the second phase to allow students to independently engage with the concept, cutting down on class time. Here, the groupwork PowerPoint presentation on the planet *Mars* involved the students researching the planet, then presenting it in an oral presentation, thus allowing the students to independently develop their understanding of *Mars* through investigation. Overall, the teacher claimed that though she used the two-phased approach to economise on class time, it was evident that the approach was successful judging from the succinct presentations delivered by the students.

Likewise, the students made it evident that this approach was a good one. One student said, “Miss is good at explaining work in class”, while another echoed, “I’m happy with the structured lessons that Miss gives us in class, I understand her explanations”. But it was evident from student interviews that the students, though generally happy with the approach in class, struggled with the independent work—the investigative tasks. Focus group interviews with the students were conducted in order to determine why this was so. The responses suggested that the students would have preferred more guidance on their investigative tasks outside the class. They said: “It would be nice to do more investigations when Miss is accessible to help us in class”. It seemed that even with the availability of relatively sophisticated technology in this class, as well as easy access to a variety of resources, the students still seemed to feel more comfortable when the teacher was available during their learning. Further interrogation on this issue during student interviews revealed that the students’ rationale for wanting the teacher present during investigations was mainly to guide them—particularly guidance with developing their ideas. One student said: “I am able to gather information through research, but it is difficult to put the information together. I would like the teacher to be available to explain difficult concepts”. Thus, the low score for the actual learning environment score on the scale *Working with Ideas* in Figure 4.4 implies that the development of concepts using this dimension did not happen often. The high score for the preferred learning environment for this scale suggests that students would have liked it to happen more often within their classroom learning environment. Hence, the fairly large gap between the actual and preferred learning environment scores in Figure 4.4. On the whole, this result confirms the validity of the quantitative data for the scale *Working with Ideas* (Figure 4.4).

The high score and small discrepancy on the scale *Respect for Difference* (Figure 4.4) was probably due to the teachers’ pivotal role in enforcing transparent rules based on respect for varying opinions. The interview with the teacher made it apparent that by creating a clear set of rules, which were openly discussed with the students and therefore transparent, made them want to participate in respecting each others’ views. She said, “I encourage the girls to express their opinions by clear rules based on respect”. The students’ awareness of the rules set by the teacher played a crucial role in the students implementing them. Interviews with the students revealed that they were aware of the rules in their class:

> …we know that when other students speak, we must listen, and Miss [the teacher] insists on it. This allows us to feel free to express ourselves in our class, even to Miss. She makes us feel comfortable to express our ideas and opinions in this class.

The teachers' creation of explicit rules resulted in the students' freedom to express themselves in class which was apparent in the classroom narrative. During the Powerpoint presentation, it was apparent that the students listened attentively, and subsequently asked questions in a respectful manner—even though there might have been opposing views during this time. The classroom narrative further revealed that this respectful manner gave the girls confidence to express themselves openly in class when they had the freedom to ask a variety of questions about theories. On the whole, this result confirms the validity of the quantitative data for the scale *Respect for Difference* (Figure 4.4).

It seemed unsurprising to the teacher that, with regard to the scale *Uncertainty in Science*, there was a fairly large discrepancy on the actual and preferred learning environment scores (Figure 4.4). The teacher said: "Students in this class are still experimenting with the concept of the uncertainty in science. There are many doubts, and I am trying to help them develop this idea". Evidence of the students' doubt about the possibility that science can be questioned was unearthed in the classroom narrative, and was particularly apparent in their curiosity about the concept of theorizing which led them to many questions. Furthermore, the students believed that science should not be questioned. They stated: "All previous teachers in science have told us that we should not question them [the teacher] or the textbook. All the answers in the textbook are correct". Classroom observations revealed that the teacher helped the students by allowing them to explain their ideas to the class and encouraged theorising through thinking about all possibilities and options. For instance, the classroom narrative suggests that the teacher guided the students' misunderstandings about science by using the concept of theorizing.

An issue that became apparent during the focus group interviews with the students was that the teachers' restrictions on time (which she called "economizing on time") suggested that the two-phase teaching approach (discussed earlier, pages 97-98) left little time for the students to question issues related to science. They also stated that even though investigative tasks allowed them to address some issues, more time interacting with the teacher might have allowed them to answer difficult questions more easily (which was discussed on page 97, on the scale *Working with Ideas*).

On the whole, the results confirm the validity of the quantitative data for the scale *Uncertainty in Science* (Figure 4.4). The low actual score might be due to the students' perception that the teacher spent too little time on allowing them to question science. On the other hand, the higher preferred score suggests that the students would like more exposure to activities underlying the scale *Uncertainty in Science*. Hence, the large gap between the actual and preferred learning environment scores could be due to the students' yearning to want to know more about the dimension against the teachers' limited exposure to the scale.

Class B

This class is at a co-educational school situated in a poor, gang-infested area in Cape Town, South Africa. Given the annual school fee of R450 per year, the school was categorized as medium SES (see Chapter 3, page 61-62). The school is well-resourced in terms of its infrastructure with regard to water and electricity which is available in all the classrooms. However, there are numerous problems regarding classroom infrastructure. The four science classrooms and one large computer room have broken equipment, which the teacher claimed was mainly due to vandalisation. The science classrooms are equipped with a laboratory that houses some broken laboratory desks and chairs, some broken plug points, some functional microscopes, a limited supply of chemicals and some functional science teaching aids. These science classrooms have been the target of vandalisation by the students themselves. The computer room is equipped with thirty computers and run by a computer science teacher. Each computer has internet access and software related to science learning. However, this room has been the target of vandalisation on numerous occasions by gangsters in the community. As a result, security plays an important role in protecting the school. But the schools limited funds have resulted in its reliance on volunteer workers from the community to act as security guards. Many of the volunteers are unemployed parents who patrol the school gates only during school hours. At night the school is left without any security. Other important facilities include a small staffroom where teachers meet. There is no room available for a school library and therefore books are unavailable for research purposes for the students.

This comparatively large school (778 students) is staffed by 23 teachers, all funded by the provincial department of education. The majority of the teachers do not have university degrees, but a four-year teaching diploma obtained from a teacher training college (see Chapter 1, page 5-6). An interview with the teacher of *Class B* made it evident that his workload was heavy. He claimed it was mainly due to the shortage of teachers at the school. Furthermore, the low school fee paid by the parents left no additional funds to employ extra teachers (see Chapter 1). As a result, the staff complement has to take on extra responsibilities. Some of these responsibilities include taking on extra classes, marking additional tests and examination scripts, increasing their administrative duties, and an increase in extramural activities. Together, these additional responsibilities increase their workload tremendously.

The Natural Science teacher, aged 29, also complained that his workload was heavy. He said, “I have been teaching at this school for the past five years—my whole teaching career—and the Department of Education has not provided any extra teachers for this school”. Furthermore, he added, “I think most newly qualified teachers, especially the ones with degrees, will not teach in a poor community like this”. Interviews with the teacher revealed that he did not have a university degree, but had completed a four-year teaching diploma at a teacher training college. During his teacher training, he claimed that he was exposed to the term social constructivism. He claimed that he tried to implement social constructivist teaching approaches, but claimed he felt restricted by his workload. With regard to the workload, he said, "That approach requires elaborate lesson plans, I don't have the time with my big workload". He furthermore added, "I feel that one can use science lessons to promote other matters".

In order to give an overall impression of the students' actual and preferred learning environment scores, Figure 4.5 represents a graphic profile of students' perceptions of various SCLES dimensions for *Class B*. It represents the average item means for the students' scores on the actual and preferred SCLES learning environment scales. The scales *Personal Relevance*, *Critical Voice* and *Uncertainty in Science* were chosen to investigate further for the qualitative data collection phase (Table 4.13). The scales, shown graphically in Figure 4.5 below, are discussed in more detail in relation to the teacher and student interviews and classroom observations.

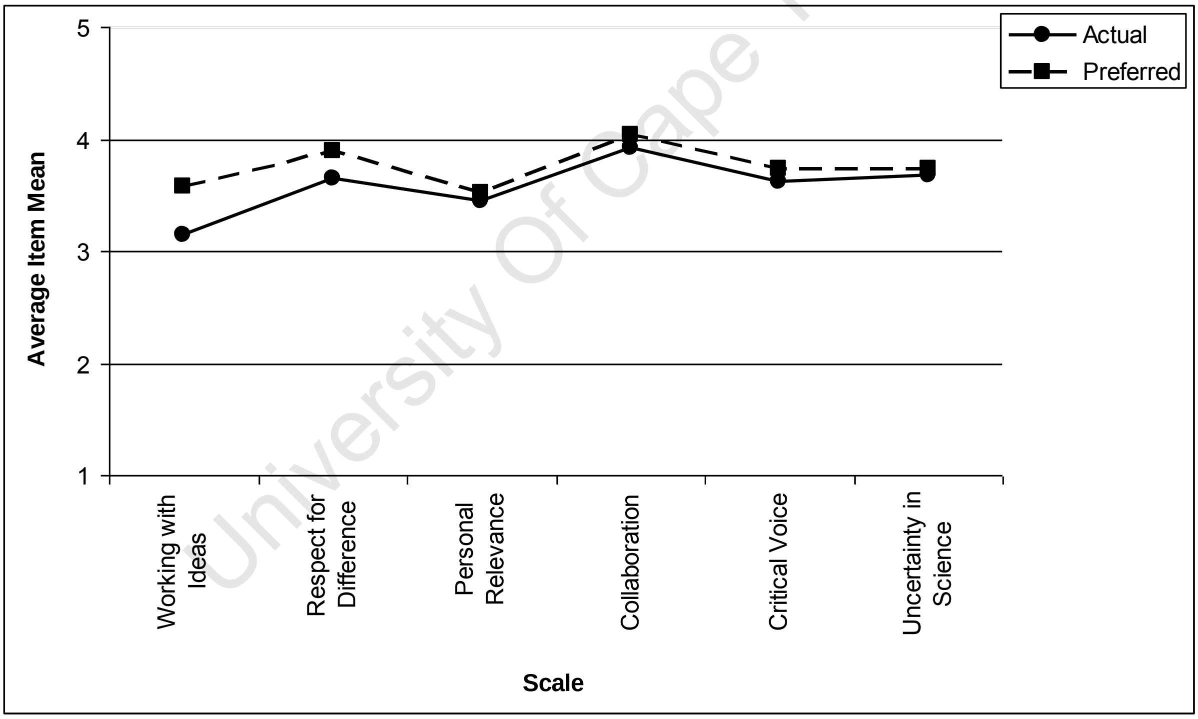

Figure 4.5 Average item mean for students' scores on the actual/preferred learning environment scales of the SCLES for the case study of Class B.

The observations are encapsulated in a typical Natural Science lesson for *Class B*. This is described below:

> We enter the class and after a brief introduction the lesson starts. Students in this class are seated at their desks facing the teacher. The teacher starts the lesson by asking questions to re-cap on the previous lesson. He does so by posing questions and then allowing individuals to answer them. After about ten minutes of this question-and-answer session, he suddenly shouts

> "Homework", and some of the students diligently take out their homework. He walks around the classroom checking the students' books, only to establish that the majority of the class did not do their homework. He compliments those who did do their homework, and after reprimanding the others, gives them a chance to complete it by the next day. Twenty minutes of the hour-long period have elapsed.
>
> The teacher introduces the topic for the lesson, which he has also written on the board: *Electrical Current*. He uses 15 minutes to explain what current is, how to calculate it, and introduces the concepts of voltage and resistance. Throughout the lesson he attempts to connect scientific knowledge with the students' everyday lives. He gives the following analogy to explain the movement of current, "…current will flow smoothly if no one disturbs it. Imagine that, one evening, you're sleeping in your house and a gangster secretly crept in through the window to rob you. He cuts the electricity supply. In other words, he broke the flow of current. The only way that the current will flow again is if we repair the break in current". This example kept the students interested. Many asked questions and related their science knowledge to the example.
>
> The students in this class tend to be distracted easily. Often they ask the teacher while he was teaching "Must we write this?", and the teacher replies, "No, first listen". The teacher holds their attention through question-and-answer sessions. He also tends to gauge the students' progress by asking questions related to the content covered. The teacher asks one of the students a question about current and the student responds, "I'm lost, Sir". He then asks the same question to another student who also responds "I'm lost, Sir". At this point the teacher stops explaining, and lets the students write notes from the overhead projector.
>
> Twenty minutes are spent copying notes. The teacher's notes are clearly written and contain many facts and equations related to current electricity. There is silence as the student's copy the notes from the overhead projector—nobody asks for clarification or question the content of the teacher's notes. At the end of the last overhead note, the students are given a homework assignment—a textbook exercise on solving equations related to current electricity, voltage and resistance. The teacher tells them to consult their notes to help them answer the questions. The siren wails, signalling the end of the period.

The narrative suggests that the teacher took a seemingly structured approach to his teaching. In some parts of his lessons, it appeared that he dominated the lesson. For instance, he would ensure that the students copied his notes verbatim, from the overhead projector, as opposed to them writing their own notes. Also, he tended to personally check whether students did their homework, as opposed to asking them whether they had completed it. Such characteristics tended to make his lessons teacher-centred. On the other hand, as again noted in the classroom narrative, the teacher was very aware of issues relating to the students' everyday lives using the example of gangsterism in the topic on *Electric Current* to illustrate a point. This awareness suggests that the teacher made lessons personally relevant to keep the students engaged. On the whole, though the teacher used some social constructivist approaches, it was more evident that his lessons were teacher-centred.

The learning environment created by the teacher was further probed by investigating the scores on the scales *Personal Relevance*, *Critical Voice* and *Uncertainty in Science*. As shown graphically in Figure 4.5, the small discrepancy between the actual and preferred learning environment scores for the scale *Personal Relevance* impressed the teacher. According to the teacher, it was probably due to the fact that he understood the students' life circumstances. Being from a similar background, the teacher said he understood the students' needs, and confirmed this by saying, "I know this community well, and include issues related to their personal lives in my lessons as a means of gaining their [the students'] trust". In the classroom narrative, the teacher connected the flow of electric current with a topic that was very relevant to their everyday lives, namely, gangsterism. His rationale for including relevant examples was articulated when he said, "I ensure that I include relevant examples to make them remember the work. The gangster example sounds a bit extreme, but this is the reality of where they live, this is what really happens at home". Furthermore, relevance in lessons leading to trust kept the students in school which allowed him to become personally involved in the students' lives, by for example, fetching them from their homes when they had been absent for long periods of time. Apparently the school drop-out rate is high in the community, a fact confirmed during interviews by not only the teacher, but also by conversations with the school principal. According to the teacher, there were forty-eight students in his class at the beginning of the year. This number was now reduced to thirty—he suspects that the drop-out rate could be due to drug-related issues. Classroom observations confirmed that the students responded positively to the teachers' use of personal relevance in his teaching. Focus group interviews with the students confirmed this, with one student citing the example on electricity referred to in the classroom narrative. The student claimed that as a result of this lesson, he was able to understand and remember the theory on electricity.

With regard to the scale *Critical Voice* it was evident that the high scores and small discrepancy on this scale (Figure 4.5) was due to the teachers' ability to make students feel comfortable enough to express themselves in the class. Unsurprised by the results, the teacher claimed that his emphasis on strict control of lesson progression seldom deterred students from expressing themselves critically in his class. He claimed that they were fairly confident to express themselves, and part of this confidence was a result of the students respecting him. He said: "I think that they take their cue from me as I respect each of them in the class, as well as their opinions". The students verified this by saying, "Sir (the teacher) is respectable toward us, that's why we make the effort to listen to one another as he expects it of us". However, the students also implied during interviews that they were hesitant to question him, as they said, "Sometimes Sir gets angry when we do not follow his instructions". This was evident in the classroom narrative, after the teacher had reprimanded the majority of students who failed to do their homework. Classroom observations revealed that many students hesitantly expressed that they did not understand the homework assignment for fear of upsetting the teacher. This was verified in interviews with the students. In agreement, they said, "We struggled to tell Sir we do not understand, as he might punish us".

Figure 4.5 shows a small discrepancy on the actual and preferred learning environment scores on the scale *Uncertainty in Science* (Table 4.13). Responses to interview questions suggest that the teacher was indifferent to promoting science as uncertain. He claimed that it was a time issue, by saying, "There's very little time to dabble with debates about the uncertainty of science". Classroom observations revealed that he seemed to follow a format for his lessons; namely, he made sure that he explained a section, then allowed the students to quietly copy notes from the overhead, and he finally ended the lesson with a homework exercise. This was apparent in the classroom narrative, where little time was left for discussion on the how science can be uncertain. Interviews with the students revealed that they generally mirrored the teachers' attitude in that they lacked interest in questioning Science. One of the students categorically stated "We are not encouraged to question Science, as there is no time in class. The notes that the teacher gives us, as well as the textbook, should not be questioned".

Class C

This is a case study of a Natural Science class that was situated in a co-educational secondary school in an affluent area in Cape Town, South Africa. The school was classified as a high SES school category, as the annual school fee is R5 400 per year (see Chapter 3, page 61-62). The school is well-resourced in terms of its infrastructure with regard to four important matters. First, facilities such as water and electricity are available in all classrooms. Second, the school is secured with a security guard who patrols during the day, a night security guard, fencing surrounding the perimeter of the school, and an intercom at the main entrance to the school grounds. Third, with regard to the classrooms, there are six science classrooms and one large computer room, both with functional equipment. The science classrooms are equipped with a laboratory that houses laboratory desks and chairs, microscopes, a variety of chemicals and many science teaching aids. The computer room is equipped with thirty-five computers and run by a computer science teacher. Each computer has internet access and software related to science learning. Lastly, other important facilities include a school library, with many science books for use during projects and research, as well as a staffroom where teachers meet.

This comparatively large school (947 learners) is staffed by well-qualified teachers (all with a university degree combined with a teaching diploma). More than 50% of the teachers are employed by the provincial education department, and the rest by the SGB (Chapter 1, page 7). The SGB, through their control of school fees, can make funds available to employ additional teachers. This control enables them to limit the class size to a maximum of 35 students. The teacher of *Class C*, however, complained that employing additional teachers did not ease her heavy workload. She made it evident during teacher interviews that her workload was particularly heavy. The teacher further claimed that she had less than five free periods per week, and had extracurricular activities three days a week. Apparently this heavy workload influenced her teaching approaches. She said, "I'm very strict with the students while teaching. My limited time with them during the week, as well as my heavy workload, prevents me from preparing innovative lessons".

The teacher has a Science degree. In addition she has an Honours degree in Education combined with a teaching diploma. Her teaching experience spans twenty-one years. Though exposed to social constructivist teaching approaches during her Honours degree, and therefore very aware of the execution of the approach, lesson time constraints influenced the degree of implementation. The teacher thus claimed that she structured her lessons for optimal content learning.

In order to give an overall impression of the students' actual and preferred learning environment scores, Figure 4.6 represents a graphic classroom profile for *Class C*. It represents the average item means for the students' scores on the actual and preferred SCLES learning environment scales.

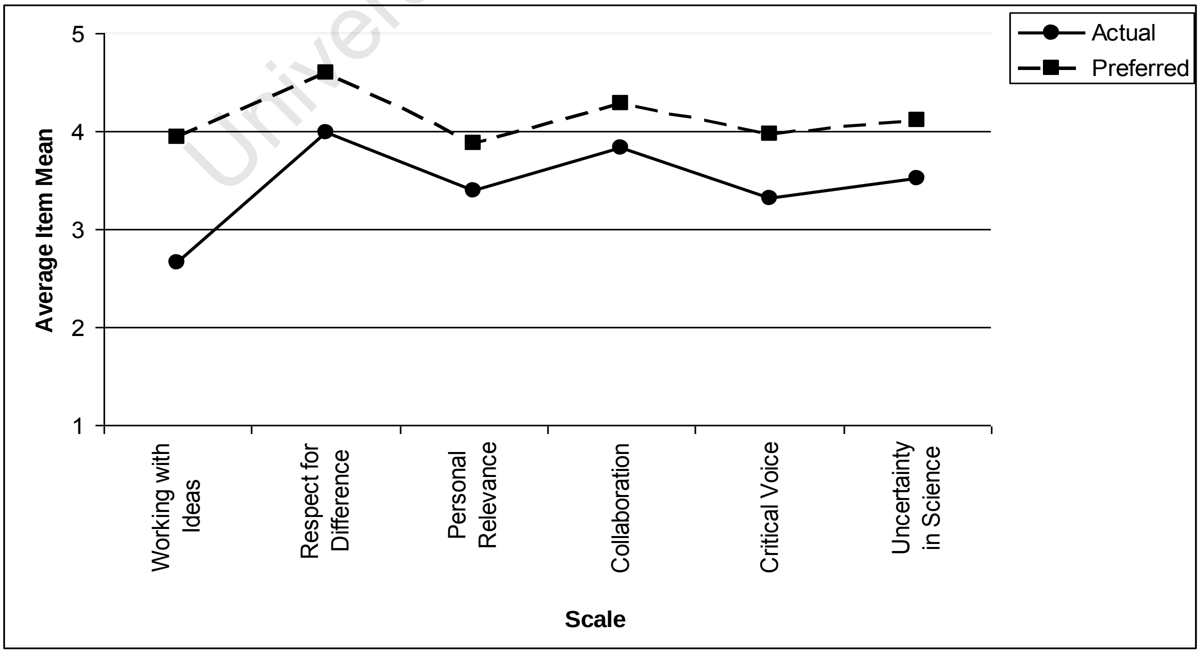

Figure 4.6 Average item mean for students' scores on the actual/preferred learning environment scales of the SCLES for the case study of Class C.

The scales *Working with Ideas*, *Respect for Difference*, *Collaboration* and *Critical Voice* were chosen to investigate further for the qualitative data collection phase (Table 4.13). The scales, shown graphically in Figure 4.6 above, are discussed in more detail in relation to the teacher and student interviews and classroom observations.

The observations are encapsulated in a typical science lesson for *Class C* which is described below:

> On the day of my visit I am introduced to the principal and one of the students leads me to the classroom where the teacher greets me warmly. The students are seated at their own desks all facing the teacher at the chalkboard. The teacher introduces me to the class and they greet me politely. I am offered an empty seat at the back of the class, and the lesson proceeds. A quick count indicates that there are 25 students in the class.
>
> The teacher continues to have a discussion with the class about the up-coming test. She gives the students advice by stating "You will get a graph, but you are still confused about variables. If you don't understand then memorise how to draw graphs". The students diligently write notes about the concepts that they have to learn for the test. After twenty minutes of the hour-long lesson has elapsed, the lesson begins.
>
> The teacher introduces the topic for the lesson. The topic and the intended learning outcomes are written on the board. The lesson topic is *Forces and Energy*. The teacher uses 15 minutes of the lesson to explain what forces are and the difference between contact and non-contact forces. The teacher constantly asks questions in-between, trying to establish whether students are following the explanations. The teacher uses an everyday example to illustrate the different types of forces that exist. She asks one of the students "If I use a box, before I push it, what is the energy called?" The student answers, "Potential". The teacher continues "…and if I push it?" Another student answers, "Kinetic". Finally the teacher asks, "If I push the box against a surface?" and a different student answers, "Frictional". The students are listening attentively and writing notes from the chalkboard.
>
> The teacher writes a word sum on the chalkboard. Before the students start writing, she tells them "I want you to make this heading—*contact forces*—then I want you to take down the first line". The students quietly follow instructions. The teacher continues "Do the calculation, then I will choose a person to give the answer by writing it on the chalkboard". The silence is broken by a group of students who suddenly become noisy and the teacher responds "I'm going to remove one of you, so stop your nonsense!"
>
> After another five minutes the teacher calls on a volunteer to write the answer on the chalkboard. As the student writes the answer the teacher states "First write down the formula…[she turns and addresses the rest of the class]…you have to learn to listen and be more meticulous about your work!" Before the end of the lesson, the teacher gives the students

more exercises from their textbook for homework. The siren wails, signalling the end of the lesson.

The narrative suggests that lessons were teacher-dominated—the teacher dominating the students' actions and how they learn. The teacher controlled the students' actions by telling them to memorise graphs as they failed to understand variables in the section on graphs. This prevented them from expressing their misunderstandings. Furthermore, the teacher controlled how the students learnt by constantly directing their actions throughout the lesson. This prevented them from taking responsibility for their own learning. For instance, during the lesson on *Forces*, it was evident that the teacher asked questions but seldom allowed the students to actively participate in lessons through stunting their questioning, resulting in complete dependence on her explanations. In addition when doing the class example on *Contact Forces*, she kept control by instructing, like saying, "I want you to make this heading—*contact forces*—then I want you to take down the first line". Then using phrases like, "Do the calculation", "I will choose", "First write the formula". These examples suggest that the teacher controlled the lesson, and lessons tended to be teacher-centred.

Unsurprisingly, the teacher claimed that the discrepancy between the actual and preferred learning environment scores on the scale *Working with Ideas* (Table 4.13) was due to the limited weekly lessons [one hour, three times a week] with the students. Interviews with the teacher revealed that she was angry about the limited time—directing her anger toward the Department of Education. She said, "We have no time for investigative work in class". Infuriated she added, "I think that the Department of Education should consider the practical implementation of the many wonderful ideas that they are proposing in the new curriculum". She implied from this statement that implementing the strategies proposed by the Department of Education is more difficult than it looks on paper.

With regard to her teaching, the teacher claimed that time-related issues influenced her teaching. Similar to *Class A*, the teacher of *Class C* also adapted her teaching approach to accommodate time constraints. She said, "In the short time that I have with them, I feel that during class-time, covering content and ensuring that their classbook notes are up to date, is more important than spending a lot of time investigating". The students, on the other hand, highlighted the importance of investigative tasks. They claimed less domination by the teacher during lessons. They furthermore claimed that through investigative tasks, their active involvement in lessons made it more interesting. They stated: "Miss explains the work well, but more experiments would make the work fun". For instance, they suggested that during the lesson on *Forces*, it would have been interesting to do their own small experiments. One student interjected: "Yes, sometimes we daydream because she talks too much, but it would be nice for her to include some interactive work in lessons—thinking or doing". On the whole, the teachers' control of the class and restraint on investigative tasks during class-time probably resulted in the low score on the scale *Working with Ideas*. On the other hand, the student's expressed that the teacher should diminish control of lessons, add more investigative tasks and therefore allow more involvement during lessons, hence the higher preferred learning environment score for this scale. As a result, the big discrepancy between the scores of the actual and preferred learning environment for the scale *Working with Ideas* confirms the validity of the quantitative results in Figure 4.6.

Students desired more involvement in lessons. They claimed during interviews that collaborating, group-work and discussions (related to the scale *Collaboration*) might lead to more involvement in lessons. They said, "If there were more group-work and discussions, Miss [the teacher] would not dominate lessons, and we would have the opportunity to express our ideas with our peers, without feeling stupid when we give the wrong answer to Miss". The teacher, on the other hand expressed apprehension about increasing collaborative time in class because she wanted to use class time productively. In support of this view she said, "I would rather use the time explaining work or checking that their class books were up to date". The teacher's other concern was borne out of the lack of control, as she questioned the students' honesty in following instructions. She said: "They are young and are learning to work with each other. As a result they are seldom focused on-task and therefore waste time by discussing other things beside science". Thus the teachers' strict control of collaborative time in class was probably a result of her struggling to keep students on task. On the whole, even with the fairly high scores reflected in Figure 4.6, there was still a large discrepancy between the actual and preferred learning environment scores for this scale, confirming the validity of the quantitative data.

As the teacher of *Class C* seldom allowed students to be involved in lessons, it might have caused misunderstanding in communication amongst students. With regard to the scale *Respect for Difference*, it was evident that lack of communication between the teacher and students might have caused misunderstanding with regard to how they perceived respect for different opinions in this class. During student interviews, the students claimed that when the teacher allowed participation in lessons, it only benefited a small portion of the class population. The teacher on the other hand claimed during interviews that she was fair to all students in the class, and claimed: "I always emphasise the importance of respect in my class as all people must be respected no matter who they are or what their opinions are". However, the students further claimed that this was not true as the teacher favoured the bright and confident students, and the majority of students in the class felt that their opinions were insignificant. Consequently, students generally claimed that their views were seldom respected. One infuriated student stated: "Even though the teacher values the confident students' opinions, I do not accept or respect their opinions because most times they [the confident students' opinions] do not make sense to me. Therefore, I don't think that the teacher instills respect for the differences in opinion in this class". Thus the lack of clear communication between the teachers and students probably resulted in the perception of inequality by the students, hence the large discrepancy between the actual and preferred learning environment scores for the scale *Respect for Difference*. These results confirmed the validity of the quantitative data for *Class C*.

With regard to the scale *Critical Voice*, the large disparity on the actual and preferred learning environment scores might have been because of the teachers' dominating approach to her lessons. Here, it was evident that most students lacked the confidence to critically evaluate the teacher or her teaching. Indeed, one student said, "The teacher makes us feel uncomfortable to make critical judgments as she seldom allows us to ask questions". Furthermore, the students claimed that they seldom clarified their own questions, suggesting that if they could not ask questions about their work, then how could they ask questions about the teachers' teaching. Thus, the evidence from the student and teacher interviews corroborates the trends observed in the quantitative data.

Class D

This case study is a co-educational school located in a middle-class area in Cape Town, South Africa. Given the annual school fee of R210 per year, the school was classified as a low SES category school. The school is located very near the city centre, however, the majority of students attending the school were from townships (see Chapter 1, page 6). Interviews with the teacher revealed that many parents thought that this was a good school for three reasons, namely, its location away from township schools, its good reputation, and its affordable school fees.

The school is well-resourced in terms of its infrastructure. First, facilities such as water and electricity are available in all classrooms. Second, the school is secured with a security guard who patrols during the day, a night security guard, fencing surrounding the perimeter of the school, and an intercom at the main entrance to the school grounds. Third, with regard to the classrooms, there is one science laboratory for the Grade 9 students and one large computer room. However some equipment in both the science classrooms and laboratory were damaged by the students themselves. The computer room is equipped with thirty-five computers, run by a computer science teacher, and each computer is equipped with internet access and software related to science learning. Lastly, other important facilities include a large staffroom for teachers to meet. There is no room available for a school library and thus books are unavailable to the students for research purposes.

This comparatively large school (1084 students) is staffed by 33 teachers, all employed by the provincial education department. An interview with the teacher revealed that the class sizes were large. He said, “My class size ranges from 30-40 students. This is considered a large class. We are not as fortunate as other schools in the area who charge very high school fees, leaving additional funds for the SGB to employ extra teachers” (see Chapter 1, page 7). The teacher believed that he had a heavy workload, partly because there were no extra teachers employed at the school, but also because of the prevalence of teacher absenteeism at the school. The teacher said, “We have a high teacher absenteeism rate…sometimes I fill in the lessons that those teachers are supposed to take”. He further claimed that even with his heavy workload he used his free lessons to research and plan for classroom instruction.

The teacher of *Class D* is a male in his early forties. He has a postgraduate science degree and a teaching diploma, and has been teaching for the past twenty years. According to the teacher, he was exposed to social constructivist teaching approaches during his studies, as well as through a few workshops offered by the provincial Department of Education. He claimed that he was enthusiastic to implement social constructivist teaching approaches. He said, “I was intrigued by this concept during my studies, and now during my part-time Honours degree studies, so I am interested in implementing it—as in theory—it has valuable benefits for the students”. Classroom observations and interviews with the students revealed that the teacher has a warm and non-threatening disposition during his teaching. The students generally said during interviews, “Sir is very friendly and we are not scared to ask him questions”.

In order to give an overall impression of the students’ actual and preferred learning environment scores, Figure 4.7 represents a graphic classroom profile for *Class D*. It represents the average item means for the students’ scores on the actual and preferred SCLES learning environment scales. The scales *Critical Voice* and *Uncertainty in Science* were chosen to investigate further for the qualitative data collection phase (Table 4.13). The scales, shown graphically in Figure 4.7, are discussed in more detail in relation to the teacher and student interviews and classroom observations.

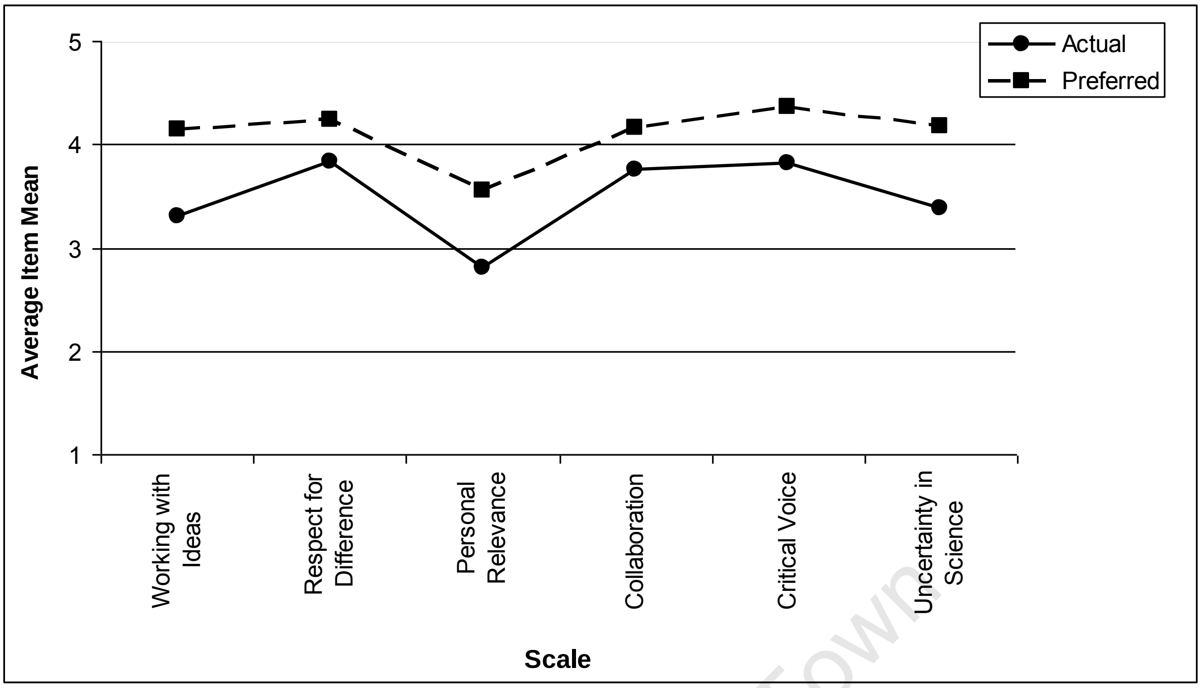

Figure 4.7 Average item mean for students' scores on the actual/preferred learning environment scales of the SCLES for the case study of Class D.

The observations are encapsulated in a typical Natural Science lesson for *Class D*. This is described below:

> I am warmly greeted by the teacher of the class, who leads me toward his classroom. As we walk toward the class, I notice that the school is very noisy. Even though the period had started about five minutes earlier, there were students giggling outside their classes—there were no teachers in their classes. The students outside the class greet the teacher, and he greets them. The students continue with their conversations while the teacher and I walk toward his class.
>
> We enter the class and the teacher greets the students, "Good morning class, and how are you this morning?" All the desks are occupied. One of the boys in the back row is asked to move to a seat in the front of the class, and I am offered his seat. A quick count indicates that there are 51 students in the class, some sharing desks as there is a shortage of desks.
>
> The lesson topic is *Climate*. The teacher brings out a globe of the world, and refers to it while probing the students with questions. He points to the globe and starts by saying, "Where are we—Cape Town?" The students respond, "Between the tropic of Cancer and Antartica". The teacher answers, "That is 34°—where Cape Town is situated?" The teacher then points to the equator, "What is the temperature around here?" He does not give the students opportunity to reply and states, "We know people living there are Black and this means that the air around the equator is warm". He then explains to the students that hot air rises and cold air sinks. During his explanation, some students seated at the back of the class, start making a noise. This,

> together with the noise outside the class, becomes unbearable and the teacher threatens to throw them (the students at the back) out of the class. They soon settle down and listen.
>
> The teacher continues by explaining what weather is and the effects it can have on the environment. He uses an analogy to explain, "I have a lot of money and can choose the area in which I want to live. But to keep the house safe, I have to pay insurance. A clause (or condition) states that I am not covered for weather hazards, for example, earthquakes, floods, etc. If I had built my house within the area of a floodplain, do you think that insurance should cover? I want you to discuss in groups whether you support one of the three options that I am giving you. They are: (1) they should not allow you to stay there; (2) insurance should pay; (3) they should build a wall protecting the area". The students divide into groups of six and discuss. Most students discuss the issue in their home language isiXhosa, even though the teacher presents the entire lesson in English. Occasionally, the students ask the teacher questions in isiXhosa, and he responds in English even though he can speak isiXhosa.
>
> The excited students, even the students in the back seats, are keen to express their views during the report-back phase of the lesson. The teacher allows one member per group to state the group's opinion accompanied by a reason. The other groups listen carefully and are interested in the other groups' opinions. After the first two groups express their points of view, the siren wails, signaling the end of the lesson.

The narrative suggests that the teacher took a seemingly eclectic approach to his teaching. In some parts of his teaching, it seemed that he structured lessons so tightly that he dominated part of the lesson. For instance, as is evident from the classroom narrative, he probed the students through question-and-and sessions, controlling the flow and tone of the lesson when covering the topic *Climate*. In addition, he would not tolerate the students in the back seats' noise with the threat to throw them out of the class. He claimed, "Given the many distractions in the class and outside, for example, the large class size with the noisy students in the back row, as well as the students' noise outside the classroom, I structure lessons, for control and engagement especially at the start of a lesson". Here the approach was thus teacher-centred, but in other parts of his teaching, he allowed more student involvement and participation. Indeed, he encouraged the students to develop the concept on their own through investigation. For instance, as is evident from the narrative, the teacher allowed the students to work in groups in order to apply the concept in a real life situation. The teacher therefore adapted the lesson to fit the context. In order to further investigate the classroom learning environment and the validity of the quantitative data, the scales *Critical Voice* and *Uncertainty in Science* were further probed.

The high absolute mean score on the actual and preferred learning environment scale *Critical Voice* was probably due to the teacher allowing students to express their critical views in class. The results from the classroom narrative suggest that the teacher allowed students to participate in lessons. For instance, through using the globe of the world, the students were able to speculate about ideas as to why air rises and sinks, and then apply it to different parts of the world. This participation might have given students the confidence to question ideas, and therefore, given the freedom to ask questions, they might have had the confidence to question even the teachers' practice. Moreover, even the troublesome students in the back seats participated and were observed asking many questions during the student report-back session. Thus, the students in this class were given opportunities to be critical about their teacher and classroom learning environment. On the other hand, it was also evident from interviews with the students, and classroom observations, that they might have held back in fully expressing themselves, very likely due to their cultural beliefs. Indeed, some students claimed that they were not allowed to question adults, and therefore needed to be careful in being too friendly with their teacher. The teacher also confirmed that the students, according to traditional cultural beliefs, were to treat the teacher with respect. These students might have wanted more expression of their critical views in class, but were held back by cultural constraints. Therefore, the interviews and observations corroborate the quantitative data, which suggests that the discrepancy between the actual and preferred learning environment scores might very likely be due to students being held back by their cultural beliefs to fully express their critical views in class.

Given the few lessons that teachers teach Natural Science per week, the teacher claimed that he controlled the students' questioning in class, as unfocussed questions might waste time. With regard to the scale *Uncertainty in Science*, the teacher claimed that questioning and then theorizing were of great interest to students, but that the exposure to approaches related to this scale needed to be controlled. For instance, in the classroom narrative, during the lessons on *Climate*, the teacher allowed students to be exposed to content beyond that in the textbook. But classroom observations reveal that he restricted students' exposure to questions about the uncertainty of science, and he justified the restriction due to the limited time he had to teach them (i.e., three lessons in a week). He said, "At their age, they question everything, therefore we could sit days questioning science as it is my interest as well, but we have limited time, therefore most times I have to stop them". The students validated their restricted questioning time by saying, "We like it when Sir talks about and makes us question science, but it would be nice if we could do more of that". Classroom observations and student interviews confirmed the students' great interest in questioning scientific phenomena, similar to *Class A*. Thus, the high scores implies that the students have been exposed to approaches related to the classroom environment scale *Uncertainty in Science*, but the large discrepancy could be due to the teachers' time restrictions related to the timetable, and the students' interest and desire to want more of this scale implemented in their class. Hence, these results confirm the validity of the quantitative results in Figure 4.7.

Class E

This case study is a co-educational school situated in a poor gang-infested area in Cape Town, South Africa. Given the annual school fee of R200 per year, the school is categorized as low SES. The school is well-resourced in terms of its infrastructure with regard to water and electricity which is available in all the classrooms. However, there are numerous problems regarding classroom infrastructure. A charity organization donated thirty computers housed in a computer laboratory, which have been the target of vandalisation by gangsters from the community on numerous occasions. Vandalisation caused many computers in the five science classrooms and two computer rooms to be damaged or stolen. Furthermore, the consequences of vandalisation were also apparent in the science classrooms evident by the broken laboratory desks and chairs, broken plug points and broken or stolen teaching aids. Consequently, similar to *Class B*, security is an important part of the infrastructure in this school. Nevertheless, the schools limited funds have resulted in its reliance on the school cleaner to double as a security guard during school hours. The cleaner cleans the small staffroom where teachers meet, as there are no other rooms, for instance a school library, for teachers to socialise.

Twenty-six teachers staff this comparatively large school (891 students). Most teachers have teaching diplomas from teacher training colleges. A small percentage has university degrees combined with postgraduate teaching diplomas. The teacher claimed during interviews that he had a big workload. He said, "I teach all five Grade 9 classes. I prepare all the tests and worksheets, and mark them. As a result, I have marking throughout the year, even during school holidays!" The teacher also claimed that there is a large staff absenteeism rate. He said, "Many teachers are absent in the week; sometimes I have no free periods as I have to substitute in those classes". The teacher therefore feels pressured in that he claims that he has little time to prepare lessons for the students.

The teacher of *Class E* is a male in his mid-forties. Classroom observations reveal that he is warm, friendly and approachable toward the students. During student interviews, students claimed, "Sir is nice to us and we always ask him questions". The students added that the teacher also helped them when they had personal problems. One student said, "Sir helped me when I had no bus fare to go home". Another added, "Sir gave me pens and pencils when my mother had no money". An interview with the teacher regarding the students revealed that he found teaching this class challenging. He said, "Dealing with these students is emotionally draining as they come from impoverished backgrounds, and many come to school bearing the emotional consequences of these problems". On many occasions, the teacher claimed that he had to stop his teaching to deal with students who felt faint because they were hungry, or counsel a child who was emotionally troubled—many because of abuse at home. Sometimes, he says, the blank looks on their faces tell him that they do not understand what he is saying. He claimed that language issues clouded their learning as many students struggled to link their school language with colloquial language at home and on the street.

The teacher is qualified with a teaching diploma obtained from a teacher training college. He claims that he had limited exposure to social constructivist teaching approaches during his teacher training but recently attended some workshops hosted by the provincial department of education and came across the term. He said,

> Perhaps I don't call it a fancy word like the Department of Education does, but I make every effort to allow the students to participate in discussions, collaborate and debate. However, given the nature of this class, they are passive and all interactions end up with them expecting me to give them the 'right' answers.

In order to give an overall impression of the students' actual and preferred learning environment scores, Figure 4.8 represents a graphic classroom profile for *Class E*. It represents the average item means for the students' scores on the actual and preferred SCLES learning environment scales. The scales *Working with Ideas* and *Personal Relevance* were chosen to investigate further for the qualitative data collection phase (Table 4.13). The scales, shown graphically in Figure 4.8, are discussed in more detail in relation to the teacher and student interviews and classroom observations.

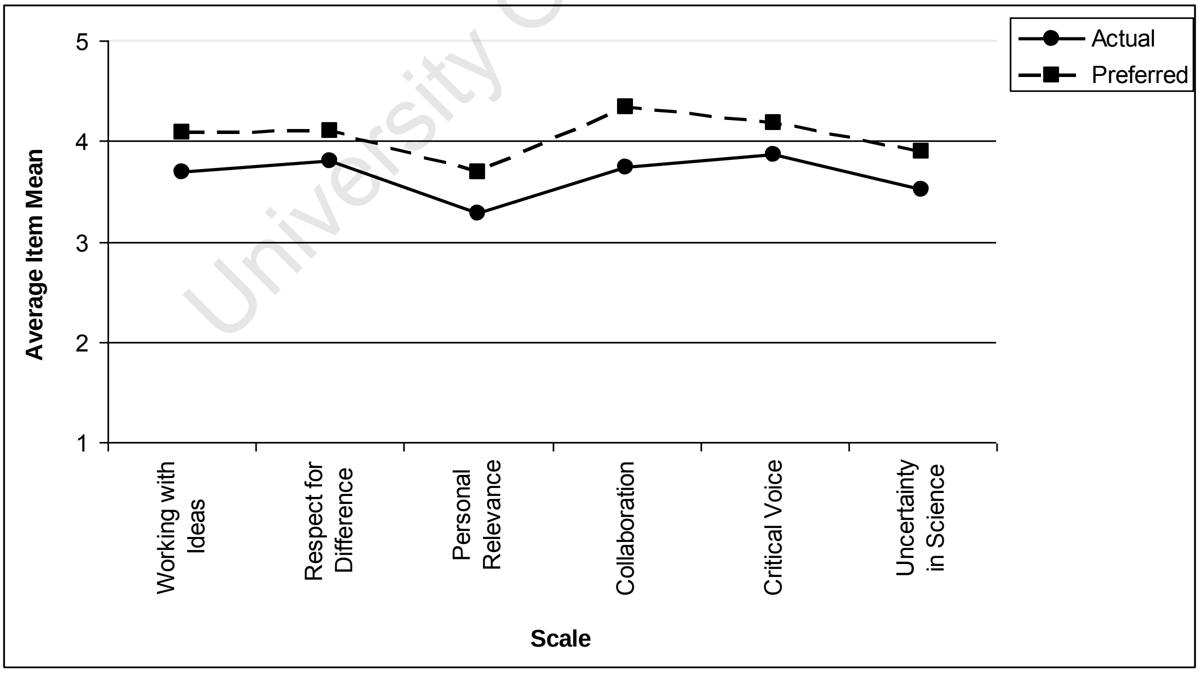

Figure 4.8 Average item mean for students' scores on the actual/preferred learning environment scales of the SCLES for the case study of Class E.

The observations are encapsulated in a typical science lesson for *Class E* which is described below:

> We enter the class and, after a brief introduction, teaching starts. The students are sitting in their own desks facing the chalkboard. A quick scan indicates that there are about 35 students in the class, even though the teacher claimed that at the beginning of the year there had been 55 students in the class. All the students in the class are African.
>
> This lesson is a continuation from a previous one. Groups of four are assigned a topic and present their research in class on the topic the *Ecosystem*. The teacher calls one group member to read the answers to the class. The task was to define and give examples of terms such as *biotic factors, abiotic factors, food chains, food webs*. One member of the group presents the work, yet I find it unclear to understand what is being said as her isiXhosa accent is so strong. The teacher asks the rest of the class if they agree with the answers that the student reported. While some students mumble that they do, most are silent. Nobody questions the groups' presentation. The teacher then explains, "I know that none of you have a problem, but remember, in this particular example, there is not a right answer. I will suggest a few options to you". As he suggests the options, the students frantically write down what he says. Nobody questions the teachers' different answer options—everyone accepts them unopposed.
>
> In the next part of the lesson the teacher writes the term *Trophic Levels* on the chalkboard and for the next ten minutes explains the concept to the students. He explains how energy is transferred from one organism to the next, and how plants are the main energy producers. Everyone listens attentively, and nobody asks a single question.
>
> The next part of the lesson is textbook-bound. The students are asked to use the food web given in the textbook and, with the use of arrows, to indicate the flow of energy in the food web. The students have to do this exercise individually and take about 15 minutes to complete it. As the students are working, the teacher walks around the classroom and probes some of the answers that they have written in their books. The students seem to be comfortable and willing to engage with the teacher at an individual level. The teacher summarises some important points on the chalkboard and the students write them in their notebooks. The lesson ends with the teacher giving the students homework, which they must submit for the next day.

The classes' complacent nature might have had an impact on the teachers' teaching. It was evident that generally the students lacked interest in asking questions and seemed to want 'the right answers' to any questions asked by the teacher. As was evident from the classroom narrative, the teacher seldom had opportunities to engage with the students, as they held back in answering questions. For instance, during the lesson on the *Ecosystem*, when answering questions related to specified terms (e.g., *biotic, abiotic* etc.), the teacher tried to probe the students through questioning, but the students held back. Interviews with the students verified this, "The teacher knows the answers better than us therefore we always wait for him to give the right answers". An interview with the teacher made it evident that the huge drop-out rate affected the character of the class. He said, "Out of the 55 students, the 35 who stayed behind are mostly diligent and ambitious students who believe that education is their way out of poverty. Some of them believe that I have all the 'right' answers' ". Furthermore, the teacher mentioned that in accordance with the African culture, they seldom questioned him. Therefore, on the whole, the teacher tended to dominate the lesson, and his lessons were classified as teacher-centred. The scales *Working with Ideas* and *Personal Relevance* will be probed further.

The very small discrepancy between the actual and preferred learning environment scores for the scale *Working with Ideas* was interesting as it represented the smallest discrepancy of all the 52 classrooms in the present study. Interviews with the teacher made it evident that he approached teaching this class by focusing mainly on explaining concepts in class and rarely focusing on independent investigations by the students. His rationale for this approach was two-fold. Firstly, he included investigations in class through textbook-bound exercises (i.e., evident from the classroom narrative), as he felt that students themselves needed constant guidance in class in developing their understanding of concepts. He claimed that investigations allowed the students to 'thinking about their thinking' through metacognition. The teacher further verified this when he said, "Exercises in class works best with this class, they prefer working through the exercises, and getting the answers from me". Secondly, and more importantly, he claimed that many students do not have access to research materials. Furthermore, even in the presence of a computer laboratory at school, the students' limited exposure to computers, as computer lessons were not formally included in the school curriculum, resulted in many of the students being computer illiterate. Moreover, the students did not use the libraries in their own communities as it was unsafe to walk in most areas in the township (see Chapter 1, page 6). In addition, none of the students in this class had internet access at home. As a result, the teacher claimed that doing exercises in class could be the best strategy he used. Interviews with the students revealed that they were generally satisfied with the teachers' approach, though students interviewed during the focus group sessions suggested that they would prefer more independent work to develop concepts. The group generally agreed with the teachers' teaching approach by saying, "We like the way Sir teaches", but the two who wanted more investigations added, "If we could do work on our own, the work would be more interesting, perhaps Sir can get material, like books or internet material, for us and we could do experiments at home to prove our ideas". On the whole, it seemed evident that the students were generally satisfied with the teachers' approach. The fairly small discrepancy between the actual and preferred learning environment scores could be because students might have liked more independence in their learning during investigative tasks.

The relatively low mean scores on the scale *Personal Relevance* was probably a result of the teaching approach adopted by the teacher. In the narrative, it was evident that there were few opportunities for student involvement during lessons. Moreover, the teacher might not have known students' everyday interests because of their lack of participation in lessons. Interviews with the teacher confirmed this; one student said, "It is difficult to interact with this class as they are so quiet". He furthermore claimed during interviews that he attempts to make classroom discussions and activities relevant to the students' everyday lives, but finds it difficult. In addition, the teacher claimed that one of his concerns was that being from a Coloured background (see Chapter 1), perhaps he could not relate to the students' everyday life situations as the majority of them were Black (African). The teacher also claimed that he made every effort to help students to be more actively involved in learning, but they often would 'want the correct answer' leading him to dominate throughout the lesson. These circumstances could partly explain the low scores between the actual and preferred learning environment scores for this scale.

Chapter Summary

In this chapter it was reported that both the SCLES and the attitude scale is reliable and valid. The factor analysis showed that the items of two scales, namely, *Investigation* and *Metacognition*, loaded on the same factor. This resulted in the final version of the questionnaire (Appendix 4) having six factors, with the number of items per scale ranging between 4 and 10 (Table 4.3).

The study also found statistically significant associations between the social constructivist-based learning environment and the student outcomes, attitude toward science, achievement and gender equity. Firstly, statistically significant associations were found between student attitudes toward science, and schools in the three SES categories. For schools in the high SES category, statistically significant associations between students' attitudes toward science and five of the six SCLES learning environment scales were found (*Investigation/Metacognition*, *Respect for Difference*, *Personal Relevance*, *Critical Voice* and *Uncertainty in Science*), with all associations being positive. For the medium SES category, five of the six scales were statistically significant and positive, except for *Collaboration*. For schools in the low SES category, there were statistically significant associations between students' attitudes toward science and all six learning environment scales. All associations were positive. Secondly, significant associations between students' academic achievement were found. For the schools in the high SES category, there were no statistically significant relationships existing between the achievement scores and any of the six scales. For schools in the medium SES category, statistically significant associations were found between achievement and the scales *Investigation/Metacognition*, *Respect for Difference* and *Personal Relevance*. For the low SES category schools, significant associations were found between achievement and the scales *Respect for Difference*, *Critical Voice* and *Uncertainty in Science*. Finally, in keeping with the tradition in the LER field (e.g., Kahle & Meece, 1994), the study examined gender differences in classroom environment perceptions, attitudes to science and academic achievement. It was found that the magnitudes of the differences between male and female students' perceptions of the actual learning environment were small for all 1955 students in the 52 schools. However, the study found that when analysed by SES school category, that females attending schools in the high and medium SES category, perceived *Respect for Difference* in their actual learning environment more favourably than males. For the low SES category, there were no significant associations between males and females.

The three SES groups were probed and compared using a one-way MANOVA as well as a Tukey HSD *post hoc* test. The results show differences in the students' perceptions of their actual classroom learning environment scores across the three SES groups. The overall results suggest that the perceptions of the students in different SES's for the actual version of the questionnaire are statistically significant for the scales *Working with Ideas*, *Respect for Difference*, *Personal Relevance*, *Critical Voice*, *Uncertainty in Science*, as well as attitude and achievement. The *Collaboration* scale is statistically non-significant. For the preferred version of the questionnaire, there are statistically significant associations for the scales *Respect for Difference*, *Personal Relevance*, *Critical Voice*, *Uncertainty in Science*, as well as attitude and achievement.

In describing science classrooms in the Western Cape Province using the SCLES, it was found that the level of each SCLES dimension perceived to be lower in the actual learning environment for every scale than students' preferred learning environment. Qualitative data were collected from five classrooms. The main findings from the qualitative data collection suggest that the teacher of *Class A* transformed her classroom toward the teaching goals of social constructivism more often than in *Classes B*, *C*, *D* and *E*. One of the primary findings of the qualitative data was that the teacher plays a pivotal role transforming a learning environment to one that encompasses social constructivist learning goals. However, other factors such as the contexts that teachers face (SES) are influencing factors. For instance, teachers of *Classes B* and *E* had to cope with students from impoverished backgrounds, who probably experienced very little structure in their own homes and therefore valued the structure of a more teacher-centred class. These students were generally comfortable with less control and responsibility for their own learning. Consequently, the results for the qualitative data varied, and teachers' decisions were shaped by other factors like SES in deciding on how to best transform their classrooms to the social constructivist teaching goals envisioned by the new curriculum, the rNCS. In the next chapter, Chapter 5, the findings of the quantitative and qualitative data well be discussed in detail.

Chapter 5
DISCUSSION AND RECOMMENDATIONS

Introduction

In this chapter, the findings of the study on the implementation of social constructivist learning environments in Grade 9 Natural Science classes in the Western Cape Province are discussed. First, the rationale for this study is highlighted and the research questions are rehearsed in order to place the study in context. Second, the research design of the study is summarised and the study's limitations are considered to allow an appropriate consideration of the findings. Third, the research questions are answered. Finally, the significance of the study is discussed and recommendations are made for classroom practice, professional teacher development programmes, and education policy-makers.

The present study was conducted in order to monitor whether teachers transform their classrooms toward social constructivist learning environments, as required by the rNCS (DoE, 2002), within classrooms in the Western Cape Province, South Africa. During Apartheid (i.e., pre-1994), the South African education system was fragmented and racially aligned. Unequal educational opportunities characterized Black schools, which encompassed irrelevant school curricula, inadequate educational facilities, inadequately qualified Black teaching staff, and an acute shortage of educational materials (Botha, 2002). In 1994, South Africa saw a significant breakthrough towards a non-racial and democratic society. This breakthrough required social changes to ensure that the country could cater for its people irrespective of race. Such a challenge necessitated a restructuring of the curriculum, which resulted in *Curriculum 2005* (C2005) (DoE, 1996). This was later revised to form the revised *National Curriculum Statement* (rNCS) (DoE, 2002). The rNCS expect that teaching should be learner-centred, which required the use of teaching theories and philosophies of outcomes-based education (OBE) and constructivism (Moll, 2002). The rNCS (DoE, 2002) for the subject Natural Science places strong emphasis on social constructivist-based theories in Natural Science classrooms (Chapter 2, pages 20-22). The theories-of-choice were individual constructivism, with an emphasis on the conceptual change theory (Chapter 2, page 15) and social constructivism, with an emphasis on the development of a concept in a social setting (Chapter 2, pages 16-18).

In a social constructivist learning environment envisaged by the rNCS (DoE, 2002), as applied to the subject Natural Science, emphasis is placed on students developing a concept through conceptual change (DoE, 2002). In such a setting, the teacher's role is to guide students toward cognitive conflict by allowing them to engage actively with knowledge, leading them to question the correctness of their ideas, toward uncertainty, then curiosity, and consequently letting the students find answers through investigation (Johnson & Johnson, 2009). Furthermore, students should be encouraged to gain co-operative skills (Johnson & Johnson, 1979, 1989, 2007, 2009) through approaches like collaboration (Mayer 1998), hands-on activity (Lebow, 1993), making knowledge personally relevant (Stears & Malcolm, 2005), investigations (Dunlap, 1999) and approaches encouraging respect for others' opinions. In addition, teachers themselves need to have mastered the knowledge and processes that they are trying to teach. If not, then they might be unable to assist students in attaining deep conceptual understandings (Beeby, 1966; Fiske & Ladd, 2004; Meier, 2003; & Onwu & Stoffels, 2005). Teachers who are unable to assist students with conceptual understanding, are further challenged when they are faced with Natural Science classes that lack practical science resources, as well as with students who lack the skills to engage with science knowledge because they are deficient in the basic (foundational) Natural Science subject knowledge learnt in prior grades (Reeves, 1999). Overall, the teacher plays a pivotal role in guiding the transformation of classrooms toward social constructivist learning environments.

The Objectives of the Study

The present study investigated whether teachers transform their classrooms toward social constructivist learning environments, required by the rNCS (DoE, 2002), within classrooms in the Western Cape Province. The study was guided by the following objectives:

a) To develop and validate a questionnaire for monitoring social constructivist-based classroom learning environments in South Africa;
b) To describe the learning environment of Natural Science classes in the Western Cape Province in both quantitative terms (using the questionnaire) and qualitative terms (using additional classroom observation and interview data);
c) To determine whether socio-economic status influences the classroom learning environment;
d) To investigate whether social constructivist-based learning environments promote (i) students' attitude toward science, (ii) student academic achievement, and (iii) gender equity, in three socio-economic status contexts.

The study therefore sought answers to the following research questions in regard to the Western Cape Province:

1) To what extent do teachers implement social constructivist-based learning environments, required by the rNCS, in Grade 9 Natural Science classes? (Objectives a & b).
2) Do different levels of congruence of students' experienced (i.e., actual) and preferred learning environments in selected Grade 9 classrooms occur and, if so, why? (Objective b).
3) Does the students' background, described in terms of their socio-economic status, influence their perceptions of their learning environment? (Objective c).
4) What is the influence of social constructivist-based learning environments in promoting student outcomes of attitude toward science, achievement, and gender equity in three socio-economic contexts? (Objective d).

In order to provide accurate, credible, and trustworthy answers to the above research questions, the study utilized a contemporary research design—the mixed method approach (e.g., Tashakorri & Teddlie, 2003).

Research Design

The mixed-method approach (Creswell, 2003; Tashakorri & Teddlie, 2003; Tobin & Fraser, 1998) combines different data collection methods within a single study. The intent of this approach is to make sense of complex social phenomena that fail to be fully understood using either quantitative or qualitative methods on its own. The mixed-method approach is largely an investigative process, where the researcher—through contrasting, comparing and classifying—slowly makes sense of social phenomena. Many investigators have verified that combining both quantitative and qualitative methods in a single study is becoming increasingly popular, particularly in the social and behavioural sciences (e.g., Tashakkori & Teddlie, 2003), science education (e.g., Erikson, 1998), and learning environment research (LER) (e.g., Fraser, 1998, 2001).

One of the major advantages of the mixed-method approach is that a large variety of data sources, as well as analyses, can be used to understand complex, multifaceted institutions or realities (Tashakorri & Teddlie, 2003). Further advantages are that the approach can provide answers to research questions that other approaches cannot. Firstly, it combines the theory generation (exploratory) and theory verification (confirmatory) aspects of qualitative and quantitative research, respectively. Secondly, it offsets the disadvantages that either quantitative or qualitative methods have by themselves. Indeed, triangulation helps to overcome the weaknesses or intrinsic biases of a single method. Finally, inferences can be made at the end of one data collection phase, leading to questions that can be answered in the second phase (Tashakorri & Teddlie, 2003).

The two-phase sequential mixed-method strategy is a popular implementation strategy associated with the mixed-method approach. A characteristic of the strategy is the collection and analysis of quantitative data followed by the collection and analysis of qualitative data (Tashakorri & Teddlie, 2003). This design is especially useful when unexpected results arise from the quantitative data (Morse, 1991), as one can follow up the quantitative data collection phase with a focused qualitative data collection phase. In the present study priority was given to the quantitative data, which is conventionally indicated by the label 'QUAN'. The qualitative data were secondary and complementary to the QUAN data and therefore labelled 'qual'. The 'QUAN+qual' design has become popular as it is easy to report because it falls into clear and separate stages (Tashakorri & Teddlie, 2003).

In the present study, the QUAN data were collected first in order to determine 1955 Grade 9 Natural Science students' actual and preferred learning environment perceptions. This was followed by the 'qual' inquiry in order to obtain explanations for the trends observed in the quantitative data, and thus to maximize the trustworthiness of the results. The qualitative inquiry took the form of classroom observations (Chapter 3, page 66), as well as interviews with five teachers and 30 students (Chapter 3, page 66). Like many learning environment studies (e.g., Fraser & Tobin, 1991; Tobin & Fraser, 1998), this study incorporated the idea of 'grain sizes', that is, the use of different-sized samples, for different research questions, varying in extensiveness and intensiveness which added to the trustworthiness of the results.

Limitations of the Study

Because a single study cannot encompass the entirety of a particular situation, limitations are unavoidable. The present study has some limitations that need to be taken into account when considering the study and its contributions to the field.

Firstly, the present study used the qualitative data to give insights into the quantitative data, but the collection of qualitative data had limitations with regard to language issues. For instance, the vast majority of students attending the low SES category schools conversed comfortably in isiXhosa—their first language. The researcher, who gave students opportunities to respond to a translator in isiXhosa, found that the students chose to be interviewed in English (their second or third language), and thus a language barrier might have existed during interviews. However, as explained in the section on Ethical Issues (Chapter 3, page 53), steps were taken into account regarding ethical considerations in order to maximise the trustworthiness of the results. These steps included that the completion of the questionnaire was voluntary, that students' identity was kept confidential during the reporting of the results, and that instructions were clearly explained in all three languages before the administration of the questionnaire. Given these steps, it was very likely that students were confident during interviews to answer questions in an open and honest manner. Notwithstanding the fact that students might have expressed themselves more clearly and been less "shy" had they expressed their views in isiXhosa, thus giving greater insights into the results.

Secondly, the findings are specific to Grade 9 Natural Science classrooms in the Western Cape Province. Caution should thus be taken when generalising the findings to, for instance, other subjects, grades and provinces. Indeed, those specific social constructivist-based classroom environment characteristics (e.g., *Collaboration*, *Personal Relevance* and *Critical Voice*) found to enhance the student outcomes (i.e., attitude toward science, achievement and gender equity) in the subject Natural Science, are not necessarily likely to enhance the outcomes in other school subjects (e.g., History and Geography). Therefore, the above limitations should be considered when answering the research questions in the next section.

Providing Answers to the Research Questions

Results from the statistical analyses of the quantitative data were integrated with the results from the qualitative data analyses in order to provide a comprehensive picture of the transformation of Grade 9 Natural Science classrooms in the Western Cape Province, South Africa, to social constructivist learning environments. The present study used the LER paradigm as a conceptual frame (see Chapter 2). Because the study is the first of its kind in South Africa and elsewhere in regard to focusing on students' perception of their social constructivist learning environments, a new survey instrument—the *Social Constructivist Learning Environment Survey* (SCLES)—had to be developed and validated.

In keeping with the established and standard practice in the field of LER, the SCLES questionnaire was developed to quantitatively determine students' perceptions of their actual and preferred learning environment in Natural Science (Table 2.1). The development of an appropriate instrument involved the determination of classroom dimensions relevant to social constructivism, which involved several steps. First, classroom dimensions were identified and developed conceptually through a review of the social constructivism literature and the rNCS government policy documents (Chapter 2, pages 20-26). Second, seven classroom dimensions relevant to social constructivism were identified (i.e., *Investigations*, *Metacognition*, *Respect for Difference*, *Personal Relevance*, *Collaboration*, *Critical Voice* and *Uncertainty in Science*) (Table 2.1). Third, taking advantage of the existence of the wide variety of questionnaires in the field of LER, scales with potential significance to a social constructivist learning environment, as required by the rNCS (DoE, 2002), were identified. Relevant scales from three internationally validated and reliable questionnaires were thus selected for the present study, namely, three scales from the *Constructivist Learning Environment Survey* (CLES) (Taylor, Fraser & Fisher, 1997), one scale each from the *Individualised Classroom Environment Questionnaire* (ICEQ) (Rentoul & Fraser, 1979), and one scale from the *Cultural Learning Environment Questionnaire* (CLEQ) (Fisher & Waldrip, 1997) (Table 2.1). Fourth, two newly developed scales were included in SCLES (i.e., *Respect for Difference* and *Metacognition* (see Chapter 2, pages 36-38).

Three student outcomes, namely, attitude toward science, achievement and gender equity were used in determining whether there were associations between the perceptions of the social constructivist classroom learning environment and the outcomes. To assess student attitude toward science, a modified version of selected items from the *Test of Science-Related Attitudes* (TOSRA) (Fraser, 1981) was used. The 8-item scale used in this study was based primarily on the *Enjoyment of Science Lessons* scale from the original TOSRA (Chapter 3, page 56). TOSRA can be considered a strong attitude scale, as its development took into account issues raised by the guidelines developed recently by Kind *et al*. (2007) (see Chapter 2, page 40). To assess student achievement, a test developed originally from a question in the national Department of Education's *Common Assessment Tasks* was used. The achievement test was modified for use by Grade 9 Natural Science students in the present study (Chapter 3, 56-58). The questions were divided into three parts: the first part assessed whether students could draw a straight line graph from given information, the second part tested whether students could read information off the graph, and the third part tested whether students could interpret information from the graph drawn (see Appendix 3). In order for all students to understand the items of the scales, as well as the instructions of the achievement test, the questionnaire was translated. The new classroom environment instrument was translated from English into Afrikaans and isiXhosa—the local vernacular, as many classrooms in the Western Cape Province are multi-lingual. By translating the questionnaire, the simultaneous available translations gave those students who were not English first-language speakers the confidence to engage with each item in their own language. The validity of the back-translations were increased because the translations were verified by three independent translators who checked the translations against the original English versions.These translations (described in Chapter 3, page 55) thus maximised the likelihood that students supplied reliable and valid responses to the items. Indeed, during pilot testing of the SCLES in five classes with 200 Grade 9 Natural Science students (Chapter 3, page 58), students indicated during the interview that this format was helpful in making sure that they understood each item of the SCLES scales. Furthermore, the pilot study not only showed that the students understood the items themselves, but also that they understood the instructions and the response format of the SCLES items.

The sample included 1955 Grade 9 Natural Science students in one class in 52 schools in four of the seven Education, Management and Development Centres (EMDC) of the Western Cape Education Department (WCED). These four EMDCs were chosen because they contained the majority of urban and public (DoE, 2003) schools in the Western Cape Province (Chapter 3, pages 59-60). Because of Apartheid (Kallaway, 1984), schools in the Western Cape Province are heterogeneous (see Chapter 1, page 7). As the heterogeneous nature of the schools can be attributed to the SES of families in the communities they serve (Fiske & Ladd, 2004, 2005; Van der Berg & Burger, 2003; Van der Berg, 2007), this necessitated that the study, firstly, considered SES during sample selection, and, secondly, used a stratified sampling approach.

First, schools mimic society (Bowles and Gintis, 1976). In the case of schools in South Africa, the composition of schools mimics SES, described in terms of family income (Chapter 2, page 42). Consequently, as articulated in Chapter 1 (page 7), SES plays a fundamental role when assessing schooling in South Africa. Indeed, in past South African research, it has been found that a reliable measure of SES in South African schools was school fees (Van den Berg, 2003; Fiske & Ladd, 2004). Therefore school fees were used as a proxy for SES in the present study (Chapter 3, pages 61-62).

Second, a stratified random sampling technique was used. Schools fees in the four EMDCs were stratified into three distinct groups. As explained in Chapter 3 (page 61-62), the two cut-off points described the distribution of school fees in urban and public schools, in the Western Cape Province. The first category, namely, fees of less than R301, described the low (L) SES category schools. The second category (i.e., fees of between R301 to R2250) described the medium (M) SES category schools; and, finally, fees of R2251 and above, described the high (H) SES category schools. In fact, many teachers were able to verify the SES and school fee correspondence during interviews. As described in Chapter 3 (pages 60-61), the ratio of High (26%), Medium (50%) and Low (24%) SES category schools in the EMDCs were reflected in the sample. For this reason the schools within each of the metropoles were identified by stratified sampling according to the H: M: L category school ratio above. This method of choosing the sample—as recommended by Creswell (2003)—ensured a total random sample of 1955 Grade 9 Natural Science students, one class in 52 schools, represented by urban and public schools in the Western Cape Province, South Africa.

To conduct meaningful research in the area of LER, a valid and reliable instrument is of paramount importance (Dorman, 2003). In order to ensure that SCLES was reliable and valid, a number of procedures were followed. First, a factor analysis was performed on the quantitative data gathered using SCLES (i.e., responses from 1955 students in 52 classes). The *a priori* factor structures of the SCLES items were checked using a principal components factor analysis with varimax rotation.

The factor analysis suggested a six-factor structure (Table 4.1), with the originally separate *Investigation* and *Metacognition* scales combining to form a new combined scale *Investigation/Metacognition* which was later changed to the scale name *Working with Ideas*. The naming of the scale followed students' interpretation of the scales during student interviews. According to the students, they perceived the two scales similarly, as both involved "working with ideas". This scale is discussed in more detail later in this chapter. After combining and re-naming the scale, the final version of the SCLES (Appendix 4) contained a total of 34 items assessing six scales of the SCLES (Table 4.1).

Following the factor analysis, the next step involved generating three indices of scale reliability from the quantitative data for both the actual and preferred versions of the SCLES. The first index of scale reliability, the Cronbach alpha reliability co-efficient (Table 4.2), for both the actual and preferred versions of SCLES and TOSRA, using the individual and the class mean as the unit of analysis, was found to be comparable with those of previous studies in LER (e.g., Fisher *et al*., 2001), and was considered to be satisfactory. The second index of scale reliability, the discriminant validity, measures the extent to which each scale measures a dimension different from that measured by any other scale. The discriminant values (Table 4.2) were small enough to suggest that each scale of the SCLES measures distinct (yet slightly overlapping) aspects of the social constructivist classroom learning environment. The third index, the analysis of variance (ANOVA), was used to assess the ability of the scales to distinguish between different classes with class membership as the independent variable. These three measures of scale reliability indicated that SCLES is reliable and valid for use in Grade 9 Natural Science classes in the Western Cape Province, South Africa. It can therefore be used with confidence in future assessments of students' perceptions of their actual and preferred social constructivist learning environment.

In the next section, the research questions will be answered. The results of the statistical analyses of the quantitative data from the 1955 Grade 9 Natural Science students are used to provide reliable and trustworthy answers to the research questions posed. Because the present study employed a mixed-method approach, the results from the qualitative data collection (i.e., the classroom observations, as well as teacher and student interviews) are intertwined into the discussion of the results of the quantitative data.

Research Question 1

To what extent do teachers implement social constructivist-based learning environments, required by the rNCS, in Grade 9 Natural Science classes?

Past LER reviews (e.g., Fraser, 2002, 1998, 1994) showed that several sources of data could be used when conducting research in the field of learning environments. These data sources may include students' perceptions, as well as observations and interviews, or ethnographic and interpretative case studies. In keeping with the LER field, this study used students' perceptions of their classroom learning environment to monitor the transformation of Natural Science classrooms towards social constructivist learning environments.

The dimensions of SCLES, namely, *Working with Ideas*, *Respect for Difference*, *Personal Relevance*, *Collaboration*, *Critical Voice* and *Uncertainty in Science* were used to describe typical Natural Science classroom environments in the Western Cape Province. For each scale, students' responses to the questionnaire were analysed using descriptive statistics. Because the number of items within each scale was different, ranging from 4 to 10, the average item mean—that is the scale mean divided by the number of items in each scale—was used as the basis of comparison. Table 4.3 reports the results for all six scales in terms of the average item means for the class as the unit of analysis. The results range between 3.15 and 3.82, showing comparatively high actual learning environment scores. This suggests that, generally, teachers are implementing the dimensions often in the classroom learning environment, and that students perceive that they experience the dimensions frequently. Though the students were exposed to the dimensions frequently in their actual classroom learning environment, the higher preferred learning environment scores (Table 4.3) show that they would like the dimensions to be incorporated more frequently in their classroom learning environment. In addition, the higher preferred classroom learning environment scores in Table 4.3, suggests that students prefer a more positive learning environment than the one that they were currently experiencing—a pattern that has been replicated in other learning environment studies with the use of other instruments both internationally (for instance, using WIHIC [e.g., Fraser & Chionh, 2000; Wong & Fraser, 1996] and QTI [Margianti *et al.*, 2001]); as well as locally, using OBLEQ (Aldridge *et al.*, 2006). Therefore, the fact that teachers are creating social constructivist learning environments required by the rNCS (DoE, 2002) in Natural Science, and that students perceive this quite favourably, implies that teachers in the Western Cape Province are generally successful in implementing the dimensions of a social constructivist learning environment required by the rNCS (DoE, 2002) in Natural Science.

The extent to which teacher's implemented social constructivist learning environments varied judging from the varying effect sizes between the actual and preferred classroom learning environment scores in Table 4.3, with effect sizes ranging from 1.65 to 3.01 standard deviation units. This implies that some dimensions were implemented more often than others were. For instance, the large effect sizes for the scales *Working with Ideas* and *Uncertainty in Science*, that is, 3.01 and 2.37 standard deviation units respectively, suggests large differences between the actual and preferred learning environment scores for both the scales. Moreover, the results suggest that students perceived that in their Natural Science learning environment, relative to the other dimensions, they had experienced the implementation of these two dimensions less often than they would have like to experience them. Therefore, the quantitative evidence suggests that, in general, students would like these dimensions to be implemented more often in their classroom learning environment compared to other dimensions.

Possible reasons for this were probed through the qualitative data. As shown in Chapter 2 (page 23-26), the two dimensions *Working with Ideas* and *Uncertainty in Science* are associated with conceptual learning through scaffolding (Chapter 2, pages 15 & 17). Scaffolding should allow students to become actively engaged in learning through exposing their ideas, then questioning their ideas, and eventually uncertainty—which is an incentive for further investigation (Johnson and Johnson, 2009). Teachers should balance such scaffolding methods with appropriate assistance. For instance, they should balance scaffolding methods like guiding students to expose, question and further investigate their ideas, with assistance comprising just-enough, just-in-time and appropriate fading of support through scaffolding (Oliver & Herrington, 2001). During interviews with the students, they claimed that they associated such scaffolding methods with meaningful learning. Students probably considered such learning to be meaningful because teachers needed to know their needs in order to scaffold effectively. Consequently, scaffolding methods very likely guide teachers toward better relationships with their students, as Paris and Winograd (1990: 24) state, "the distinguishing feature of scaffolded instruction is the prominent role between the teacher and student".

Indeed, classroom observations showed that teachers scaffolded when using the two dimensions *Working with Ideas* and *Uncertainty in Science* (discussed in more detail in Research Question 2). However, during interviews, teachers claimed that they incorporated these two dimensions less often in their learning environment because attaining the balance between the scaffolding methods, and the appropriate assistance during scaffolding, was difficult. They further claimed that short workshops from the Department of Education were not enough to support them in attaining such balance (e.g., Chapter 4, Class C, page 107). Moreover, they claimed that time constraints, related to class time with the students (Chapter 4, Class B, page 104; Class C, page 107) also curtailed the implementation of these dimensions in their classroom teaching (discussed in more detail in Research Question 2). Furthermore, they claimed that the implementation of the dimensions with the smaller effect sizes in Table 4.3 namely, *Collaboration*, *Personal Relevance*, *Critical Voice* and *Respect for Difference*, was easier.

Most teachers claimed during interviews that "groupwork" (*Collaboration*) (Narrative, Class A, page 95; Narrative Class D, page 111) and "connecting knowledge to the students' personal lives" (*Personal Relevance*) (Narrative, Class A, page 95; Narrative Class B, page 101) were used often during teaching. In addition, they claimed that these teaching approaches were primary tenets of the rNCS (DoE, 2002) which implied that they should incorporate them frequently into their classroom learning environment. Teachers further claimed that groupwork, as well relating the classroom lesson topic to students' everyday experiences, boosted students' confidence, whilst giving them opportunities to interact with their peers. Indeed, students in all the classes were frequently observed working co-operatively and discussing their ideas in small groups with their peers. Students claimed that they favoured these activities as they cited them as a means of clarifying their science ideas. In general, the students further claimed that they were satisfied with the implementation of the dimensions, *Collaboration*, *Personal Relevance*, *Critical Voice* and *Respect for Difference*, and that these dimensions increased their understanding of science. Consequently, this result shows that teachers implement some dimensions key to constructivist teaching approaches more often than others, probably to evade approaches involving scaffolding.

In conclusion, in answering Research Question 1, the fact that teachers are frequently incorporating dimensions related to meaningful learning and characteristics of social constructivist learning environments, made it evident that Natural Science teachers in the Western Cape Province are generally successful in creating social constructivist learning environments. The results further suggest that the extent of implementation varied, depending on the teachers' ability to scaffold effectively and their classroom circumstances.

Research Question 2

> *Do different levels of congruence of students'experienced (i.e., actual) and preferred learning environments in selected Grade 9 classrooms occur and, if so, why?*

This question is actually two questions in one. Firstly, it asks about the existence of levels of congruence between students' perceptions of their actual and preferred learning environment. Secondly, it asks the reasons for such levels of congruence. The former question will be answered first while the answer to the latter question will be provided last. Results from the qualitative inquiries of the classroom observations and teacher and student interviews are integrated with the quantitative analysis in order to explain the causes of the discrepancies between the actual and preferred Natural Science classroom perceptions.

In answering the first part of the question, the quantitative evidence (Table 4.3), particularly the varying effect sizes, suggest that different levels of congruence of students' perceptions of their actual and preferred Grade 9 learning environments indeed occurred. In answering the second part of the research question, reasons as to why there were different levels of congruence between the students' perceptions of their actual and preferred learning environment were sought. As the quantitative evidence could only provide limited information to explain this result, a qualitative inquiry was embarked in order to create a more comprehensive picture of the reasons for the teachers' choice of dimensions to incorporate in their classroom learning environment. Here, the researcher drew mainly on the narratives of Classes A, B, C, D and E, as well as classroom observations and student and teacher interviews (Chapter 4, pages 93-118).

A central theme in the discussion below suggests that teachers are using inappropriate scaffolding methods at inappropriate times. The discussion below on each of the scales, primarily to verify the discrepancy between the actual and preferred learning environment scores, gave further insights or 'clues' as to the reasons why teachers used inappropriate scaffolding methods at inappropriate times. These reasons might be very influential in determining teachers' success in creating social constructivist learning environments in Grade 9 Natural Science classrooms in the Western Cape Province, South Africa. In the next section, each scale will be examined in more detail, starting with the scale with the biggest effect size from Table 4.3.

Working with Ideas

Teachers play an important role in modelling metacognition in classrooms. A study involving metacognition in the field of LER suggest that teachers' selection of thinking and learning strategies influences students' attainment of metacognitive control of their thinking (Thomas & Au Kin Mee, 2005). Moreover, students' metacognitive behaviour is influenced by their social environment (Thomas, 2002 ab). Therefore, if teachers model metacognitive behavior and strategies incorrectly, it might have adverse effects on students' learning in a social constructivist learning environment.

The factor analysis shows that students perceived the scales *Investigation* and *Metacognition* similarly (Table 4.1). This suggests that teachers implemented the two dimensions similarly. Consequently, it might be that the teachers modelled the scales incorrectly or perhaps not in line with the rNCS's interpretation of how the scales should be implemented. Indeed, during interviews, teachers generally claimed that the best strategy for implementing the scale *Metacognition* was through lecture-style teaching, given the classroom constraints. They claimed that the classroom constraints, namely, the pre-determined outcomes in OBE, the group setting of the classroom, and more importantly, time constraints imposed by the curriculum (i.e, the period length, and the number of times that they were able to teach the students in a week-long cycle [on average 4 times]), left little interaction time with the students. Therefore, in contrast to the rNCS's notion (DoE, 2002) of experiential or discovery learning, they used teacher-centred lecture style teaching to "economise on their time". For instance, the teacher of Class A used a "two-step approach", which combined a mixture of lecture-style teaching in the first half of the lesson and, thereafter, an application of the knowledge through an independent investigative task (*Investigations*), which the students used to peer teach each other during group presentations (e.g., Narrative, Class A, page

95). Overall, the evidence suggests that both the scales were very likely taught in a lecture-style manner, and thus it could be that students perceived the two scales similarly because of this.

From a theoretical standpoint, the lecture-style teaching was possibly the most feasible strategy for teachers to use, given their limited interaction time with the students. One can infer several reasons as to why they did so. First, they might be able to practice a form of group metacognition (Bryceson, 2007), which expands the idea of metacognition to the whole group. Second, they might have externalised their tacit (in-head) knowledge to the whole group instead of individuals, giving students opportunities to compare their personal knowledge with the teachers' formal knowledge, which might have been time-consuming if students were left to do so independently. Third, they might have accessed many ZPDs associated with the 'weaving metaphor' (Brown, 1994; Bryson, 2007), which expands the idea of scaffolding beyond the individual to the whole class where there are multiple ZPDs (Woods *et al*., 1976; Woods, 1991). In addition, teachers claimed during interviews that they incorporated the rNCS's (DoE, 2002) notion of 'discovery learning' by giving students an investigative task subsequent to them actively engaging with concepts. Indeed, it was evident during classroom observations that teachers might have done so as a way of remediating, as generally teachers felt obligated to include the notion of 'discovery learning' in all aspects of their teaching. Overall, all these scaffolding strategies guided teachers to implement the dimension *Working with Ideas* which helped them to "economise on their time" (e.g., Class A, page 98).

One of the consequences of teachers' understanding of the dimension *Working with Ideas* is that it highlights the centrality of lesson pace in academic success. Specifically, two factors might contribute toward increasing the lesson pace, namely, how resources are used, and teachers' subject knowledge. First, with regard to resources, it was evident during classroom observations that teachers were more likely to cover additional content because of the extra support received through the use of resources. For instance, the teacher of Class A, who had access to an interactive whiteboard linked to a computer with internet access, very likely increased the pace of the lesson because students had immediate access to information whilst being guided by the teacher (Chapter 4, Narrative, Class A, page 95). Second, teachers' subject knowledge very likely aided with increasing the pace of the lesson. For instance, the teacher of Class C (Chapter 4, Narrative, page 106), who primarily used the chalkboard as a teaching resource, could pace the lesson faster because of her vast subject knowledge. This allowed her to sequence the lesson in a way that guided students toward understanding the lesson on *Energy*. Consequently, having additional support helped teachers by covering more content in a shorter time period during teaching. This might have equipped students with more knowledge to help them during the investigatative stage in their learning. Indeed, this result supports previous South African research (e.g., Fleisch, 2008). For instance, Hoadley (2003) found that working-class teachers cover substantially less content and teach to the slowest student. This reduces the amount of content covered, and slows the pace of instruction relative to middle-class teachers who worked at a much faster pace and covered more content. In fact, Howie's analysis of the South African 1999 TIMSS study (Howie, 2005) suggests that teachers teach to the slowest or weakest student as a way of coping because their own subject knowledge is weak. Thus, the lesson pace was very likely faster in high SES category schools because of the support from extra resources, as well as experienced teachers with vast subject knowledge. This is an interesting result and warrants further investigation in future research.

The evidence further suggests that teachers teaching in the high SES category schools were generally more competent at implementing the dimension *Working with Ideas* very likely because they used their time more efficiently. Indeed, classroom observations revealed that students in the high SES category schools worked independently on their investigative tasks, more likely because they were familiar with content, and were able to use the content at higher levels of conceptual development compared to their low SES counterparts. For instance, two contrasting class profiles corroborated this result, namely, for Classes A and C (Figures 4.4 & 4.6, pages 95 & 105) (two high SES category schools), and Classes B and E (Figures 4.5 & 4.8, pages 101 & 115) (a middle and low SES category school). Moreover, during classroom observations, it was evident that the high SES category students applied the skills gained during the first part of the approach (i.e., when the teacher used lecture-style teaching to explain work) more easily to the second part of the approach, the investigative tasks. From student interviews it was further evident that students in high SES category schools preferred investigative work because it very likely allowed them more independence during learning. On the other hand, students in the low SES category classes were far more dependent on the teachers' knowledge because they appeared to enjoy the constant guidance from the teacher. A typical example of this is the students in the low SES category school of Class E. These students claimed during interviews that they would rather have their teacher explain work to them than work independently. Furthermore, during classroom observations it was evident that teachers engaged in off-task behavior on numerous occasions which wasted valuable class time that could be used to develop content. This was evident when students in the low SES category schools generally needed the teacher to keep track of their behavior as they would lose concentration easily (e.g., Chapter 4, Class B, Narrative, page 101). In fact, during interviews, the teacher of Class B verified that he had to keep the students focused and on track with their work (Chapter 4, page 104). Overall, students in the high SES category schools showed better metacognitive skills than those in the low SES category schools, probably because their teachers modelled better metacognitive methods to guide students toward developing concepts, leading to independence in learning.

In summary, the large discrepancy between the actual and preferred learning environment scores for the scale *Working with Ideas* appeared to be because teachers might have misunderstood the dimensions resulting in them teaching in a way that modeled metcognitive behaviour inaccurately.

Teachers generally taught in a lecture-style manner contrary to the rNCS's expectation of 'discovery learning'. They might have taught in this way to counter the limited interaction time they had with the students. However, those teachers teaching in high SES category schools might have been at an advantage given their vast resources and subject knowledge, which probably increased the lesson pace. This gave teachers in high SES category schools chances to display better metacognitive behaviour, most likely resulting in students gaining better metacognitive skills, and therefore displaying independence in their learning.

Uncertainty in Science

Most constructivists argue that learning should be durable, transferable and self-regulated (e.g., Di Vesta, 1987). For this to occur, mechanisms in the form of interactivity or active learning must be in place to engage their interest, and to facilitate deeper learning (Biggs, 1999). By applying scaffolding through the ZPD, the teacher is the knowledgeable guide during learning (as discussed in the previous section) (Tharp & Gallimore, 1988). Teachers should engage students' interests during teaching, particularly at the edge of the students' competence. Indeed, the teacher should provide critical guidance when students are at the edge of their competence by making the critical decision to remove the support—or scaffold—when students accept full control of the task—a term called 'fading' (Oliver & Herrington, 2001) (see Chapter 2, page 17).

Choosing an appropriate scaffold might illuminate a students' competence at a particular point in a lesson, and is very likely to guide teachers to make appropriate decisions critical to the concept fading. For instance, through questioning, using techniques such as divergent or open-ended questions, teachers should expose students' tacit knowledge (Baker & Levya, 2003). Guidance through questioning allows students to actively engage with knowledge. Students should be allowed to expose their ideas, and develop them, eventually leading to uncertainty—incentives to further investigation (Johnson and Johnson, 2009) (see Chapter 2, pages 23-25). In addition, by giving students opportunities to question science ideas, the student might realize that science ideas are not always perfect and that old theories can be improved. These are some of the characteristics that the scale *Uncertainty in Science* (Chapter 2, pages 23-25) encapsulates. Judging from the discrepancy between the actual and preferred learning environment scores on this scale, it was evident that students would like this dimension to occur more frequently in their classroom learning environment.

Classroom observations revealed that the discrepancy in students' perceptions was very likely a result of the teachers' classroom practice, especially regarding questioning techniques. Indeed, a distinction arose between teachers who allowed students to ask questions and those who did not. Firstly, it was evident that some teachers seldom allowed students to question their own and others' ideas. The teachers of Classes B and C dominated during lessons (Chapter 4, Narratives, pages 101 & 106 respectively), stifling opportunities for students to ask questions. For instance, in the narrative of Class C (page 106) it was evident that the teacher often used questions only to get students to give the answers that she wanted to hear. When she asked questions about the different types of forces, she seldom guided students in a step-by-step process, that is, through scaffolding, toward developing their ideas. She rather concentrated on expressing her own ideas. It appeared that her goal during the lesson was to make her own meaning public (e.g., Edwards & Mercer, 1987; Wood, 1991). Similarly, the teacher of Class B (Narrative, Chapter 4, page 101) seldom used effective scaffolding in his lesson on ‘current flow’. Taken as a whole, if teachers seldom gave students opportunities to question ideas in class, then they might have prohibited them to crystallize their thoughts toward meaningful learning.

Teachers generally claimed during teacher interviews that they curtailed students’ questioning time because they faced time constraints with regard to period length (lessons were on average 45 minutes long) and lesson time (most teachers saw the students three times in a two-week cycle). They further claimed that these time pressures seldom allowed them to tolerate unfocussed questions from students during lesson time. One teacher further claimed during an interview (e.g., Class C, page, 108) that she did not trust the students would spend her time explaining work to determine if they learnt the content. Indeed, the observations of lessons in Classes B and C corroborate the explanations above, that teachers engaged in ‘question-and-answer sessions’ in pursuit of what they (the teachers) wanted to hear, therefore making learning less meaningful in terms of the constructivist approach.

The teacher of Class A, on the other hand, allowed students to ask questions beyond the classroom content—allowing them to theorise (Chapter 4, Narrative, page 95). Though she agreed with many teachers in other classes, who claimed during teacher interviews that most students were “not ready to engage with the uncertainty of science” (pages 99 & 104), her rationale was that she wanted students to learn that one can speculate and offer alternatives to ideas in science. Furthermore, she often hinted in the narrative (Chapter 4, page 95) that science changes over time, and that students should explore the development of science concepts through questioning. However, she further claimed during interviews that she allowed opportunities to question ideas in science during classtime because she received support from sophisticated technological resources (Chapter 4, page 98). In addition, she claimed that the interactive whiteboard, internet access in class, as well as students having internet access at home, saved time during teaching by increasing the pace of the lesson. Indeed, the classroom narrative (Narrative Class A, Chapter 4, page 95) verify that the teachers’ willingness to give students opportunities to question science concepts in class, boosted their confidence, as the students were willing to ask questions about theorizing, which was beyond the scope of the content covered in class. This was contrary to the majority of students in other classes, for instance, Classes B and C (Narratives, pages 101 & 106 respectively) who might have lacked the confidence to question ideas in science during classtime because of less frequent opportunities given by their teachers. Thus, teachers who encouraged the students to question science concepts appeared to give students the confidence to develop ideas conceptually. As this dimension is so important to most social constructivist learning environments with regard to developing ideas in science, this result warrants further investigation in future research.

In summary, students who had opportunities to question ideas in science became confident enough to ask questions to further their understanding of science concepts. Nevertheless, although many students favoured the occurrence of the dimension, the frequency of occurrence was to a large degree dependent on the teacher giving students opportunities to do so. This very likely boosted students' confidence to think beyond their current processes, leading them to conceptually develop ideas, and thus make learning more meaningful. Therefore, the discrepancy between the actual and preferred learning environment scores for the scale *Uncertainty in Science* was largely dependent on teachers giving students opportunities to question ideas in science.

Collaboration

During learning, each individual builds up his or her own conceptual structures and it is uncertain whether all students produced the same construct during learning (Von Glasersfeld, 1989). If the individual constructs are shared, we can assume that the meanings are shared, hence the term "taken-as-shared" (Marshall, 1998: 451). Furthermore, in the case of teachers and students, their private worlds are "taken as shared", with the teacher proceeding *as if* meaning were shared. During teaching, the teacher 'inputs' meaning into students' constructions, giving them more viability—the inter-subjective—which is the constructivists substitute for objectivity (Bryceson, 2007). In the case of scaffolding, new meaning should be created beyond that which any of the participants had, through the notion of inter-subjectivity or shared meaning of the task (Rogoff, 1990). *Collaboration* allowed students to co-construct meaning through discussion, negotiation and questioning in teams or groups, and thus test their understanding of science concepts with others (Chapter 2, page 16). In South Africa, working in groups has been found to be synonymous with the new curriculum and this emphasis may have been exacerbated by the discourse of the new curriculum policy (Brodie *et al*., 2002). In fact, groupwork is regarded as the core pedagogical shift required of the rNCS (Fiske & Ladd, 2004; Harley & Wedekind, 2004).

The mean scores for both the actual and preferred environment responses, depicted in Figure 4.1, were high compared to the rest of the SCLES scales. This implies that students perceived that the dimension occurred frequently in their learning environment. Indeed, classroom observations revealed that teachers practiced groupwork in all classes. In line with other South African research

(Brodie *et al.*, 2002), teachers across the sample regarded groupwork as essential to the social constructivist learning environment. The role of the teacher was to guide students toward a shared understanding. However, putting students in groups without appropriate guidance from the teacher did not necessarily translate to meaningful learning. For instance, the groupwork task for Class D (Narrative, Chapter 4, page 111) did not seem to contribute significantly toward students' insight into the development of the topic. Both the students and teacher probably lacked an understanding that groupwork might make learning more meaningful. Meaningful learning through groupwork should let the students' meanings be expressed in class, allow for better engagement for more students, and enable opportunities for more responsive scaffolding during teaching (Brodie *et al.*, 2002). However, in most lessons observed, there was little interaction between the teachers and students. In some cases few students dominated the lessons (e.g., Class C, page 104), whilst in other cases teachers did not set out tasks to enable the development of ideas (e.g., Class B, Narrative, page 101) and therefore did not scaffold tasks appropriately. Instead, the teachers withdrew from the learning process, leaving students to develop the concept further amongst themselves. Constructivist approaches do not leave the teacher to sit idly by while the class partakes in an activity. Instead, the teacher must guide class discussions in groups so that dialogue can be meaningful. Furthermore, the teacher must interact with students, to challenge them to think beyond what they already know, and to constantly assess their progress (Windschitl, 2002). This might be more draining on a teacher than step-by-step procedures during teacher-centred teaching.

In addition, during occasions when the teacher was able to manage the class, it was evident during classroom observations that teachers lacked the skills to scaffold appropriately. It was evident that they did not scaffold completely, and faded too soon (Oliver & Herrington, 2001). By fading too soon, it was apparent that teachers were not able to guide students toward complete understanding of science concepts, and therefore students would proceed to the next level with inappropriate foundational knowledge, leading to the lack of meaningful learning. This result is in line with South African research, which suggests that teachers implement the form (i.e., the approach) but not the practice (i.e., the principles behind the approach) during groupwork (Brodie *et al.*, 2002). Furthermore, research on teachers' practice in relation to *Curriculum 2005* suggests that while teachers are generally enthusiastic about the new curriculum and often believe that they are working with its principles in their classrooms, much teaching remains teacher-centred (Chisholm *et al.*, 2000; Jansen, 1999; Taylor & Vinjevold, 1999). This is consistent with international research which suggests that teacher-centred practices are remarkably resistant to change (Cuban, 1993; Edwards & Mercer, 1987; Sugrue, 1997).

Overcrowded classrooms affected groupwork. Because of the overcrowding, most classes were noisy and unmanageable, and teachers' attempts to manage the class very likely slowed the lesson pace and limited personal interaction with the groups. For instance, the students were not able to hear the teacher because of the small-sized classroom and noise (inside and outside the classroom)

(Chapter 4, Narrative, Class D, page 111). The teachers' efforts to manage these classes wasted time, and the distraction often resulted in students seldom completing their groupwork tasks. Student interviews with Class D (Chapter 4, pages 112-113) revealed that they could not explain how the groupwork exercise benefited them. They generally felt that their teacher over-used groupwork, which they claimed could lead to meaningless discussion. In addition, if not monitored, then the students claimed that they generally did not discuss the class topic, leading to noisy discussion. In fact, during teacher interviews, the majority of teachers claimed that they were not certain as to whether the students were in fact discussing school work. As this dimension is so important to social constructivist learning environments, it will be investigated further in Research Question 3, regarding the effect that this scale has on students' attitude toward science and their achievement scores.

In summary, the discrepancy between the actual and preferred learning environment scores on the scale, *Collaboration*, was partly due to constraints like small classrooms resulting in overcrowding. However, when these factors were in place, it might not have led to meaningful learning. Other factors, for instance, the teachers' inability to scaffold, might also have averted meaningful learning. As this dimension is so important to the social constructivist learning environment, this result warrants further investigation in future research.

Critical Voice

As discussed in Chapter 2 (page 25), teachers can empower students to make decisions regarding teaching strategies if they foster an environment where students might be allowed to critically voice their views. Taylor *et al.* (1994: 5) claim that teachers should "willingly demonstrate to the class their pedagogical accountability by fostering students' critical attitudes toward teaching and learning activities". Indeed, in the present study it was evident that students' critical voice was largely dependent on whether teachers were able to a create a risk-free environment for students to socially interact in class, which very likely explains the discrepancy between the actual and preferred learning environment scores for the dimension *Critical Voice*.

The small discrepancies between the actual and preferred learning environment scores shown in Figures 4.5 and 4.8 (pages 101 & 115, respectively) for Classes B and E suggest that students in these classes were able to communicate openly and frequently. This result was evident despite the teachers' domination through authoritarian teacher-centred approaches. For instance, the teacher of Class B (see Figure 4.5) presented information in a teacher-centred manner, with overhead notes which the students copied word for word. Yet the students seldom questioned him with regard to the content of the notes, or his method of teaching (Narrative, page 101). Similarly, the students in Class E (see Figure 4.8) seldom questioned the teacher (Narrative, page 116). These students would take notes verbatim to ensure that they captured the teachers' every word. Interviews with the students of Class E revealed that they trusted their teachers' knowledge and therefore accepted the way they were taught. During teacher interviews, the teachers of Classes B and E claimed that the students regarded them highly because of the high status that science teachers had in the community. These teachers, who taught at schools classified as middle and low SES category schools, respectively, further claimed that it might be that they were the only positive adult role models in the students' lives, given the poor communities that they came from. Therefore, it could be argued that teacher-centred teaching gave students a sense of emotional security.

The teacher of Class B further claimed that teacher-centred teaching (see Chapter 4, pages 103-104), allowed him to control and thus provide structure to lessons. By enforcing structure, he verified that this was a means of emotional security to the students—a sense of predictable protocol during every lesson (Chapter 4, Narrative, page 101): predictable enough for the students to feel self-assured, which he claimed was an emotion that many of them seldom felt at home. Moreover, many students in his class suffered from drug-related problems, and if he allowed unstructured lessons, those with stronger personalities might dominate. Indeed, interviews with the students verified the teachers' stance. They claimed that there were many advantages when the teacher taught in a highly structured teacher-centred manner (Chapter 4, Class B, page 103). The strict control during lessons, they claimed, enabled them to cover a substantive amount of work, whilst additionally receiving good notes from the teacher, which made them enjoy science lessons.

On the other hand, the students in Classes A and C at the high SES category schools had a different perspective about teachers. These students claimed, during interviews, that they were less dependent on teachers for emotional security. Contrary to students in the lower SES category schools, many students in the high SES category schools regarded teachers as professionals who supported them more so academically than emotionally. Furthermore, during classroom observations it was evident that the high SES category students in Classes A and C were more critical of their teachers' teaching. For instance, they often questioned the teachers' teaching methods with some students going as far as stating that the "teachers' lessons were boring" and that "the teacher should change her approach by adding more investigations" (Chapter 4, Class C, pages 107-108). Similarly, the students in Class A criticized the way that the teacher taught during lessons, which they claimed could be improved with more investigations (Chapter 4, Class A, page 98).

In summary, the discrepancy in the actual and preferred learning environment scores for the scale *Critical Voice* was largely due to students being critical of their classroom learning environment. Students in high SES category schools, evidently, were more critical than the students in the low SES category schools. This could imply that the results of this scale are SES-related. As a consequence, this result will be investigated further in the next section, Research Question 3, by focusing on the varying SES groups with regard to students' attitude toward science and achievement.

Personal Relevance

The importance of learning science in contexts that draw on authentic or real-life situations has been highlighted in many previous research studies (e.g., Campbell, Luben & Dlamini, 2000; Henderson & Reid, 2000; Stears & Malcolm, 2005; Yager, Simmons & Penick, 1989) (also see Chapter 2, page 22-23). When linking students' everyday and formal knowledge, teachers need to know students' everyday life interests. By knowing the interests of students, teachers might be able to formulate lessons that help students 'close the gap' (Reeves, 1999: 59) between their everyday and formal knowledge. Making formal knowledge relevant to students' everyday life experiences is the goal of the dimension *Personal Relevance*. Interestingly, the overall profile for all 1955 students depicted in Figure 4.1 shows that the mean scores for both the actual and preferred student responses to the scale *Personal Relevance* was the lowest relative to the rest of the SCLES scales. By combining the qualitative evidence to this result, it was evident that teachers who were likely to show interest in the students' lives, and maintain good relationships with the students, were more likely to 'close the gap' (Reeves, 1999: 59) between students' everyday and formal knowledge.

It is argued that teachers who show interest in the students' everyday life situations are more likely to know their everyday interests. For instance, the teacher of Class B (Chapter 4, page 100-103) was able to maintain a good relationship with his students and often made knowledge personally relevant. In fact, this class showed an unusually small gap between the actual and preferred learning environment scores (Figure 4.5). During teacher interviews, the teacher claimed that he often related formal knowledge to students' everyday real-life experiences. For instance, he claimed that he used the gangster example (Chapter 4, Narrative page 101) to draw on the students' real-life experiences of gangsterism in their community. Classroom observations revealed that the students trusted him to do so. Therefore, this teacher was more likely to formulate lessons using contextualized knowledge, which students claimed made the lessons more interesting.

However, during classroom observations of Class C it was evident that the teacher struggled to contextualize knowledge mainly because of her authoritarian manner during teaching (Chapter 4, Narrative, page 106), which hindered good relationships with her students. Moreover, the Class C profile showed a large discrepancy between the students' actual and preferred learning environment scores on this scale (Figure 4.6) relative to the other scales, which suggests that the teacher was not making knowledge personally relevant as often as students would have liked her to. In fact, during student interviews they claimed that her lessons were boring. They further claimed that the teacher

distanced herself from them, and showed no interest in their everyday life experiences. Overall, the evidence suggests that teachers' use of familiar scenarios during lessons increased the chances that they could link students' scientific knowledge with their everyday knowledge.
In Chapter 2 (pages 14 & 22), the theory suggested that presenting information that is relevant to students' everyday life experiences is very likely to translate into meaningful science learning. In fact, to a certain extent, evidence in this study supports this view. For instance, judging from the evidence in Class B, this teacher was more likely to present information that is relevant to students' everyday life experiences, than the teacher of Class C. Nevertheless, classroom observations further suggest that both class teachers seldom engaged students in meaningful learning. Sugrue (1994) states that creating a friendly and caring environment does not necessarily translate into relevant pedagogy. This further implies that knowing students' interests does not necessarily translate into meaningful learning. Indeed, classroom observations revealed that the teacher of Class B used the gangster example to engage or 'hook' the students, but he did not necessarily succeed at the pedagogical level. He lacked the skills to scaffold completely by merging the scientific knowledge and everyday knowledge, because he was unable to contribute meaningfully to the students' understanding of the lesson topic the 'flow of current'. In fact, he might have confused the students as it was not apparent to them what the scientific knowledge and everyday knowledge was. For instance, the teacher did not make explicit the difference between the everyday understanding and familiar or general use of the word 'flow', and the more scientific conception of 'current flow', thus failing to link the two ideas. In another example, the teacher of Class D (Chapter 4, Narrative, page 111) failed to bring about meaningful science learning by using the globe (a concrete representation) to enhance students' understanding during the lesson on *Climate.* The conceptual goal of the activity was for the students to learn that because of the varying temperatures in different parts of the world, air will react differently by rising or sinking. It was evident during student interviews that the students did not understand the relationship between the varying positions of countries on the globe, and the concept of air rising or sinking. In fact, interviews with the students suggested that the use of the globe more likely confused them. Thus teachers, in an effort to 'close the gap' between everyday understanding and scientific conceptions (Reeves, 1999: 59), could very well create conceptual confusion when using everyday metaphors or representations.

In summary, the low scores for the actual and preferred learning environment perceptions for the scale *Personal Relevance* were primarily due to how the teacher related students' everyday and formal conceptions. Furthermore teacher's who were able to familiarize themselves with the students and their everyday interests were more likely to formulate lessons around the students' interests. However, this did not necessarily translate into meaningful learning.

Respect for Difference

In a plural society like South Africa, where "learners in Natural Science think in terms of more than one world view" (DoE, 2002: 12), students should be tolerant enough to allow the voices of all children and communities they come from to be heard in the classroom. However, if teachers do not create a safe environment for students to openly express their views, then students with diverse views and opinions about scientific and other phenomena might be trapped in contentious situations (see Chapter 2, page 26). Moreover, in a social constructivist learning environment, there is a high degree of student interaction. Thus, for students to feel emotionally safe to express their views in collaborative groups, away from "emotionally threatening situations" (Järvelä, 1998), teachers need to create a safe environment for participation.

From the overall profile for all 1955 students depicted in Figure 4.1 it is evident that the discrepancy between the mean scores for the actual and preferred student responses to the scale *Respect for Difference* was the smallest relative to the rest of the SCLES scales. This result implies that teachers were frequently enforcing that students respect each other's opinions. For instance, the teacher in Class A (Chapter 4, page 98) claimed that the high score for the actual and preferred learning environment for this scale is because she enforced that students listen to one another. She often discussed this in lessons, and formulated clear rules for students to follow. The first rule, she claimed, was that they raise their hands if they wanted to express themselves. This behaviour was evident during classroom observations (Chapter 4, Narrative, page 95). The second rule, she claimed, was that the students allow those who were speaking to complete their thoughts before expressing their own view. This too was evident during classroom observations (Chapter 4, Narrative, page 95). Furthermore, the teacher claimed during interviews that these rules or boundaries were fundamental to successful approaches involving, for instance, groupwork, discussion, investigation and metacognition. In addition, she claimed that it was important that everyone knew the rules and therefore she occasionally addressed it through discussion. Indeed, the students in Class A claimed that they knew the rules and respected them (Chapter 4, page 98-99). They further claimed that because of these rules, they felt confident to express their opinions in class. Classroom observations verified this. It was evident that the students expressed themselves in an open and confident manner (Chapter 4, Narrative, page 95). Overall, it was evident that most teachers in other classes followed a similar pattern and created their own special rules, which the students seemed to be aware of and respected, resulting in the small discrepancy between the actual and preferred learning environment scores.

In conclusion, in answering Research Question 2, the quantitative evidence showed that different levels of congruence existed between the actual and preferred learning environment scores, and the qualitative data provided plausible reasons for why this was so. The evidence suggests that a primary concern in a social constructivist learning environment was whether a teacher could scaffold. Indeed, teachers should be highly skilled in order to make critical decisions regarding scaffolding. First, teachers should understand key dimensions, and then implement them. For instance, this was evident on the scale *Working with Ideas*, where it was very likely that teachers misunderstood the separate scales, *Investigation* and *Metacognition*, leading them to model inappropriate metacognitive behaviour, and students emulating this behaviour by aquiring inappropriate metacognitive skills. This situation appeared to be SES-influenced, as students in high SES category schools acquired better metacognitive skills, probably because of the support from resources and highly skilled teachers. Second, teachers' understanding of the students' needs is pivotal to successful scaffolding. This was evident on the scales *Personal Relevance* and *Critical Voice*. However, though knowing the students' needs could help teachers to create an environment encouraging respect for others' views (*Respect for Difference*) it was evident that this does not necessarily translate into appropriate pedagogy to bring about meaningful learning. Indeed, the importance of pedagogical knowledge and skills to bring about meaningful learning was evident on the scale *Uncertainty in Science*, to guide teachers toward appropriate questioning techniques, and the scale *Collaboration*, to guide teachers toward appropriate groupwork skills (often in overcrowded and unmanageable classrooms).

Research Question 3

Does the students' background, described in terms of their socio-economic status, influence their perceptions of their learning environment?

In answering Research Question 3, the three SES categories were probed and compared using a one-way MANOVA, as well as a Tukey HSD *post hoc* test (Chapter 4, pages 90 & 91). The results in Table 4.11 and 4.12 (pages 89 & 90) show scores for the students' perceptions of their actual classroom learning environment across the three SES groups. In Table 4.11, the scores for the actual version of the questionnaire show that the perceptions of the students across all three SES categories are statistically significant for the scales *Working with Ideas*, *Respect for Difference*, *Personal Relevance*, *Critical Voice*, *Uncertainty in Science*, as well as for the scale *Attitude toward Science* and achievement. Furthermore, the results for the preferred version of the questionnaire were statistically significant for the scales *Respect for Difference*, *Personal Relevance*, *Critical Voice* and *Uncertainty in Science*. In addition, the results in Table 4.12 show the magnitudes of the differences in the pairs of SES categories (i.e., H/L, H/M and M/L) based on their mean scores and effect sizes. The biggest contrast in effect sizes was between the high and low SES category schools. Given this result, and the fact that the high and low SES category schools represent equal numbers of schools in the sample—14 schools each—(Chapter 3, pages 60-62), the results will be interpreted primarily for the high and low SES category schools. On occasion, use of the medium SES category school results will clarify interpretations.

The discussion that follows focuses on the results in the high and low SES category schools in Tables 4.11 and 4.12. Firstly, the results in Table 4.12 show statistically significant differences ($p<0.05$) for the scales *Working with Ideas*, *Respect for Difference*, *Personal Relevance* and *Critical Voice* (with effect size ranging from 0.20 to 3.12), as well as for the outcomes *Attitude toward Science* (with effect size of 2.35) and achievement (with effect size 3.20). Secondly, the original average item means in Table 4.11 showed that students in the high SES category schools perceived *Respect for Difference* and *Personal Relevance* to have occurred more frequently in their social constructivist classroom learning environment than the other scales. On the other hand, students in the low SES category schools perceived that *Working with Ideas* and *Critical Voice* to have occurred more frequently in their social constructivist learning environment. Therefore, possible differences in the social constructivist learning environments of these two groups were probed further through the qualitative data, which will be discussed next.

Students in the high SES category schools perceived that teachers frequently related knowledge to their everyday life experiences (*Personal Relevance*) in a safe environment where they promoted expressing their views (*Respect for Difference*). Indeed, these results corroborate the discussions on these two scales in Research Question 2 (page 130), where, on the scale *Personal Relevance* (see page 140), teachers who had good relationships [e.g., Class B, Chapter 4, page 103] with the students were more likely to 'close the gap' (Reeves, 1999: 59) between students' everyday and formal knowledge. Furthermore, on the scale *Respect for Difference* (see Chapter 5, page 141), teachers made students feel emotionally safe to express their personal views, by creating a learning environment like those of, for instance, Class A, a high SES category school, where the teacher created "rules" (see Chapter 4, pages 98-99) during learning. In addition, as was evident during classroom observations, teachers enhanced the learning environment experienced by students in the high SES category schools by making critical decisions during scaffolding through, for example, when to withdraw a scaffold (Oliver & Herrington, 2002). Taken as a whole, the environment experienced by students in the high SES category schools encouraged participation, and the promotion of higher order thinking skills (Chapter 2, page 14), and therefore independent learning.

On the other hand, the students in the low SES category schools perceived that teachers frequently guided the development of conceptual knowledge (*Working with Ideas*) whilst giving students opportunities to question the teachers' teaching methods (*Critical Voice*). Indeed, students in the low SES category school of Class E enjoyed the constant engagement with the teacher (see the scale *Working with Ideas* in Research Question 2, page 131). Though given opportunities to question the teachers' methods, their regard for their teachers were so high that they seldom did (e.g., Narratives, Classrooms B & E, pages 101 & 116, respectively; see discussion for the scale *Critical Voice* in Research Question 2, page 138). Therefore, students in the low SES category schools perceived a high degree of guidance from, and consequently, a dependence on, the teacher during learning.

The two learning environments experienced by the high and low SES category students very likely influenced their achievement scores. Indeed, the achievement results shown in Table 4.11 indicate large effect sizes between the high and low SES category schools. This implies that the emphasis on particular scales encouraging independent learning in high SES category schools might be creating a social constructivist learning environment conducive to better achievement by students. Indeed, one might argue that the learning environment experienced by students in high SES category schools foster meaningful learning (Chapter 2, page 14-15), giving these students a deeper conceptual understanding of knowledge and thus better achievement scores. This learning environment is in stark contrast to that experienced by low SES category students, which most likely did not foster meaningful learning due to their rote-learning style, giving students a surface approach to learning (Slavin, 1994), and therefore resulting in weak achievement scores relative to students in the high SES category schools. Therefore, one can infer very valuable information about the classroom learning environment.

First, it might be that the scales emphasised in the high SES category schools were more likely to help students develop better skills to draw graphs than those in low SES category schools, and hence the higher achievement scores in the high SES category schools. The present study tested graph-drawing skills guided by the assessment standard—evaluating and communicating findings (Chapter 3, page 56-58), namely, whether students could draw, interpret and extrapolate from a graph. According to a panel of experts in the subject Natural Science (Chapter 3, page 56-57), all students should have gained these skills at the time of data collection. However, as can be seen from the assessment standard (Figure 3.2), the development of these skills start from the foundational levels of Grades 7 and 8. Moreover, if Grade 9 students struggled to attain advanced skills, then it suggests that these students might lack the foundational skills specified in the assessment standard. Therefore, judging from the achievement test scores in Table 4.11 it could be assumed that students in high SES category schools gained the foundational skills to gain full competence of graph drawing, interpretation of graphs and extrapolating from graphs, and were simultaneously supported in their current Grade 9 learning environment. Hence the high achievement scores for this group of students. On the other hand, it could be that students in the low SES category schools did not have the foundational skills to gain full competence of graphs, hence the weaker achievement scores. This trend was evident in previous research in the Western Cape Province described in Chapter 1 (pages 9-10). Therefore, it was evident that SES could play a very influential role in the students' classroom learning environment, especially with regard to their achievement scores.

Second, it might be that teachers in high SES category schools chose to work with scales in line with the rNCS (DoE, 2002), which promote the conceptual development of knowledge, as these teachers had better support (through, for instance, better resources, subject knowledge and good quality students), and thus interpreted the curriculum (or recontextualised) better than those in low SES category schools. In fact, the curriculum and OBE might have made matters worse for students in low SES category schools. Indeed, teachers teaching in low SES category schools (see Chapter 2, pages 43-44) need more guidance from the rNCS (DoE, 2002) considering that many teachers teaching in these schools lack key skills to teach conceptually (Reeves, 1999). Indeed, many teachers, including those teaching in high SES category schools, complained that the lack of explicit explanation and support from the curriculum (e.g., Chapter 4, Class C, page 107) strongly influenced their ability to create social constructivist learning environments. For instance, the achievement test was framed within the assessment standard with a focus on students evaluating data and communicating findings (see Figure 3.2). This assessment standard specifies that students' ability to evaluate and communicate findings develop progressively from Grades 7 to 9. However, teachers, with as little more than an assessment standard as guidance, are expected to design and implement appropriate learning programmes to achieve the outcome whilst using methods that address the unique needs of the child. For teachers to cover all these processes successfully, they need to be highly skilled to sequence and pace the lessons to reach the outcome. As was seen in the results under Research Question 2 (pages 130-143), a feat that was difficult to accomplish when teachers implemented the scale *Working with Ideas*. Moreover, whilst considering the sequencing and pacing of lessons, they simultaneously should have considered students' individual needs (as with individual constructivism, see Chapter 2 [pages 13-16]) and other factors like students' current knowledge, available resources, and time constraints. Furthermore, they should carefully consider content that would lead them to the outcome, and then select appropriate examples considering students' level of knowledge whilst also identifying misconceptions. For an average teacher in South Africa, who struggles with subject content knowledge and has inadequate textbooks among other things, in the absence of detailed guidance from the curriculum, the task of being a 'curriculum designer' is simply overwhelming. Therefore, with all these complexities, especially in low SES category schools, it could be a big task to ensure that students achieve good results, implying that this result is SES-related.

Third, it might be that students' background influenced their attitude toward their Natural Science classes. The low SES category students had lower achievement scores than the high SES category students. However, the results were reversed for the scale *Attitude toward Science* (Table 4.11) In fact, from the discussion on the scale *Critical Voice* (page 138) in Research Question 2, it was evident that students in the low SES category schools were less critical of their teachers' teaching, which could have contributed toward their higher attitude toward science score (Table 4.11). Indeed, teachers play a pivotal role in the classroom learning environment (Fraser, 1998), and as a result, the low SES students' less critical attitude toward teachers might have had an impact on the students' more positive attitude toward science in this group.

Another factor that might have contributed toward the low SES category students' high scores for the student outcome *Attitude toward Science* is that these students might have perceived science as a means to improve their lives. Indeed, this result corroborates previous research (e.g., Lemke, 2001) which argues that contemporary science is a product of European cultures, and that those within the orbit of this culture perceive science positively only if they enjoy the subject. Moreover, those who lie outside the orbit of this culture may want to enter the science culture, not for personal enjoyment, but for the longer-term advantages that a career in science might give them. Asian pupil life story studies (Woodrow, 1996), which similarly show that students take science subjects for its career advantages, further show that parents have a particularly important effect on student choice. Similarly, students in the present study were also influenced by their parents in their decision-making of science as a subject. For instance, the students in Class E (page 114) cited that their cultural values made them respect teachers, implying that their families had an influence on their decision-making. Interviews with these students suggested that they might have perceived science as an important stepping-stone toward a fulfilling career that might improve their (and their family's) lives through the financial rewards. This expectation might have resulted in them having more positive attitudes toward science.

Interestingly, the students in the high SES category schools, having higher achievement scores than the the low SES group, showed lower attitude toward science scores than the high SES group (Table 4.11). It might be that the students in high SES category schools were negative toward Natural Science as the subject because it is compulsory at Grade 9 level. One might argue that, given the choice, the students might have chosen another subject above Natural Science. As was claimed above, it is possible that the students' personal interests might have become a dominant factor in their subject choice. With no personal interest in Natural Science, the students probably felt less freedom to construct their self-identity, and thus a possible explanation for the lower attitude toward science scores is that those middle-class students actively construct their self-identity through their subject choice rather than accept pre-destined routes (Breakwell & Beardsell, 1992; Ramey & Ramey, 1994). A typical example is that the high SES category schools of Classes A and C (pages 93 & 104, respectively) it was evident during student interviews that students would rather choose careers where they aided people (which influenced their self-identity). In fact, research shows that that careers like a scientist/engineer, which are strongly associated with advanced technology—might not appeal to most high SES category students, as it probably lacks the personal fulfillment to help people (Osborne, 2008). Therefore, this result further supports that students' background plays an important role in their decision-making, and in this case, their decision-making about science, and hence their attitude toward science.

In answering Research Question 3, it was evident that SES is very influential in social constructivist learning environments, especially with regard to students' achievement scores, their attitudes toward science and teachers' interpretation of the curriculum. These outcomes are explored further in the next research question.

Research Question 4

What is the influence of social constructivist-based learning environments in promoting student outcomes of attitude toward science, achievement, and gender equity in three socio-economic contexts?

Past research studies reported important relationships between the science classroom learning environment and the attitudinal and achievement outcomes of primary students (e.g., Chin & Wong, 2003). Classroom dimensions can be useful predictors of student learning outcomes (Fraser and Fisher, 1982). For instance, Rawnsley and Fisher (1998), in their study about associations between mathematics classrooms and students attitudes, found that students developed more positive attitudes toward mathematics in classes where the teacher was perceived to be highly supportive, equitable, and gave students freedom and responsibility. Furthermore, gender equity has been included as a third student outcome because of the emphasis on this outcome by the rNCS (DoE, 2002) and international research on gender-fair teaching (e.g., Alexakos & Antoine, 2003; Osborne & Dillon, 2008). Therefore, the findings of the influence of social constructivist-based classroom learning environments in promoting student outcomes, attitude toward science, achievement and gender equity are discussed separately below.

Social constructivist learning environment and student attitude toward science

Within the area of LER, the investigation of student attitudes toward science has been a common feature (e.g., Fraser & Fisher, 1982a & b; Nair & Fisher, 2001). The present study, in keeping with this tradition investigated the relationship between the social constructivist learning environment and students' attitude toward science. To assess students' attitude toward science, an attitude scale was adopted and adapted from the *Test of Science Related Attitudes* (TOSRA, Fraser, 1981) (Chapter 3, page 56). The scale *Attitude toward Science* was incorporated into the SCLES questionnaire (Appendix 3); was translated into Afrikaans and isiXhosa (Chapter 3, pages 54-55); and piloted to 1955 students in the 52 classrooms in the Western Cape Province, South Africa.

The Cronbach alpha co-efficient was used to determine the internal consistency reliability for the *Attitude toward Science* scale. This was found to be satisfactory as they were 0.82 and 0.92 for the individual and class means, respectively (Table 4.2). Similarly, past studies also found the *Attitude toward Science* scale to be reliable (e.g., Henderson & Reid, 2000; Margianti, Fraser & Aldridge, 2001; Rawnsley & Fisher, 1998). Overall, the validation provides support for the confident future use of the the scale *Attitude toward Science* in Grade 9 Natural Science classes in South Africa.

Simple correlations and multiple regression analyses were conducted to examine whether associations existed between students' perceptions of the learning environment and the outcome of student attitude toward science for the high, medium and low SES category schools. Simple correlation analyses indicated that there were statistically significant associations at the individual level between student *Attitude toward Science* and five of the six scales for the high SES category, as well as all six scales for the medium and low SES categories (Table 5.1).

Table 5.1 A summary of of the presence (✓) or absence (×) or [negative (–) correlation] of statistically significant (p<0.05) simple correlations for associations between student attitude toward science and the SCLES scales in South Africa for students in the high (H), medium (M) and low (L) SES categories with the individual and class means as the units of analysis.

Scale	Unit of Analysis	Student Attitude toward Science		
		H	**M**	**L**
Working with Ideas	Individual	✓	✓	✓
Respect for Difference	Individual	✓	✓	✓
Collaboration	Individual	×	✓(–)	✓
Personal Relevance	Individual	✓	✓	✓
Critical Voice	Individual	✓	✓	✓
Uncertainty in Science	Individual	✓	✓	✓
Working with Ideas	Class Mean	×	✓	×
Personal Relevance	Class Mean	✓	✓	✓
Critical Voice	Class Mean	✓	✓	×
Uncertainty in Science	Class Mean	✓	✓	✓

The multiple correlation was statistically significant for the high and medium SES category schools at both the individual and class mean levels of analysis, while for the low SES category schools only at the individual level (Tables 4.4, 4.5 & 4.6, pages 76, 77 & 79 respectively). Standardised regression co-efficients, showing the independent predictors of attitude toward science, indicate that teachers in both high and medium SES category schools should incorporate lessons where the students could explore their own ideas (*Working with Ideas*, *Uncertainty in Science*) that are relevant to their lives (*Personal Relevance*) in an environment where students respect each others' views (*Respect for Difference*), and are able to openly express their opinions (*Critical Voice*). Such an environment would enhance individual students' attitude toward science. While teachers in the low SES category schools should focus specifically on letting students explore their own ideas (*Working with Ideas*) in an environment where everyone's views are respected (*Respect for Difference*). Therefore, teachers wishing to improve student attitudes toward science should include lessons that allow for more activities that exemplify each of the scales. The pattern of associations between the students outcomes of attitude toward science have been replicated frequently in past research (Fraser, 1998, Goh & Khine, 2002).

Though the associations were positive for all the scales, the simple correlation for the medium SES category schools on the scale *Collaboration* showed a negative correlation with attitude toward science. As discussed in earlier, the importance of this result lies in the fact that teachers in South Africa have associated working in groups as being the core pedagogical shift required of the rNCS (Harley & Wedekind, 2004, Fiske & Ladd, 2004). Here students often work in teams, interact, share and discuss ideas with each other, as well as compare and contrast experiences. However, the teachers in the medium SES category schools might have (over)emphasised students' collaborative work. Moreover, as discussed in earlier, in many cases, teachers who use the dimension often add little meaning to the lesson, resulting in them failing to contribute toward students' overall understanding of the lesson (e.g., Class B, Chapter 4, page 101). Furthermore, from the students' perspective, the constant exposure and therefore possible overuse of collaborative work, sometimes in unmanageable classroom situations, may have frustrated them, thus affecting their attitude toward science negetively. Students suggested during interviews that they lacked the necessary skills and support from the teacher during collaborative work (see Chapter 5, page 136). In addition, though students appreciated working with their friends, and sometimes considered working in groups "more fun than working alone", many students complained about the imbalances in workload as well as some students copying work, which frustrated them, influencing their attitude toward science negetively. Wolf and Fraser (2008) report similar findings in the USA on the association between the scale *Cooperation* and outcome *Attitude toward Science*.

Social constructivist learning environment and student academic achievement

In order to determine whether there were associations between achievement and the social constructivist learning environment, an achievement test was developed (Chapter 3, page 56). The achievement test was developed for the present study. It assessed whether students had the necessary skills related to line graphs regarding drawing, interpreting and extrapolating (see Appendix 3). Simple correlation and multiple regression analyses were conducted to examine whether associations existed between students' perceptions of the learning environment and the outcome of achievement for students in the high, medium and low SES category schools. The results of only the statistically significant simple correlations are reported in Tables 5.2. The simple correlation analyses indicated that there were statistically significant associations at the individual level between achievement and three of the six scales for the medium SES category, as well as one scale, that is, *Respect for Difference*, for the low SES category with the class mean as the unit of analysis.

The multiple correlation was statistically significant for the medium and low SES category schools at both the individual and class mean levels of analysis respectively (Tables 4.5 & 4.6, pages 77 & 79). Standardised regression co-efficients, showing the independent predictors of achievement, indicate that teachers in the medium SES categories should incorporate lessons where the students could respect each others' views (*Respect for Difference*) but should be cautious when allowing students to explore their ideas (*Working with Ideas*). Those in the low SES category schools should allow students to explore their ideas (*Uncertainty in Science*) and respect for each other's views (*Respect for Difference*) but should be cautious when allowing students to express their views (*Critical Voice*). Therefore, teachers wishing to improve students' achievement scores in the medium and low SES categories respectively should include lessons that allow for more activities that exemplify each of the scales.

Table 5.2 A summary of the presence (✓) or absence (×) or [negative (–) correlation] of statistically significant (*p*<0.05) simple correlations for associations between achievement and SCLES scales in South Africa for students in the high (H), medium (M) and low (L) SES categories with the individual and class means as the units of analysis.

Scale	Unitof Analysis	Achievement		
		H	**M**	**L**
Working with Ideas	Individual	×	✓(–)	×
Respect for Difference	Individual	×	✓	×
Personal Relevance	Individual	×	✓	×
Respect for Difference	Class Mean	×	×	✓

The pattern of associations between the students outcomes of attitude toward science have been replicated frequently in past research (Fraser, 1998, Goh & Khine, 2002). However, teachers in the medium SES category should be tentative when incorporating the scale *Working with Ideas*, while those in the low SES category should be tentative when incorporating the scale *Critical Voice*. These negative outcome-environment associations are interesting and warranted further exploration through student interviews and classroom observations.

The pattern of associations between the learning environment and the student outcome achievement has been replicated frequently in past research (Fraser, 1998; Goh & Khine, 2002). However, this study highlights that students in different SES contexts might achieve better results given exposure to specific dimensions. Moreover, several studies of a constructivist nature show that students can increase their achievement scores (e.g., Abell, 1999; Dalton & Morocco, 1997; Henderson, Fisher & Fraser, 2000) given opportunities to share ideas that are of interest to them (*Personal Relevance*) in a risk-free environment (*Respect for Difference*). However, when faced with dimensions where the teacher takes control in order to conceptually develop ideas (*Working with Ideas*) (see Chapter 5, page 131), it might create a more teacher-centred environment where students might feel stifled to express themselves. Furthermore, in the low SES category schools, students seldom questioned the teachers' practice or knowledge to further their understanding of concepts (*Critical Voice*) (see Chapter 5, page 138). Therefore, these environments might have a negative effect on students' achievement scores, and for that reason such environments warrants further investigation in future research.

Social constructivist learning environment and gender equity

The rNCS (2002) places emphasis on teachers treating girls and boys equally (see Chapter 2, page 40). Creating an environment to ensure balances when teaching males and females has received much attention in the literature (e.g., Osborne, 2008), and is becoming increasingly important. Teachers need to be aware of techniques to create this balance during teaching (Alexakos & Antoine, 2003). Furthermore, exploring these techniques by SES category, might give insight into whether teachers in these categories should adjust their teaching for optimal participation by boys and girls.

Gender equity was examined through a one-way MANOVA for repeated measures and using the within-class gender subgroup mean as the unit of analysis. Firstly, gender equity was examined to get an overall picture of the classroom learning environment for all the classes in the study. The result for all 1955 students in the 52 classes (Table 4.3) suggest that male and female perceptions are statistically significantly different ($p<0.05$) for the scales *Respect for Difference* and *Critical Voice*. In both cases, females perceived a more positive learning environment than males did. Furthermore, the effect sizes were small, ranging between 0.03 and 0.45 standard deviations for the different scales (Table 4.3).

The results were further inspected by SES. Indeed, the results (Tables 4.8 to 4.10, pages 86 to 88) suggest that females in the high and medium SES category schools perceived activities related to the dimension *Respect for Difference* to occur more frequently in their classrooms than males did, and in both the SES categories, the females would like the frequency of this dimension to increase. Furthermore, females in the high SES category schools would like more frequent occurrence of particular scales, namely, *Working with Ideas*, *Personal Relevance*, *Collaboration* and *Uncertainty in Science*. Therefore, females, especially those in the high SES category schools, perceive their classroom learning environment less positively than their male counterparts. International studies support this result, suggesting that females become increasingly more negative toward their science classes (Bacharach *et al.*, 2003; Osborne, 2008).

Surprisingly, students in the low SES category (Table 4.10), exhibited no significant differences in gender perceptions of their learning environment. This finding is important as it suggests that males and females perceive their classroom similarly and that teachers are probably creating learning environments that cater for both males and females. However, the result is contrary to previous international research (e.g., Osborne, 2008), which showed that at their present average age (i.e., 14 years old) females start developing a more negative attitude toward their science classes than males do. Further research is required to give insights into this result and to find out the possible reasons for why the low SES category students do not consider gender equity important in their learning environment, or whether teachers in these schools are, in fact, implementing gender fair practices. Overall, the results for the associations between the social constructivist learning environment and gender equity suggest that SES might be very influential in the social constructivist learning environment. The result further highlight that those teachers who teach in high SES category schools, should consider including gender-fair practices in their classroom learning environments.

To answer Research Question 4, the results show that the social constructivist learning environment influences the student outcomes of attitudes toward science, academic achievement and gender equity. The results replicate previous learning environment research studies that established a strong association between the classroom learning environment and student attitudinal and academic achievement outcomes (Fraser, 1998, Goh & Khine, 2002). It further emphasized, as in Research Question 3, the increasingly important role of SES when considering the classroom learning environments in Grade 9 in the subject Natural Science.

Implications and Recommendations

The present study revealed important findings which have the potential of improving the social constructivist-based learning environment of Grade 9 Natural Science classes in the Western Cape Province, South Africa. Based on these findings, particular recommendations can be suggested for classroom practices, professional development programs for science teachers, and for policymakers. The recommendations arising from this study are therefore discussed under these categories in the following paragraphs.

With regard to classroom practice, teachers play a very influential role in creating social constructivist learning environments. By allowing students to experience positive learning environments, it is likely to maximize key student outcomes such as, students' *Attitude toward Science* and achievement. The effect of better attitudes toward science might allow more students to pursue science-oriented classes in high school and university, especially in South Africa where few students are taking subjects like science at the senior secondary school level (Department of Education, 2003). Furthermore, the effect of improving their science marks could improve students' achievement scores, especially in South African schools, where the pass rate amongst

African schools is very low, at about 22% (Khan, 2004). Therefore, teachers might be the single-most important factor to have a positive influence on their classroom learning environment.

With regard to professional development programs for science teachers, teachers need to be sensitized during training that there is no 'one size fits all' (Tomlison, 1999) approach during teaching (i.e., one approach of teaching is suitable to all students). The study highlighted that when teaching toward a social constructivist learning environment, then the teachers' success in creating such an environment is largely dependent on three factors, namely, appropriate scaffolding techniques, SES and gender equity. In fact, these three factors should always be considered when implementing any dimension. The three factors will be discussed in turn.

First, the results highlighted that appropriate scaffolding techniques influenced the success of understanding a concept in a social constructivist learning environment. Teachers need to use scaffolding to guide students toward meaningful learning. Moreover, teachers should make critical decisions involving scaffolding, that is, when to add, or withdraw a scaffold. Withdrawing too quickly or even 'over-scaffolding' can have detrimental effects to meaningful learning in a social constructivist learning environment. The present study highlighted that these critical decisions are pivotal to the successful implementation of the scales *Working with Ideas* (conceptually developing knowledge), *Uncertainty in Science* (when using appropriate questioning strategies), *Collaboration* (keeping students engaged and focused during groupwork), and *Personal Relevance* (knowing the students' interests to link personal knowledge and formal knowledge). Therefore, teachers should develop skills related to scaffolding. They should further avoid withdrawing too quickly or over-scaffolding, as these actions might be detrimental to meaningful teaching and therefore students' achievement scores.

Second, teachers need to be sensitized during training that they might have to consider that students' SES background is influential to the way they teach. The results suggest that students in high SES category schools enjoy independent learning, and that independence in their learning have a positive influence on the student outcome, achievement, but a negative effect on their attitudes to science. Furthermore, students in low SES category schools were shown to be more dependent on the teachers' knowledge. Therefore, in order to maximise students' outcomes, teachers should find a balance when implementing social constructivist dimensions by carefully considering the impact of individual dimensions on the social constructivist learning environment. For instance, the scale *Critical Voice* showed a negative correlation with the outcome achievement for the low SES category schools. Furthermore, teachers in medium SES category schools need to be careful when implementing the scale *Collaboration*, as it was a negative predictor of students' attitude toward science. In addition, the scale *Working with Ideas* showed a negative correlation with the outcome achievement for the medium SES category schools. Overall, these results suggest that teachers teaching in different SES category schools need to be very careful about the dimensions they use, as it might have a detrimental influence on the student outcomes, such as attitude toward science and achievement.

Third, teachers need to be sensitized during training that they should consider creating gender-fair learning environments in high and medium SES category schools, as these students, particularly females in high SES category schools, consider gender equity important in their social constructivist learning environment. Furthermore, the impact of gender equity for females in high SES category schools has an influence on their attitude toward science. Therefore, teachers should consider addressing lessons that would cater for girls, without violating the basic processes of a social constructivist learning environments in order to help to improve their attitudes toward science.

Teachers also need support from policymakers when implementing social constructivist learning environments. The guidelines for teaching from policy documents need to be clear and explicit. If not, then the influence of curriculum policy documents, workshops, publicity, including rhetoric, might send mixes messages to teachers. This was typically evident when the two scales of *Investigation* and *Metacognition* came together during the factor analysis. Indeed, this result implies that students might be unable to differentiate between the processes related to *Investigation* and *Metacognition* in their classroom environments—processes which are pivotal in the development of a concept. Furthermore, the consequence of teachers' over-emphasis on groupwork for the scale *Collaboration* meant that teachers were unable to use this dimension to teach a concept for meaningful learning (see Chapter 2, page 14). The scale *Personal Relevance* was also used in a way that led to less meaningful learning, in most cases leading to conceptual confusion, a result exacerbated in low SES schools. In addition, because of mixed messages from policy documents, teachers might have down-played dimensions that could to a large degree be taught in a teacher-centred way (i.e., *Working with Ideas* and *Uncertainty in Science*). Yet, in a subject like Natural Science, where foundational knowledge is essential for the further development of more complex concepts, it is necessary, at times, that teachers use approaches in ways that help students develop ideas through scaffolding. Noddings (1990, p. 14) suggested the following, which is of particular relevance to this topic:

> As a cognitive position, constructivism asserts that all mental activity is constructive. Even when students are in what look to be rote learning situations, they must perforce construct, because that is the way the mind operates. So it seems to me that constructivists should talk about weak and strong acts of construction rather than acts involving or not involving construction.

Therefore, if policy document guidelines have explicit instructions on how to implement teaching approaches to promote a social constructivist learning environment, then teachers should be able to develop a deeper understanding of the curriculum and pedagogy. Thus, it might put them in a position to evaluate and use the ideas of the new curriculum in effective ways.

Teachers with weak conceptual frames might need even more explicit guidelines. These teachers can benefit from many examples for possibilities on developing conceptual knowledge for students, as well as scaffolding students' ideas. Firstly, these might include individual units of activities developed in the subject Natural Science to guide their interpretation of curriculum documents. Secondly, teachers need to be guided as to how to manage their time to sequence and pace their lessons for meaningful teaching and learning. Constructing deeper meaning of scientific concepts takes time—time which is not available within the current school year. One way to alleviate this problem would be to reduce content coverage and add a laboratory component to complement the theoretical understanding of concepts, so that teachers can be available to students when developing a concept further. As the research evidence suggests, students felt less self-assured when teachers were absent during independent work, by using laboratory work, students might gain the confidence to eventually work independently, whilst it might also give teachers the time to scaffold without withdrawing the scaffold too early. Creating such a balance might provide additional time for the teachers to establish constructivist learning environments, and to slow down the pace of lessons which could provide students with the time necessary to construct deeper meaning of concepts. If it is not feasible to increase the amount of class time, then policy-makers should consider re-examining the amount of content included in the current Natural Science syllabus. In addition, to save on classroom time, as most students needed to move their desks during group-work, teachers wanting to incorporate social constructivist approaches should use rooms with tables to facilitate groupwork and negotiation. Thus, teacher support through the proper use of classroom time might aid in the creation of meaningful social constructivist learning environments.

Finally, another way to guide students could be through assessing students' current knowledge. Teachers should assess students in order to determine the students' current foundational skills. Once assessed, then teachers can decide on the best approaches to help the students to achieve a competence. As was found in the achievement test, it was evident that the results related to whether students can draw, extrapolate from and interpret a graph, which was influenced by the SES category of the school. It was evident that students in high SES category schools performed better on all three skills relative to the students in the low SES schools students. This implies that teachers in the different SES category schools might need to assess students' needs before teaching a section. If this is practiced, then students might benefit through maximization of student outcomes.

Significance of the Study

This study is timely as it acts as a yardstick as to how educational reform in South Africa is faring since the inception of the new social constructivist approach in Natural Science. By monitoring the transformation of Natural Science classrooms to social constructivist learning environments, it can give insights into the extent to which transformation is progressing and, furthermore, how a social constructivist learning environment can influence student outcomes.

In this study, a newly-developed instrument provides an important new tool for teachers, teacher educators and researchers in the Western Cape Province and elsewhere in South Africa to monitor their social constructivist learning environment. The perceptions of students' actual and preferred social constructivist learning environment, through a newly developed questionnaire—the *Social Constructivist Learning Environment Survey* (SCLES)—are expected to critically evaluate teachers' success in transforming their classroom learning environment toward the social constructivist teaching goals as envisaged by the rNCS (DoE, 2002). Therefore, the study contributed to the field of LER by adding a new instrument that specifically assesses the classroom environment within the social constructivist education teaching and learning setting. No other research study has previously reported on assessment of student actual and preferred perceptions of their social constructivist learning environment and how these perceptions are associated with student cognitive and affective outcomes. In addition, teachers might use the SCLES to monitor their own learning environment towards a more focused social constructivist approach.

This study is important as it is the first study in South Africa assessing the social constructivist learning environment in junior secondary (Grade 9) schools in Natural Science classrooms. Whilst previous South African studies have used LER as a conceptual frame (e.g., Sebela *et al*., 2003; Aldridge *et al*., 2006), these studies have been conducted in poor and rural provinces. The present study is conducted in the Western Cape Province, the second wealthiest province in South Africa (Phurutse, 2005: 10) and thus provides a necessary complimentary perspective in science education in South Africa. This study also provides an additional focus in that it gives important insights into factors like SES, described in terms of the students' family background, which are related to resources, and how SES influence and shape the creation of a social constructivist learning environment through the choice of teaching approaches by teachers.

Finally, despite the 30-odd years that the field has been in existence (Fisher & Fraser, 2003), the field of LER is has emerged only recently in South Africa. Therefore, the present study is significant in a broader sense as it has contributed to the LER field by providing a better understanding of learning environments in South Africa.

Recommendations for Further Research

The present study has provided additional research directions in the assessment of learning environments, and the findings can be considered possible avenues for further research. These findings will be discussed, firstly, with regard to the SCLES questionnaire, and, secondly, general studies that could stem from the current study. These will be discussed in turn.

With regard to the SCLES questionnaire, firstly, as achievement has become very important in assessing South Africa's current educational climate, the achievement test used in this study could be expanded to test a wider set of skills beyond only the drawing of line graphs. Secondly, as teachers play a pivotal role in the social constructivist learning environments, an equivalent teacher's questionnaire could be constructed to assess teachers' perceptions of their classroom learning environments. This could be done in order to assess both teacher' and students' perceptions simultaneously to give richer insights into the classroom learning environment. Thirdly, there is a need to investigate reasons to explain the unexpected negative correlations. Attention should be focused on the scales *Critical Voice* (which showed a negative correlation with the outcome achievement for the low SES category schools), *Collaboratio*n (which showed a negative correlation the outcome students' attitude toward science in medium SES category), and *Working with Ideas* (which showed a negative correlation with the outcome achievement for the medium SES category schools). Fourthly, there is a need to investigate the reasons why teachers in different SES category schools struggle with scaffolding. Specific attention should be paid to the scales *Working with Ideas* (conceptually developing knowledge), *Uncertainty in Science* (when using appropriate questioning strategies), *Collaboration* (keeping students engaged and focused during groupwork), and *Personal Relevance* (knowing the students' interests to link personal knowledge and formal knowledge). Finally, there is a need to investigate why teachers are unable to differentiate between the processes related to *Investigation* and *Metacognition* in their classroom environments, processes which are pivotal in the development of a concept.

With regard to general studies originating from this research, there is a need to investigate how teachers can improve their strategies to implement the scales *Collaboration* and *Personal Relevance* to bring about meaningful learning. The present study involved many classrooms from urban environments and no classrooms from rural learning environments, thus the focus on rural schools might give insights on how Grade 9 teachers in these schools transform their classrooms toward social constructivist learning environments. Finally, the study could be extrapolated to other provinces, especially poorer provinces like the Limpopo province. These studies could provide a contrast between rich and poor provinces, and in addition, how teachers can transform their classrooms towards social constructivist learning environments.

Concluding Summary

The primary objective of this study was to investigate the transformation of classrooms toward social constructivist learning environments in Grade 9 Natural Science classrooms in the Western Cape Province. The study developed and validated a new instrument,—the *Social Constructivist Learning Environments Survey* (SCLES)—used for assessing students' actual and preferred perceptions of their social constructivist science classroom environment. Using the SCLES with a sample of 1955 students and using classroom observations as well as teacher and student interviews, the study found that education in South Africa is transforming. Different approaches were emphasized in different school contexts. This result is resonant with Jansen (1999) who argues that teachers take-up new ideas differently in relation to their contexts, positions and knowledge. However, the study found that successful implementation of social constructivism depends on important factors such as the teachers' ability to teach conceptually and the availability of resources.

The second objective was to describe the social constructivist learning environment in the Western Cape Province. The study replicated findings of past LER studies by revealing that students preferred more positive social constructivist-based classroom learning environments than they were actually experiencing. Furthermore, different levels of congruence between students' actual and preferred learning environment perceptions were found and reasons for these discrepancies were established through qualitative inquiries that took the form of classroom observations and teacher and student interviews.

The third objective was to determine whether SES influences the social constructivist learning environment in the Western Cape Province. The study has shown that SES plays a very influential role in the social constructivist learning environment by the way teachers used teaching approaches, and that ultimately there is no 'one size fits all' approach to teaching.

The fourth objective was to investigate whether the social constructivist learning environment promotes key student outcomes. As in other studies in the LER field (e.g., Fraser, 1998), this study has successfully demonstrated that a valid and reliable instrument can be used to assess the classroom learning environment. The quality of social constructivist-based classroom experiences has been shown to be influential as far as students' cognitive and affective outcomes are concerned. The findings of this study have shown—as have other studies—that student perceptions can be used to predict their learning outcomes. Importantly, student perceptions are influenced by SES, which in turn, influence the key student outcomes, attitude toward science, achievement and gender equity.

APPENDICES

Appendix 1

Letter of Permission from the Western Cape Education Department

Navrae
Enquiries Dr RS Cornelissen
IMibuzo

Telefoon
Telephone (021) 467-2286
IFoni

Faks
Fax (021) 425-7445
IFeksi

Verwysing
Reference 20061012-0040
ISalathiso

Wes-Kaap Onderwysdepartement

Western Cape Education Department

ISebe leMfundo leNtshona Koloni

Dear Mrs M. Luckay

RESEARCH PROPOSAL: IMPLEMENTING THE RNCS: MONITORING THE CONSTRUCTIVIST LEARNING ENVIRONMENT OF GRADE 9 SCIENCE CLASSROOMS IN WESTERN CAPE SCHOOLS.

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **9th March 2007 to 21st September 2007**.
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December 2007).
7. Should you wish to extend the period of your survey, please contact Dr R. Cornelissen at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the Principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as submitted to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Education Research.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:
    The Director: Education Research
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.

Signed: Ronald S. Cornelissen
for: **HEAD: EDUCATION**
DATE: 9th March 2007

MELD ASSEBLIEF VERWYSINGSNOMMERS IN ALLE KORRESPONDENSIE / PLEASE QUOTE REFERENCE NUMBERS IN ALL CORRESPONDENCE / NCEDA UBHALE IINOMBOLO ZESALATHISO KUYO YONKE IMBALELWANO

GRAND CENTRAL TOWERS, LAER-PARLEMENTSTRAAT, PRIVAATSAK X9114, KAAPSTAD 8000
GRAND CENTRAL TOWERS, LOWER PARLIAMENT STREET, PRIVATE BAG X9114, CAPE TOWN 8000

WEB: http://wced.wcape.gov.za

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VEILIGE SKOLE/SAFE SCHOOLS ☎ 0800 45 46 47

Appendix 2

Letter to the School Requesting Permission to Conduct Research

UNIVERSITY OF CAPE TOWN

School of Education
Rondebosch 7701
Fax: (+27 21)
Email:

THE PRINCIPAL / HOD NATURAL SCIENCE

Dear Sir/Madam

Research Project: *Researching the National Curriculum Statement (NCS)*: *Constructivist learning environments of Grade 9 Science classrooms*

I am currently conducting a research project on the above topic. Using learners' perceptions, the project aims to describe, analyse and compare how learner-centred learning environments are being created in Natural Science in Grade 9 in a variety of school settings. The project thus contributes toward urgently-needed empirical evidence that may be used to inform the teaching of the Natural Science NCS. **This project is supported by the Western Cape Education Department (see attached letter).**

Your school has been randomly selected as one of 50 schools in the Western Cape to participate in this project, which begins in the second term (i.e., from 16 April 2007). Only one Grade 9 Natural Science classroom can be selected per school. The research project involves conducting a survey of the learners, which will be in the form of a pencil-and-paper questionnaire. A "once-off" time period of approximately 45 minutes will be required for learners to complete the questionnaire, which is available in three languages, namely, English, Afrikaans and isiXhosa. Participation in the study is voluntary, and individual participants and schools are assured anonymity and confidentiality. In exchange for your participation, I will gladly provide feedback in the form of a short report on learner responses to all teachers who participate in the study.

I would appreciate confirmation of your participation in the study by completing the reply slip overleaf. Assuming that you are acceding my request, could you please provide the name and contact details of the Natural Science head of department so that I can make further arrangements with him/her. Kindly fax the completed reply slip to me or alternatively confirm your participation telephonically or via E-mail.

Should you have any queries regarding the project or my request, please contact me. My contact details are:

Fax (021) 708-0145 / Cell no. 083-362-8379 / via E-mail at "Melanie.Luckay@uct.ac.za".

Thank you. I look forward to your positive response.

Yours sincerely,

<u>Melanie Luckay</u> (Researcher)

<u>A/Prof. RC Laugksch</u> (Supervisor)

Encl.

Please reply....

ATT: MELANIE LUCKAY

(Researcher – School of Education, UCT)

Cell no: 083-560-8309 **E-mail: rmmluckay@discoverymail.co.za** **Fax: (021) 7050045**

Name of school:

I confirm my school's participation in the *(please tick)* YES NO

Gr. 9 Natural Science Learning Environments Project

HOD (Natural Science) NAME:

HOD (Natural Science) CONTACT DETAILS:

Tel: **Cell:**

Email:

Appendix 3

Social Constructivist Learning Environment Survey

Social Constructivist Learning Environment Survey

BACKGROUND QUESTIONS / *AGTERGRONDVRAE* / IINKCUKACHA ZAKHO

Name of your school *U skool se naam* Igama lesikolo sakho						
Your name and surname *U naam en van* Igama lakho						
Your teacher's name *U onderwyser se naam* Igama likatitshala/titshalakazi wakho						
What grade are you in? *In watter graad is u?* Ukwibanga						
Your age (*Please circle your answer*) U ouderdom? (Omkring u antwoord) Iminyaka yakho. (Biyela impedulo yakho)	13	14	15	16	17	
Are you a girl or a boy? (*Please circle your answer*) Is u 'n seun of 'n dogter? (Omkring u antwoord) Uyinkwenkwe okanye uyintombi? (Biyela impedulo yakho)	Girl Dogter ***Ndiyintombazana***				Boy Seun ***Ndiyinkwenkwe***	

SOCIAL CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY (SCLES)

INSTRUCTIONS / ***INSTRUKSIES*** / IMIGAQO

1. This questionnaire contains statements about practices that could take place in this **NATURAL SCIENCE** class. You will be asked how often each practice takes place.

*Hierdie vraelys bevat stellings omtrent gebruike/oefeninge wat in die **NATUURWETENSKAPKLAS** kan plaasvind. U sal gevra word hoe gereeld elke gebruik /oefening plaasvind.*

Eli phepha–mibuzo lineentetho malunga neenkqubo zokwenza izinto kweli gumbi ezeNZULULWAZI. Uzakubuzwa ke ukuba ezi nkqubo zixhaphake kangakanani na.

2. This is not a test and there are no ‘right’ or ‘wrong’ answers. Your <u>opinion</u> is what is wanted.

Hierdie is nie n toets nie en daar is nie “regte” of “verkeerde” antwoorde nie. U opinie is waarin ons belangstel.

Asilo vavanyo olu kwaye akukho zimpendulo ‘zilungileyo’ ‘nezingalunganga’. <u>Uluvo</u> lwakho yiyo into efunwayo.

3. The *‘Actual’* column is to be used to describe how often each practice actually takes place in your class.

Die “Werklikheid”-kolom moet gebruik word om te verduidelik hoe gereeld elke gebruik/oefening werklik in die klas plaasvind.

Umqolo wenkqubo ‘Eyenzekayo’ uyakusetyenziswa ukuchaza ukuxhapaka kwenkqubo nganye egumbini lakho lokufundela.

4. The *‘Preferred’* column is to be used to describe how often you would like each practice to take place (a wish list).

Die “Verkiesde”-kolom moet gebruik word om te verduidelik hoe gereeld u sou wou hê elke gebruik/oefening moet plaasvind (wenslys).

Umqolo wenkqubo ‘Enqwenelekayo’ uyakusetyenziswa ukuchaza ukuba ungathanda ixhaphake kangakanani na inkqubo leyo (uluhlu lweminqweno).

5. Each number indicates how often you think the event in the item occurs:

Elke nommer dui aan hoe gereeld u dink die gebeurtenis plaasvind:

Inombolo nganye ibonisa ukuba ucinga ukuba sixhaphake kangakanani na isenzeko eso sibhaliweyo:

1. Never	2. Seldom	3. Sometimes	4. Often	5. Always
1. Nooit	*2. Selde*	*3. Soms*	*4. Gereeld*	*5. Altyd*
1. Zange	2. Inqabile	3. Ngamaxesha	4. Soloko	5. Rhoqo

6. Please circle the number that corresponds to your responses.

Omkring die nommer wat met u reaksie ooreenstem.

Nceda ubiyele inombolo ehambelana neempendula zakho ngesangqa.

Example / *Voorbeeld* / Umzekelo***:***

	Actual *Werklikheid* Eyenzekayo	Preferred *Verkiesde* Enqwenelekayo
Science is interesting *Wetenskap is interessant* EzeNzukulwazi yenza umdla	1 2 3 4 5	1 2 3 4 5

7. If you change your mind about a number, simply <u>cross it out</u> and circle a new number.

Indien u van plan verander omtrent 'n nommer moet u eenvoudig 'n kruis daardeur trek en 'n nuwe nommer omkring.

Ukuba ufuna ukuyitshintsha impendulo yakho, beka u nongxabalaza kuyo uze ubeke isangqa kwinombolo entsha.

Example / *Voorbeeld* / *Umzekelo:*	Actual *Werklikheid* Eyenzekayo	Preferred *Verkiesde* Enqwenelekayo
Science is fun. *Wetenskap is prêt.* EzeNzukulwazi ziyonwabisa	1 2 3 4 5	1 2 3 4 5

8. All the information you give here will be treated as confidential and will not be disclosed without your permission to anyone other than the research team.

Al die inligting wat u hier bekend maak sal as vertroulik behandel word en sal nie sonder u toestemming aan enigiemand, behalwe die navorsingsspan, bekend gemaak word.

Zonke iikukacha ozinika apha ziyakuphathwa ngemfihlelo kwaye azinakutyhilwa ngaphandle kwemvume yakho nakubani na ngaphandle kwengqina yophando.

9. Complete all sections of the questionnaire.

Voltooi alle afdelings van die vraelys.

Phendula imibuzo kuwo onke amacandelo.

Now please respond to the statements on the next page.
Reageer nou op die stellings op die volgende bladsy.
Ngoku ke nceda uphendule kweli phepha lilandelayo.

	Attitude to Science/ **Houding teenoor wetenskap/** **Imvakalelo kwezeNzululwazi**	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometime s *Soms* ***Ngama-***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometime s *Soms* ***Ngama-***	Often *Gereel d* **Solok**	Always *Altyd* ***Rhoqo***
1.	I look forward to lessons in Natural Science. *Ek sien uit na wetenskaplesse* Ndisoloko ndinxanelwe izifundo zezeNzululwazi.	1	2	3	4	5	1	2	3	4	5
2.	Lessons in Natural Science are fun. *Natuurwetenskaplesse is prêt.* Izifundo zezeNzululwazi ziyonwabisa.	1	2	3	4	5	1	2	3	4	5
3.	I dislike lessons in Natural Science. *Ek hou nie van Natuurwetenskaplesse nie.* Andizithandi izifundo zezeNzululwazi.	1	2	3	4	5	1	2	3	4	5
4.	Lessons in Natural Science bore me. *Natuurwetenskap verveel my.* Izifundo zezeNzululwazi ziyandidika.	1	2	3	4	5	1	2	3	4	5
5.	Natural Science is one of the most interesting school subjects. *Natuurwetenskap is een van die mees interessante vakke op skool.* INzululwazi yenye yezona zifundo zesikolo ezenza umdla.	1	2	3	4	5	1	2	3	4	5
6.	I enjoy lessons in Natural Science. *Ek geniet Natuurwetenskaplesse.* Ndiyazonwabela izifundo zezeNzululwazi.	1	2	3	4	5	1	2	3	4	5
7.	Lessons in Natural Science are a waste of time. *Natuurwetenskaplesse is 'n vermorsting van tyd.* Izifundo zezeiNzululwazi yinkcitha xesha.	1	2	3	4	5	1	2	3	4	5
8.	Lessons in Natural Science make me interested in science. *Natuurwetenskaplesse maak my geïntreseerd in wetenskap.* Izifundo zezeNzululwazizindenza ndibenomdla zezeNzululwazi.	1	2	3	4	5	1	2	3	4	5

Continued from page 4		ACTUAL (How it is) *WERKLIKHEID (Hoe dit is)* ***EYENZEKAYO (Indlela eyiyo)***					PREFERRED (How I want it.) *VERKIESDE (Hoe ek dit wil hê)* ***ENQWENELEKAYO (Indlela endinqwenela ibeyiyo)***				
Investigations/ *Ondersoeke*/ Uphando In my Natural Science class… ***In my Natuurwetenskapklas*** Kwigumbi lam leNzululwazi		Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* **Ngama-xesha**	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometims *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
9.	I carry out investigations to test my ideas. *Doen ek ondersoeke om my idees te toets.* Ndenza uphando ukuvavanya iingcinga zam**.**	1	2	3	4	5	1	2	3	4	5
10.	I am asked to think about the supporting facts for statements. *Word ek gevra om te dink oor die feite wat stellings ondersteun.* Ndifunwa ukuba ndicinge ngokuxhasa ngolwazi iintetho zam.	1	2	3	4	5	1	2	3	4	5
11.	I carry out investigations to answer questions coming from discussions. *Doen ek ondersoeke om vrae te beantwoord wat spruit uit besprekings.* *Ndenza uphando ukuphendula imibuzo ephuma kwiingxoxo.*	1	2	3	4	5	1	2	3	4	5
12.	I explain the meaning of statements, diagrams and graphs. *Verduidelik ek die betekenis van stellings, diagramme en grafieke.* Ndiyazicacisa iintetho kunye nezinto ezithethwa yimifanekiso neegrafu.	1	2	3	4	5	1	2	3	4	5
13.	I carry out investigations to answer the teacher's questions. *Doen ek ondersoeke om die onderwyser se vrae te beantwoord.* Ndenza uphando ukuphendula imibuzo katitshala/titshalakazi.	1	2	3	4	5	1	2	3	4	5
14.	I find out answers to questions by doing investigations. *Vind ek antwoorde op vrae deur ondersoeke te doen.* Iimpendulo zemibuzo ndizifumana ngokwenza uphando.	1	2	3	4	5	1	2	3	4	5

	Continued from page 5	ACTUAL (How it is) *WERKLIKHEID (Hoe dit is)* ***EYENZEKAYO (Indlela eyiyo)***					PREFERRED (How I want it.) *VERKIESDE (Hoe ek dit wil hê)* ***ENQWENELEKAYO(Indlela endingwenela ibeyiyo)***				
	Respect for difference / *Respek vir andersheid* / Intlonipho yeyantlukwano In my Natural Science class…. ***In my Natuurwetenskapklas****…* Kwigumbi lam leNzululwazi…	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama -xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama -xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
15.	The teacher sets rules that we must follow when we talk about our opinions about science. *Stel die onderwysers reels vas wat ons moet nakom wanneer ons praat oor ons opinies oor wetenskap.* Utitshala/titshalakazi ubeka imiqathango emasiyilandele xa sithetha ngezimvo zethu.	1	2	3	4	5	1	2	3	4	5
16.	I am aware that my classmates have different opinions about science. *Is ek bewus dat my klasmaats ander opinies het oor wetenskap.* Ndiyayazi ukuba abafundi abakwigumbi lam lokufunda banezimvo ezahlukeneyo ngeNzululwazi.	1	2	3	4	5	1	2	3	4	5
17.	I listen to my classmates' opinions about science. *Luister ek na my klasmaat se opinie oor wetenskap.* Ndiyazimamela izimvo zabafundi abakwigumbi lam lokufunda ngeNzululwazi.	1	2	3	4	5	1	2	3	4	5
18.	Before I agree or disagree with my classmates' opinions about science, I first think about what they said. *Dink ek eers na oor wat my klasmaats gesê het voor ek saamstem of van hulle verskil.* Phambi kokuba ndivume okanye ndingavumelani nezimvo zabafundi abakwigumbi lam lokufunda, ndiqala ndicinge ngabakuthethileyo.	1	2	3	4	5	1	2	3	4	5
19.	I try to understand my classmate's opinions about science. *Probeer ek my klasmaats se opinie oor wetenskap verstaan.* Ndiyazama ukuziqonda izimvo zabafundi abakwigumbi lam lokufunda ngeNzululwazi	1	2	3	4	5	1	2	3	4	5
20.	I respect my classmates' opinions about science. *Respekteer ek my klasmaat se opinie oor wetenskap.* Ndiyazihlonipha izimvo zabafundi abakwigumbi lam lokufunda ngeNzululwazi.	1	2	3	4	5	1	2	3	4	5

	Continued from page 6	ACTUAL (How it is) *WERKLIKHEID (Hoe dit is)* ***EYENZEKAYO (Indlela eyiyo)***					PREFERRED (How I want it.) *VERKIESDE (Hoe ek dit wil hê)* ***ENQWENELEKAYO (Indlela endingwenela ibeyiyo)***				
	Metacognition/ *Meta-kognisie/* Ukucinga ngeengcinga In my Natural Science class…. *In my Natuurwetenskapklas…* Kwigumbi lam leNzululwazi…	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama -xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
21.	I think about my ideas in science. *Dink ek na oor my idees in wetenskap.* Ndiyacinga ngeengcinga zam kwiNzululwazi.	1	2	3	4	5	1	2	3	4	5
22.	I write down my ideas in science. *Skryf ek my idees in wetenskap neer.* Ndizibhala phantsi iingcinga zam kwiNzululwazi.	1	2	3	4	5	1	2	3	4	5
23.	I check my ideas in science with my teacher. *Gaan ek my idees in wetenskap met my onderwyser na.* Iingcinga zam kwiNzululwazi ndizikhangela kutitshala/titshalakazi wam.	1	2	3	4	5	1	2	3	4	5
24.	I check my ideas in science with my classmates. *Gaan ek my idees in wetenskap met my klasmaats na.* Iingcinga zam kwiNzululwazi ndizikhangela kubafundi abakwigumbi lam lokufunda.	1	2	3	4	5	1	2	3	4	5
25.	I check my ideas in science by reading. *Gaan ek my idees in wetenskap na deur te lees.* Iingcinga zam kwiNzululwazi ndiziqinisekisa ngokufunda.	1	2	3	4	5	1	2	3	4	5
26.	I welcome my classmate's thoughts about my ideas in science. *Verwelkom ek my klasmaats se gedagtes oor my idees in wetenskap.* Ndiyazamkela iingcinga zabafundi abakw igumbi lam lokufunda kwiNzululwazi.	1	2	3	4	5	1	2	3	4	5

	Continued from page 7	ACTUAL (How it is) WERKLIKHEID (Hoe dit is) **EYENZEKAYO (Indlela eyiyo)**					PREFERRED (How I want it.) VERKIESDE (Hoe ek dit wil hê) **ENQWENELEKAYO (Indlela endingwenela ibeyiyo)**				
	Metacognition/ *Meta-kognisie/* Ukucinga ngeengcinga In my Natural Science class…. *In my Natuurwetenskapklas…* Kwigumbi lam leNzululwazi…	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama -xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama- xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
27.	I defend my ideas in science when I discuss them with others. *Verdedig ek my idees in wetenskap wanneer ek dit met ander bespreek.* Ndiyazikhusela iingcinga zam xa ndixoxa nabanye.	1	2	3	4	5	1	2	3	4	5
28.	When I discuss my ideas about science to my classmates, I explain my reasoning. *Veduidelik ek my redenasie wanneer ek my idees omtrent wetenskap met my klasmaats bespreek.* Ndiyayicacisa indlela endicinga ngayo xa ndixoxa ngeengcinga zam kubafundi abakwigumbi lam lokufunda.	1	2	3	4	5	1	2	3	4	5
29.	When I need to, I change my ideas about science. *Verander ek my gedagtes omtrent wetenskap wanneer ek moet.* Xa ndifuna ndiyazitshintsha iingcinga zam ngeNzululwazi.	1	2	3	4	5	1	2	3	4	5

	Continued from page 8	ACTUAL (How it <u>is</u>) WERKLIKHEID (Hoe dit is) **EYENZEKAYO (Indlela eyiyo)**					PREFERRED (How I <u>want</u> it.) VERKIESDE (Hoe ek dit wil hê) **ENQWENELEKAYO(Indlela endingwenela ibeyiyo)**				
	Personal Relevance/ ***Persoonlike voorkeur /*** Malunga nam In my Natural Science class…. *In my Natuurwetenskapklas* Kwigumbi lam leNzululwazi…	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
30.	I learn about the world outside of school. *Leer ek omtrent die wêreld buite die skool.* Ndifunda ngelizwe elingaphandle kwesikolo.	1	2	3	4	5	1	2	3	4	5
31.	My new learning starts with problems about the world outside of school. *Begin my nuwe leer(proses) met probleme buite die wêreld van die skool.* Ufundo lwam olutsha luqala ngeengxaki ezingelizwe elingaphandle kwesikolo.	1	2	3	4	5	1	2	3	4	5
32.	I get better understanding of the world outside of school. *Verkry ek 'n beter begrip van die wêreld buite die skool.* Ndiliqonda ngcono ilizwe elingaphandle kwesikolo.	1	2	3	4	5	1	2	3	4	5
33.	I learn interesting things about the world outside of school. *Leer ek baie interessante dinge omtrent die wêreld buite die skool.* Ndifunda izinto ezenza umdla ngelizwe elingaphandle kwesikolo.	1	2	3	4	5	1	2	3	4	5
34.	What I learn has nothing to do with my out-of-school life. *Het wat ek leer niks te doen met my lewe buite die skool nie.* Into endiyifundayo ayinanto yakwenza nobom bam obungaphandle kwesikolo.	1	2	3	4	5	1	2	3	4	5
35.	What I learn I can use in my out-of-school life. *Kan ek dit wat ek leer in my lewe buite die skool gebruik.* Into endiyifundayo ndinakho ukuyisebenzisa kubom bam obungaphandle kwesikolo.	1	2	3	4	5	1	2	3	4	5

		ACTUAL (How it is) WEKLIKHEID (Hoe dit is) **EYENZEKAYO (Indlela eyiyo)**					PREFERRED (How I want it) VERKIESDE (Hoe ek dit wil hê) **ENQWENELEKAYO (Indlela endinqwenela ibeyiyo)**				
	Continued from page 9										
	Collaboration / *Samewerking* / Intsebenziswano In my Natural Science class…. *In my Natuurwetenskapklas…* Kwigumbi lam leNzululwazi…	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
36.	I like working in groups. *Hou ek daarvan om in groepe te werk.* Ndiyathanda ukusebenza ngokwamaqela.	1	2	3	4	5	1	2	3	4	5
37.	I feel that it is important for the class to work together as a team. *Voel ek dat dit belangrik is vir die klas om as 'n span saam te werk.* Ndiyazivela nje ukuba kubalulekile ukuba iklasi isebenze kunye njengeqela.	1	2	3	4	5	1	2	3	4	5
38.	I would rather decide what to do as a group than to make a decision myself. *Sal ek eerder as 'n groep 'n besluit wat om te doen as om 'n besluit op my eie te doen.* Ndingakhetha ukuba sithathe izigqibo njengeqela kunokuba ndisithathe ngkwam.	1	2	3	4	5	1	2	3	4	5
39.	It is important for me to be involved in class discussions. *Is dit vir my belangrik om deel te neem aan klasbesprekings.* Kubalulekile kum ukuba ndibekho kwiingxoxo zeklasi.	1	2	3	4	5	1	2	3	4	5
40.	I like to work with other students. *Hou ek daarvan om met ander leerders te werk.* Ndiyathanda ukusebenza nabanye abafundi.	1	2	3	4	5	1	2	3	4	5

		ACTUAL (How it is) WERKLIKHEID (Hoe dit is)					PREFERRED (How I want it.) VERKIESDE (Hoe ek dit wil hê)				
	Critical voice / *Kritiese stem* / Ilizwi elingundoqo In my Natural Science class…. *In my Natuurwetenskapklas…* Kwigumbi lam leNzululwazi…	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
41.	It's OK for me to ask the teacher "Why do I have to learn this?" *Is dit in die haak dat ek die onderwyser vra "Hoekom moet ek dit leer?"* Kulungile **kum ukuba ndimbuze utitshala/titshalakazi "Kutheni kufuneka ndiyifundile lento?"**	1	2	3	4	5	1	2	3	4	5
42.	It's OK for me to question the way I am being taught. *Is dit in die haak dat ek die manier waarop ek onderrig word, bevraagteken.* Kulungile kum ukuba ndiyibuze indlela endifundiswa ngayo.	1	2	3	4	5	1	2	3	4	5
43.	It's OK for me to complain about teaching activities that are confusing. *Is dit in die haak dat ek kla oor onderrigaktiwiteite mat verwarrend is.* Kulungile kum ukuba ndikhalaze ngeendlela zokufundisa ezibhidisayo.	1	2	3	4	5	1	2	3	4	5
44.	It is important for me to be involved in class discussions. *Is dit belangrik vir my om betrokke te wees by klasbesprekings.* Kubalulekile kum ukuba ndibekho kwiingxoxo zeklasi.	1	2	3	4	5	1	2	3	4	5
45.	It's OK for me to complain about anything that prevents me from learning. *Is dit in die haak dat ek kla oor enigiets wat my verhoed om te leer.* Kulungile kum ukuba ndikhalaze nangantoni na endithintelayo ekufundeni.	1	2	3	4	5	1	2	3	4	5
46.	It's OK for me to express my opinion. *Is dit in die haak as ek my opinie lig.* Kulungile kum ukuba ndiveze izimvo zam.	1	2	3	4	5	1	2	3	4	5
47.	It's OK for me to speak up for my rights. *Is dit in die haak dat ek opkom vir my regte.* Kulungile kum ukuba ndiwathethele amalungelo am.	1	2	3	4	5	1	2	3	4	5

	Continued from 11	ACTUAL (How it is) WERKLIIKIED (Hoe dit is) **EYENZEKAYO (Indlela eyiyo)**					PREFERRED (How I want it) VERKIESDE (Hoe ek dit wil hê) **ENQWENELEKAYO (Indlela endinqwenela ibeyiyo)**				
	Uncertainty in Science/ *Onsekerheid in Wetenskap* / **Ukungaqiniseki kwiNzululwazi** In my Natural Science class…. *In my Natuurwetenskapklas…* ***Kwigumbi lam leNzululwazi…***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* Soloko	Always *Altyd* ***Rhoqo***
48.	I learn that science cannot provide perfect answers to problems. *Leer ek dat wetenskap nie perfekte antwoorde vir probleme kan bied nie.* Ndifunda ukuba iNzululwazi ayinakunika zimpendulo zingenaziphene emibuzweni.	1	2	3	4	5	1	2	3	4	5
49.	I learn that science has changed over time. *Leer ek dat wetenskap oor tyd verander het.* Ndifunda ukuba iNzululwazi iye yatshintsha apha ekuhambeni kwexesha.	1	2	3	4	5	1	2	3	4	5
50.	I learn that science is influenced by people's values and opinions. *Leer ek dat wetenskap deur mense se waardes en opinies beïnvloed word.* Ndifunda ukuba iNzululwazi iphenjelelwe zizimvo needlela zokuphila zabantu.	1	2	3	4	5	1	2	3	4	5
51.	I learn about the different sciences used by people in other cultures. *Leer ek omtrent die ander wetenskappe wat deur mense in ander kulture gebruik word.* Ndifunda ngeeNzululwazi ezahlukileyo ezisetyenziswa ngabantu kwezinye iinkcubeko.	1	2	3	4	5	1	2	3	4	5
52.	I learn that modern science is different from the science of long ago. *Leer ek dat moderne wetenskap anders is as die wetenskap van lank gelede/van die verlede.* Ndifunda ukuba iNzululwazi yalemihla yahlukile kwiNzululwazi yakudala.	1	2	3	4	5	1	2	3	4	5
53.	I learn that science is about creating theories. *Leer ek dat wetenskap gaan oor die skep van teorieë.* Ndifunda ukuba iNzululwazi imalunga nokwenza iithiyori (theories).	1	2	3	4	5	1	2	3	4	5

Read the following passage and answer the questions in the spaces provided below.

Thandi has been making tea at home. She has tried an experiment to see how much time it takes to boil the kettle to make tea. She used different amounts of water to obtain the results shown in the table.

Number of cups of water in the kettle	1	2	3	4	5	6
Time for the kettle to boil in seconds	60	120	180	240	300	X

<u>Questions</u>:

1. Plot a line graph of Thandi's results on the graph grid . (11)

2. Find the value of X in the table above. (2)

3. Describe ***in your own words*** what this line graph shows? (2)

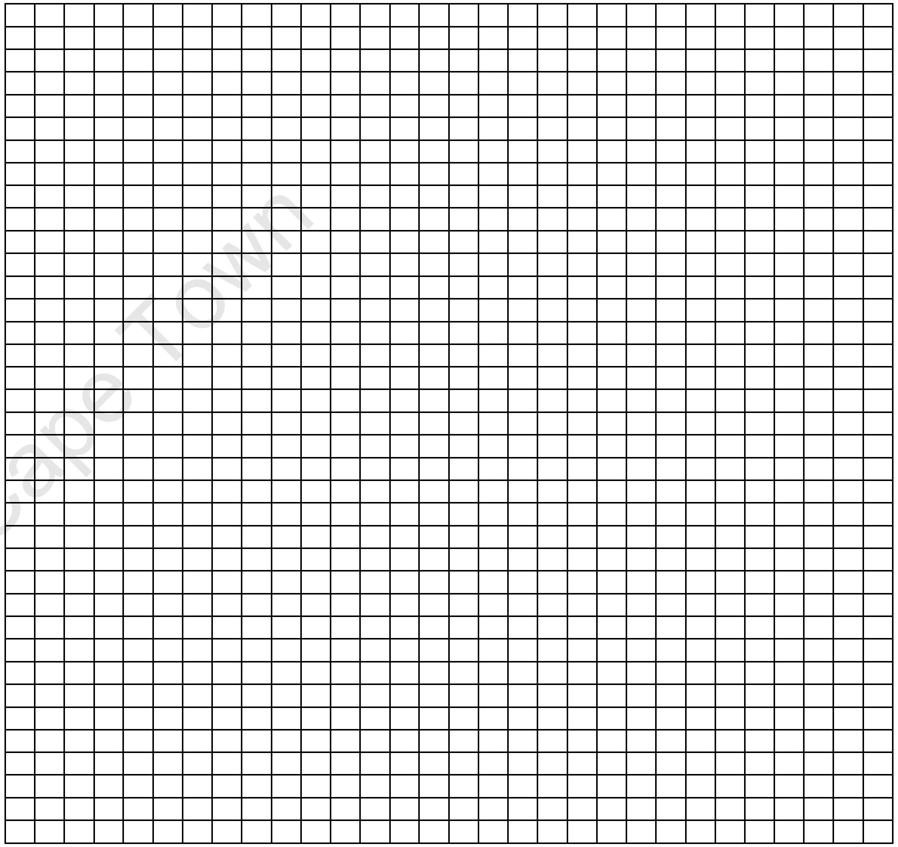
Lees die volgende paragraaf en antwoord die vrae wat daarop volg in die gegewe ruimtes.

Thandi maak tee tuis. Sy probeer ´n experiment om te sien hoe lank dit neem om die water in ´n ketel te laat kook. Sy het verskillende hoeveelhede water gebruik om die volgende resultate in die tabel hieronder te verkry.

Getal koppies water in die ketel.	1	2	3	4	5	6
Tyd wat dit neem om die ketel te laat kook in sekondes	60	120	180	240	300	X

<u>**Vrae**</u>:

1. Teken ´n graphiek deur Thandi se resultate op die grafiekpapier. (11)



2. Bepaal die waarde van X in die tabel hierbo. (2)

3. Beskryf in u eie woorde wat hierdie grafiek bewys ? (2)

Funda esi sicatshulwa silandelayo uze uphendule imibuzo kwizikhewu ozinikiweyo apha ngezantsi.

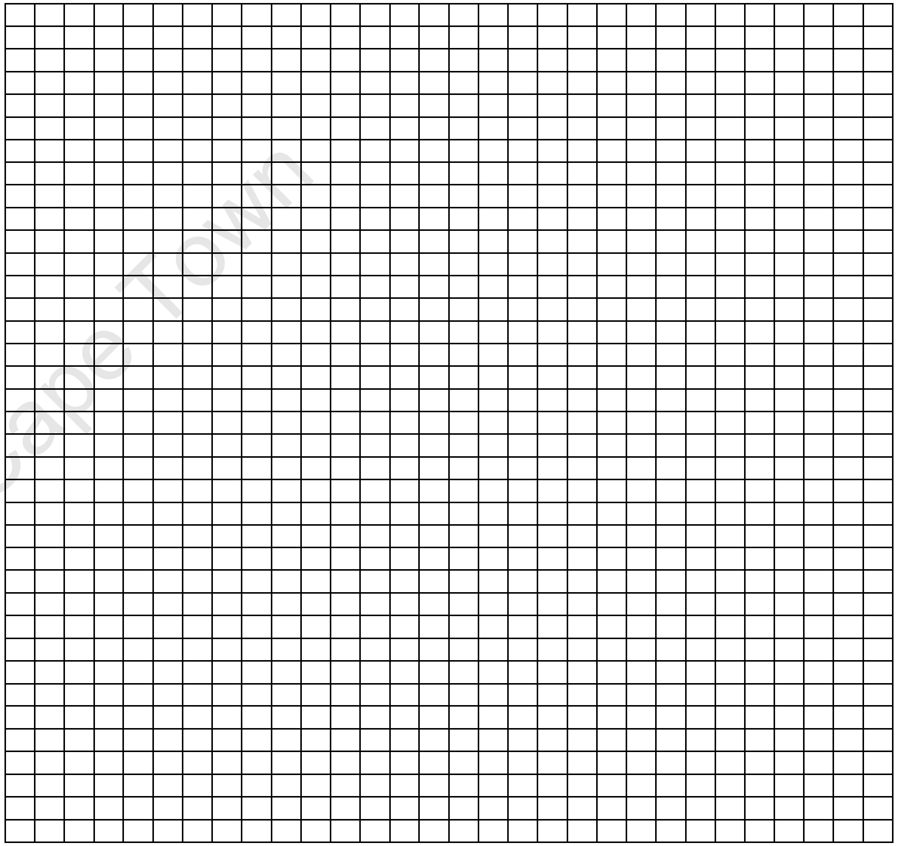
UThandi ebesenza iti ekhaya. Ubekhe wazama i-eksperimenti ukuze abone ukuba kuthabatha ixesha elingakanani na ukubilisa iketile ukwenza iti. Uzebenzise imiyinge yamanzi eyahlukeneyo ukuze afumane ezi ziphumo zibonakaliswe apha ngezantsi.

Inani leekomityi zamanzi aseketileni	1	2	3	4	5	6
Ixesha lokubila kweketile ngokwemizuzwana	60	120	180	240	300	X

<u>**Imibuzo**</u>:

1. Zoba igrafu yomgca yeziphumo zikaThandi kule gridi yegrafu ilapha ngezantsi.

(11)



2. Fumanisa ukuba u-X ungakanani na kule-table ingasentla.

(2)

3. Chaza ***ngawakho amazwi*** ukuba ibonisa ntoni na le grafu yomgca?

Appendix 4

Social Constructivist Learning Environment Survey (Final)

Social Constructivist Learning Environment Survey

BACKGROUND QUESTIONS / *AGTERGRONDVRAE* / IINKCUKACHA ZAKHO

Name of your school *U skool se naam* Igama lesikolo sakho						
Your name and surname *U naam en van* Igama lakho						
Your teacher's name *U onderwyser se naam* Igama likatitshala/titshalakazi wakho						
What grade are you in? *In watter graad is u?* Ukwibanga						
Your age (*Please circle your answer*) U ouderdom? (Omkring u antwoord) Iminyaka yakho. (Biyela impedulo yakho)	13	14	15	16	17	
Are you a girl or a boy? (*Please circle your answer*) Is u 'n seun of 'n dogter? (Omkring u antwoord) Uyinkwenkwe okanye uyintombi? (Biyela impedulo yakho)	Girl Dogter ***Ndiyintombazana***				Boy Seun ***Ndiyinkwenkwe***	

SOCIAL CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY (SCLES)

INSTRUCTIONS / ***INSTRUKSIES*** / IMIGAQO

1. This questionnaire contains statements about practices that could take place in this **NATURAL SCIENCE** class. You will be asked how often each practice takes place.

*Hierdie vraelys bevat stellings omtrent gebruike/oefeninge wat in die **NATUURWETENSKAPKLAS** kan plaasvind. U sal gevra word hoe gereeld elke gebruik /oefening plaasvind.*

Eli phepha–mibuzo lineentetho malunga neenkqubo zokwenza izinto kweli gumbi ezeNZULULWAZI. Uzakubuzwa ke ukuba ezi nkqubo zixhaphake kangakanani na.

2. This is not a test and there are no ‘right’ or ‘wrong’ answers. Your <u>opinion</u> is what is wanted.

Hierdie is nie n toets nie en daar is nie “regte” of “verkeerde” antwoorde nie. U opinie is waarin ons belangstel.

Asilo vavanyo olu kwaye akukho zimpendulo ‘zilungileyo’ ‘nezingalunganga’. <u>Uluvo</u> lwakho yiyo into efunwayo.

3. The *‘Actual’* column is to be used to describe how often each practice actually takes place in your class.

Die “Werklikheid”-kolom moet gebruik word om te verduidelik hoe gereeld elke gebruik/oefening werklik in die klas plaasvind.

Umqolo wenkqubo ‘Eyenzekayo’ uyakusetyenziswa ukuchaza ukuxhapaka kwenkqubo nganye egumbini lakho lokufundela.

4. The *‘Preferred’* column is to be used to describe how often you would like each practice to take place (a wish list).

Die “Verkiesde”-kolom moet gebruik word om te verduidelik hoe gereeld u sou wou hê elke gebruik/oefening moet plaasvind (wenslys).

Umqolo wenkqubo ‘Enqwenelekayo’ uyakusetyenziswa ukuchaza ukuba ungathanda ixhaphake kangakanani na inkqubo leyo (uluhlu lweminqweno).

5. Each number indicates how often you think the event in the item occurs:

Elke nommer dui aan hoe gereeld u dink die gebeurtenis plaasvind:

Inombolo nganye ibonisa ukuba ucinga ukuba sixhaphake kangakanani na isenzeko eso sibhaliweyo:

1. Never	2. Seldom	3. Sometimes	4. Often	5. Always
1. Nooit	*2. Selde*	*3. Soms*	*4. Gereeld*	*5. Altyd*
1. Zange	2. Inqabile	3. Ngamaxesha	4. Soloko	5. Rhoqo

	ACTUAL (How it is) *WERKLIKHEID (Hoe dit is)* ***EYENZEKAYO (Indlela eyiyo)***	PREFERRED (How I want it.) *VERKIESDE (Hoe ek dit wil hê)* ***ENQWENELEKAYO (Indlela endingwenela ibeyiyo)***

10. Please circle the number that corresponds to your responses.

Omkring die nommer wat met u reaksie ooreenstem.

Nceda ubiyele inombolo ehambelana neempendula zakho ngesangqa.

Example / *Voorbeeld* / *Umzekelo:*

	Actual *Werklikheid* Eyenzekayo	Preferred *Verkiesde* Enqwenelekayo
Science is interesting *Wetenskap is interessant* EzeNzukulwazi yenza umdla	1 2 3 4 5	1 2 3 4 5

11. If you change your mind about a number, simply cross it out and circle a new number.

Indien u van plan verander omtrent 'n nommer moet u eenvoudig 'n kruis daardeur trek en 'n nuwe nommer omkring.

Ukuba ufuna ukuyitshintsha impendulo yakho, beka u nongxabalaza kuyo uze ubeke isangqa kwinombolo entsha.

Example / *Voorbeeld* / *Umzekelo:*

	Actual *Werklikheid* Eyenzekayo	Preferred *Verkiesde* Enqwenelekayo
Science is fun. *Wetenskap is prêt.* EzeNzukulwazi ziyonwabisa	1 2 3 4 5	1 2 3 4 5

12. All the information you give here will be treated as confidential and will not be disclosed without your permission to anyone other than the research team.

Al die inligting wat u hier bekend maak sal as vertroulik behandel word en sal nie sonder u toestemming aan enigiemand, behalwe die navorsingsspan, bekend gemaak word.

Zonke iikukacha ozinika apha ziyakuphathwa ngemfihlelo kwaye azinakutyhilwa ngaphandle kwemvume yakho nakubani na ngaphandle kwengqina yophando.

13. Complete all sections of the questionnaire.

Voltooi alle afdelings van die vraelys.

Phendula imibuzo kuwo onke amacandelo.

Now please respond to the statements on the next page.
Reageer nou op die stellings op die volgende bladsy.
Ngoku ke nceda uphendule kweli phepha lilandelayo.

	Attitude to Science/ **Houding teenoor wetenskap/** **Imvakalelo kwezeNzululwazi**	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
1.	I look forward to lessons in Natural Science. *Ek sien uit na wetenskaplesse* Ndisoloko ndinxanelwe izifundo zezeNzululwazi.	1	2	3	4	5	1	2	3	4	5
2.	Lessons in Natural Science are fun. *Natuurwetenskaplesse is prêt.* Izifundo zezeNzululwazi ziyonwabisa.	1	2	3	4	5	1	2	3	4	5
3.	I dislike lessons in Natural Science. *Ek hou nie van Natuurwetenskaplesse nie.* Andizithandi izifundo zezeNzululwazi.	1	2	3	4	5	1	2	3	4	5
4.	Lessons in Natural Science bore me. *Natuurwetenskap verveel my.* Izifundo zezeNzululwazi ziyandidika.	1	2	3	4	5	1	2	3	4	5
5.	Natural Science is one of the most interesting school subjects. *Natuurwetenskap is een van die mees interessante vakke op skool.* INzululwazi yenye yezona zifundo zesikolo ezenza umdla.	1	2	3	4	5	1	2	3	4	5
6.	I enjoy lessons in Natural Science. *Ek geniet Natuurwetenskaplesse.* Ndiyazonwabela izifundo zezeNzululwazi.	1	2	3	4	5	1	2	3	4	5
7.	Lessons in Natural Science are a waste of time. *Natuurwetenskaplesse is 'n vermorsting van tyd.* Izifundo zezeiNzululwazi yinkcitha xesha.	1	2	3	4	5	1	2	3	4	5
8.	Lessons in Natural Science make me interested in science. *Natuurwetenskaplesse maak my geïntreseerd in wetenskap.* Izifundo zezeNzululwazizindenza ndibenomdla zezeNzululwazi.	1	2	3	4	5	1	2	3	4	5

Continued from page 4

		ACTUAL (How it is) WERKLIKHEID (Hoe dit is) EYENZEKAYO (Indlela eyiyo)					PREFERRED (How I want it.) VERKIESDE (Hoe ek dit wil hê) ENQWENELEKAYO (Indlela endingwenela ibeyiyo)				
	Investigations/ *Ondersoeke*/ **Uphando** In my Natural Science class… *In my Natuurwetenskapklas* **Kwigumbi lam leNzululwazi**	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
9.	I carry out investigations to test my ideas. *Doen ek ondersoeke om my idees te toets.* **Ndenza uphando ukuvavanya iingcinga zam.**	1	2	3	4	5	1	2	3	4	5
10.	I am asked to think about the supporting facts for statements. *Word ek gevra om te dink oor die feite wat stellings ondersteun.* **Ndifunwa ukuba ndicinge ngokuxhasa ngolwazi iintetho zam.**	1	2	3	4	5	1	2	3	4	5
11.	I carry out investigations to answer questions coming from discussions. *Doen ek ondersoeke om vrae te beantwoord wat spruit uit besprekings.* ***Ndenza uphando ukuphendula imibuzo ephuma kwiingxoxo.***	1	2	3	4	5	1	2	3	4	5
12.	I explain the meaning of statements, diagrams and graphs. *Verduidelik ek die betekenis van stellings, diagramme en grafieke.* **Ndiyazicacisa iintetho kunye nezinto ezithethwa yimifanekiso neegrafu.**	1	2	3	4	5	1	2	3	4	5
13.	I carry out investigations to answer the teacher's questions. *Doen ek ondersoeke om die onderwyser se vrae te beantwoord.* **Ndenza uphando ukuphendula imibuzo katitshala/titshalakazi.**	1	2	3	4	5	1	2	3	4	5
14.	I find out answers to questions by doing investigations. *Vind ek antwoorde op vrae deur ondersoeke te doen.* **Iimpendulo zemibuzo ndizifumana ngokwenza uphando.**	1	2	3	4	5	1	2	3	4	5

Continued from page 5

Respect for difference / *Respek vir andersheid* / **Intlonipho yeyantlukwano** **In my Natural Science class....** *In my Natuurwetenskapklas...* **Kwigumbi lam leNzululwazi...**	ACTUAL (How it is) *WERKLIKHEID (Hoe dit is)* *EYENZEKAYO (Indlela eyiyo)* Never / *Nooit* / *Zange*	Seldom / *Selde* / *Inqabile*	Sometimes / *Soms* / *Ngama -xesha*	Often / *Gereeld* / Soloko	Always / *Altyd* / *Rhoqo*	PREFERRED (How I want it.) *VERKIESDE (Hoe ek dit wil hê)* *ENQWENELEKAYO(Indlela endingwenela ibeyiyo)* Never / *Nooit* / *Zange*	Seldom / *Selde* / *Inqabile*	Sometimes / *Soms* / *Ngama -xesha*	Often / *Gereeld* / Soloko	Always / *Altyd* / *Rhoqo*
15. The teacher sets rules that we must follow when we talk about our opinions about science. *Stel die onderwysers reels vas wat ons moet nakom wanneer ons praat oor ons opinies oor wetenskap.* **Utitshala/titshalakazi ubeka imiqathango emasiyilandele xa sithetha ngezimvo zethu.**	1	2	3	4	5	1	2	3	4	5
16. I am aware that my classmates have different opinions about science. *Is ek bewus dat my klasmaats ander opinies het oor wetenskap.* **Ndiyayazi ukuba abafundi abakwigumbi lam lokufunda banezimvo ezahlukeneyo ngeNzululwazi.**	1	2	3	4	5	1	2	3	4	5
17. I listen to my classmates' opinions about science. *Luister ek na my klasmaat se opinie oor wetenskap.* **Ndiyazimamela izimvo zabafundi abakwigumbi lam lokufunda ngeNzululwazi.**	1	2	3	4	5	1	2	3	4	5
18. Before I agree or disagree with my classmates' opinions about science, I first think about what they said. *Dink ek eers na oor wat my klasmaats gesê het voor ek saamstem of van hulle verskil.* **Phambi kokuba ndivume okanye ndingavumelani nezimvo zabafundi abakwigumbi lam lokufunda, ndiqala ndicinge ngabakuthethileyo.**	1	2	3	4	5	1	2	3	4	5
19. I try to understand my classmate's opinions about science. *Probeer ek my klasmaats se opinie oor wetenskap verstaan.* **Ndiyazama ukuziqonda izimvo zabafundi abakwigumbi lam lokufunda ngeNzululwazi**	1	2	3	4	5	1	2	3	4	5
20. I respect my classmates' opinions about science. *Respekteer ek my klasmaat se opinie oor wetenskap.* **Ndiyazihlonipha izimvo zabafundi abakwigumbi lam lokufunda ngeNzululwazi.**	1	2	3	4	5	1	2	3	4	5

Continued from page 6

	ACTUAL (How it is) WERKLIKHEID (Hoe dit is) EYENZEKAYO (Indlela eyiyo)					PREFERRED (How I want it.) VERKIESDE (Hoe ek dit wil hê) ENQWENELEKAYO (Indlela endingwenela ibeyiyo)				
Metacognition/ *Meta-kognisie/* **Ukucinga ngeengcinga** **In my Natural Science class....** *In my Natuurwetenskapklas...* **Kwigumbi lam leNzululwazi...**	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama -xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
21. I think about my ideas in science. *Dink ek na oor my idees in wetenskap.* **Ndiyacinga ngeengcinga zam kwiNzululwazi.**	1	2	3	4	5	1	2	3	4	5
22. I write down my ideas in science. *Skryf ek my idees in wetenskap neer.* **Ndizibhala phantsi iingcinga zam kwiNzululwazi.**	1	2	3	4	5	1	2	3	4	5
23. I check my ideas in science with my teacher. *Gaan ek my idees in wetenskap met my onderwyser na.* **Iingcinga zam kwiNzululwazi ndizikhangela kutitshala/titshalakazi wam.**	1	2	3	4	5	1	2	3	4	5
24. I check my ideas in science with my classmates. *Gaan ek my idees in wetenskap met my klasmaats na.* **Iingcinga zam kwiNzululwazi ndizikhangela kubafundi abakwigumbi lam lokufunda.**	1	2	3	4	5	1	2	3	4	5
25. I check my ideas in science by reading. *Gaan ek my idees in wetenskap na deur te lees.* **Iingcinga zam kwiNzululwazi ndiziqinisekisa ngokufunda.**	1	2	3	4	5	1	2	3	4	5
26. I welcome my classmate's thoughts about my ideas in science. *Verwelkom ek my klasmaats se gedagtes oor my idees in wetenskap.* **Ndiyazamkela iingcinga zabafundi abakw igumbi lam lokufunda kwiNzululwazi.**	1	2	3	4	5	1	2	3	4	5

Continued from page 7

	ACTUAL (How it is) WERKLIKHEID (Hoe dit is) EYENZEKAYO (Indlela eyiyo)					PREFERRED (How I want it.) VERKIESDE (Hoe ek dit wil hê) ENQWENELEKAYO (Indlela endingwenela ibeyiyo)				
Metacognition/ *Meta-kognisie* / **Ukucinga ngeengcinga** **In my Natural Science class....** *In my Natuurwetenskapklas...* **Kwigumbi lam leNzululwazi...**	Never *Nooit* **Zange**	Seldom *Selde* **Inqabile**	Sometimes *Soms* **Ngama -xesha**	Often *Gereeld* **Soloko**	Always *Altyd* **Rhoqo**	Never *Nooit* **Zange**	Seldom *Selde* **Inqabile**	Sometimes *Soms* **Ngama-xesha**	Often *Gereeld* **Soloko**	Always *Altyd* **Rhoqo**
27. I defend my ideas in science when I discuss them with others. *Verdedig ek my idees in wetenskap wanneer ek dit met ander bespreek.* **Ndiyazikhusela iingcinga zam xa ndixoxa nabanye.**	1	2	3	4	5	1	2	3	4	5
28. When I discuss my ideas about science to my classmates, I explain my reasoning. *Veduidelik ek my redenasie wanneer ek my idees omtrent wetenskap met my klasmaats bespreek.* **Ndiyayicacisa indlela endicinga ngayo xa ndixoxa ngeengcinga zam kubafundi abakwigumbi lam lokufunda.**	1	2	3	4	5	1	2	3	4	5
29. When I need to, I change my ideas about science. *Verander ek my gedagtes omtrent wetenskap wanneer ek moet.* **Xa ndifuna ndiyazitshintsha iingcinga zam ngeNzululwazi.**	1	2	3	4	5	1	2	3	4	5

Continued from page 8

Personal Relevance/ ***Persoonlike voorkeur*** / **Malunga nam** In my Natural Science class…. *In my Natuurwetenskapklas* **Kwigumbi lam leNzululwazi…**	ACTUAL (How it is) *WERKLIKHEID (Hoe dit is)* *EYENZEKAYO (Indlela eyiyo)*					PREFERRED (How I want it.) *VERKIESDE (Hoe ek dit wil hê)* *ENQWENELEKAYO(Indlela endingwenela ibeyiyo)*				
	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
30. I learn about the world outside of school. *Leer ek omtrent die wêreld buite die skool.* **Ndifunda ngelizwe elingaphandle kwesikolo.**	1	2	3	4	5	1	2	3	4	5
31. My new learning starts with problems about the world outside of school. *Begin my nuwe leer(proses) met probleme buite die wêreld van die skool.* **Ufundo lwam olutsha luqala ngeengxaki ezingelizwe elingaphandle kwesikolo.**	1	2	3	4	5	1	2	3	4	5
32. I get better understanding of the world outside of school. *Verkry ek 'n beter begrip van die wêreld buite die skool.* **Ndiliqonda ngcono ilizwe elingaphandle kwesikolo.**	1	2	3	4	5	1	2	3	4	5
33. I learn interesting things about the world outside of school. *Leer ek baie interessante dinge omtrent die wêreld buite die skool.* **Ndifunda izinto ezenza umdla ngelizwe elingaphandle kwesikolo.**	1	2	3	4	5	1	2	3	4	5
34. What I learn has nothing to do with my out-of-school life. *Het wat ek leer niks te doen met my lewe buite die skool nie.* **Into endiyifundayo ayinanto yakwenza nobom bam obungaphandle kwesikolo.**	1	2	3	4	5	1	2	3	4	5
35. What I learn I can use in my out-of-school life. *Kan ek dit wat ek leer in my lewe buite die skool gebruik.* Into endiyifundayo ndinakho ukuyisebenzisa kubom bam obungaphandle kwesikolo.	1	2	3	4	5	1	2	3	4	5

Continued from page 9

Collaboration / *Samewerking* / **Intsebenziswano** In my Natural Science class.... *In my Natuurwetenskapklas...* **Kwigumbi lam leNzululwazi...**	ACTUAL (How it is) WEKLIKHEID (Hoe dit is) **EYENZEKAYO (Indlela eyiyo)** Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	PREFERRED (How I want it) VERKIESDE (Hoe ek dit wil hê) **ENQWENELEKAYO (Indlela endinqwenela ibeyiyo)** Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama-xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***
36. I like working in groups. *Hou ek daarvan om in groepe te werk.* **Ndiyathanda ukusebenza ngokwamaqela.**	1	2	3	4	5	1	2	3	4	5
37. I feel that it is important for the class to work together as a team. *Voel ek dat dit belangrik is vir die klas om as 'n span saam te werk.* **Ndiyazivela nje ukuba kubalulekile ukuba iklasi isebenze kunye njengeqela.**	1	2	3	4	5	1	2	3	4	5
38. I would rather decide what to do as a group than to make a decision myself. *Sal ek eerder as 'n groep 'n besluit wat om te doen as om 'n besluit op my eie te doen.* **Ndingakhetha ukuba sithathe izigqibo njengeqela kunokuba ndisithathe ngkwam.**	1	2	3	4	5	1	2	3	4	5
39. It is important for me to be involved in class discussions. *Is dit vir my belangrik om deel te neem aan klasbesprekings.* **Kubalulekile kum ukuba ndibekho kwiingxoxo zeklasi.**	1	2	3	4	5	1	2	3	4	5
40. I like to work with other students. *Hou ek daarvan om met ander leerders te werk.* **Ndiyathanda ukusebenza nabanye abafundi.**	1	2	3	4	5	1	2	3	4	5

Continued from page 10

		ACTUAL (How it is) WERKLIKHEID (Hoe dit is) EYENZEKAYO (Indlela eyiyo)					PREFERRED (How I want it.) VERKIESDE (Hoe ek dit wil hê) ENQWENELEKAYO(Indlela endingwenela ibeyiyo)				
	Critical voice / *Kritiese stem* / **Ilizwi elingundoqo** In my Natural Science class.... *In my Natuurwetenskapklas...* **Kwigumbi lam leNzululwazi...**	Never *Nooit* **Zange**	Seldom *Selde* **Inqabile**	Sometimes *Soms* **Ngama -xesha**	Often *Gereeld* **Soloko**	Always *Altyd* **Rhoqo**	Never *Nooit* **Zange**	Seldom *Selde* **Inqabile**	Sometimes *Soms* **Ngama -xesha**	Often *Gereeld* **Soloko**	Always *Altyd* **Rhoqo**
41.	It's OK for me to ask the teacher "Why do I have to learn this?" *Is dit in die haak dat ek die onderwyser vra "Hoekom moet ek dit leer?"* **Kulungile kum ukuba ndimbuze utitshala/titshalakazi "Kutheni kufuneka ndiyifundile lento?"**	1	2	3	4	5	1	2	3	4	5
42.	It's OK for me to question the way I am being taught. *Is dit in die haak dat ek die manier waarop ek onderrig word, bevraagteken.* **Kulungile kum ukuba ndiyibuze indlela endifundiswa ngayo.**	1	2	3	4	5	1	2	3	4	5
43.	It's OK for me to complain about teaching activities that are confusing. *Is dit in die haak dat ek kla oor onderrigaktiwiteite mat verwarrend is.* **Kulungile kum ukuba ndikhalaze ngeendlela zokufundisa ezibhidisayo.**	1	2	3	4	5	1	2	3	4	5
44.	It is important for me to be involved in class discussions. *Is dit belangrik vir my om betrokke te wees by klasbesprekings.* **Kubalulekile kum ukuba ndibekho kwiingxoxo zeklasi.**	1	2	3	4	5	1	2	3	4	5
45.	It's OK for me to complain about anything that prevents me from learning. *Is dit in die haak dat ek kla oor enigiets wat my verhoed om te leer.* **Kulungile kum ukuba ndikhalaze nangantoni na endithintelayo ekufundeni.**	1	2	3	4	5	1	2	3	4	5
46.	It's OK for me to express my opinion. *Is dit in die haak as ek my opinie lig.* **Kulungile kum ukuba ndiveze izimvo zam.**	1	2	3	4	5	1	2	3	4	5
47.	It's OK for me to speak up for my rights. *Is dit in die haak dat ek opkom vir my regte.* **Kulungile kum ukuba ndiwathethele amalungelo am.**	1	2	3	4	5	1	2	3	4	5

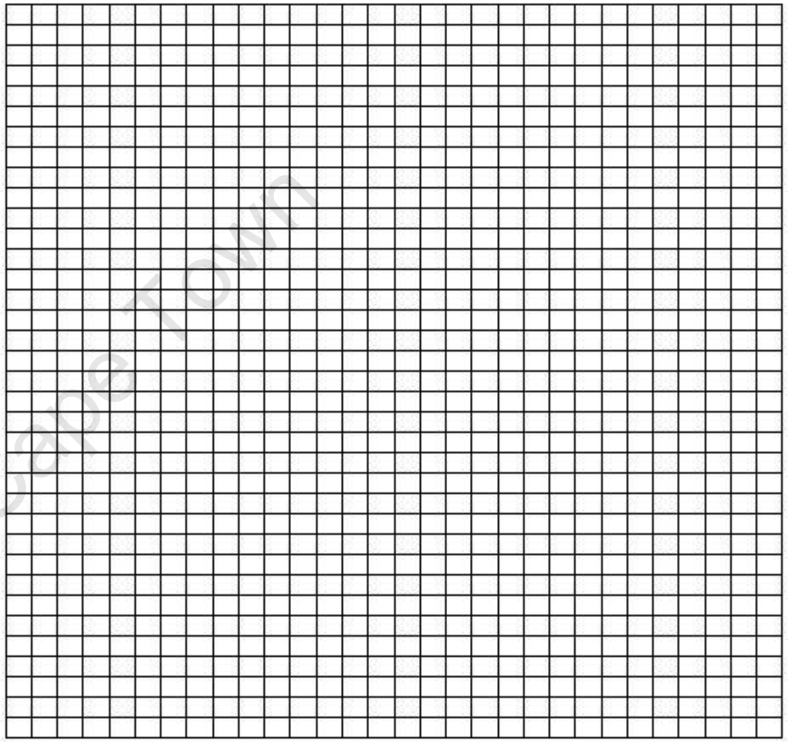
Continued from 11

		ACTUAL (How it is) WERKLIIKIED (Hoe dit is) **EYENZEKAYO (Indlela eyiyo)**					PREFERRED (How I want it) VERKIESDE (Hoe ek dit wil hê) **ENQWENELEKAYO (Indlela endingwenela ibeyiyo)**				
	Uncertainty in Science/ *Onsekerheid in Wetenskap* / *Ukungaqiniseki kwiNzululwazi* In my Natural Science class.... *In my Natuurwetenskapklas...* ***Kwigumbi lam leNzululwazi...***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama -xesha***	Often *Gereeld* **Soloko**	Always *Altyd* ***Rhoqo***	Never *Nooit* ***Zange***	Seldom *Selde* ***Inqabile***	Sometimes *Soms* ***Ngama -xesha***	Often *Gereeld* Soloko	Always *Altyd* ***Rhoqo***
48.	I learn that science cannot provide perfect answers to problems. *Leer ek dat wetenskap nie perfekte antwoorde vir probleme kan bied nie.* **Ndifunda ukuba iNzululwazi ayinakunika zimpendulo zingenaziphene emibuzweni.**	1	2	3	4	5	1	2	3	4	5
49.	I learn that science has changed over time. *Leer ek dat wetenskap oor tyd verander het.* **Ndifunda ukuba iNzululwazi iye yatshintsha apha ekuhambeni kwexesha.**	1	2	3	4	5	1	2	3	4	5
50.	I learn that science is influenced by people's values and opinions. *Leer ek dat wetenskap deur mense se waardes en opinies beïnvloed word.* **Ndifunda ukuba iNzululwazi iphenjelelwe zizimvo needlela zokuphila zabantu.**	1	2	3	4	5	1	2	3	4	5
51.	I learn about the different sciences used by people in other cultures. *Leer ek omtrent die ander wetenskappe wat deur mense in ander kulture gebruik word.* **Ndifunda ngeeNzululwazi ezahlukileyo ezisetyenziswa ngabantu kwezinye iinkcubeko.**	1	2	3	4	5	1	2	3	4	5
52.	I learn that modern science is different from the science of long ago. *Leer ek dat moderne wetenskap anders is as die wetenskap van lank gelede/van die verlede.* **Ndifunda ukuba iNzululwazi yalemihla yahlukile kwiNzululwazi yakudala.**	1	2	3	4	5	1	2	3	4	5
53.	I learn that science is about creating theories. *Leer ek dat wetenskap gaan oor die skep van teorieë.* **Ndifunda ukuba iNzululwazi imalunga nokwenza iithiyori (theories).**	1	2	3	4	5	1	2	3	4	5

Read the following passage and answer the questions in the spaces provided below.

Thandi has been making tea at home. She has tried an experiment to see how much time it takes to boil the kettle to make tea. She used different amounts of water to obtain the results shown in the table.

Number of cups of water in the kettle	1	2	3	4	5	6
Time for the kettle to boil in seconds	60	120	180	240	300	X



<u>Questions</u>:

1. Plot a line graph of Thandi's results on the graph grid . (11)

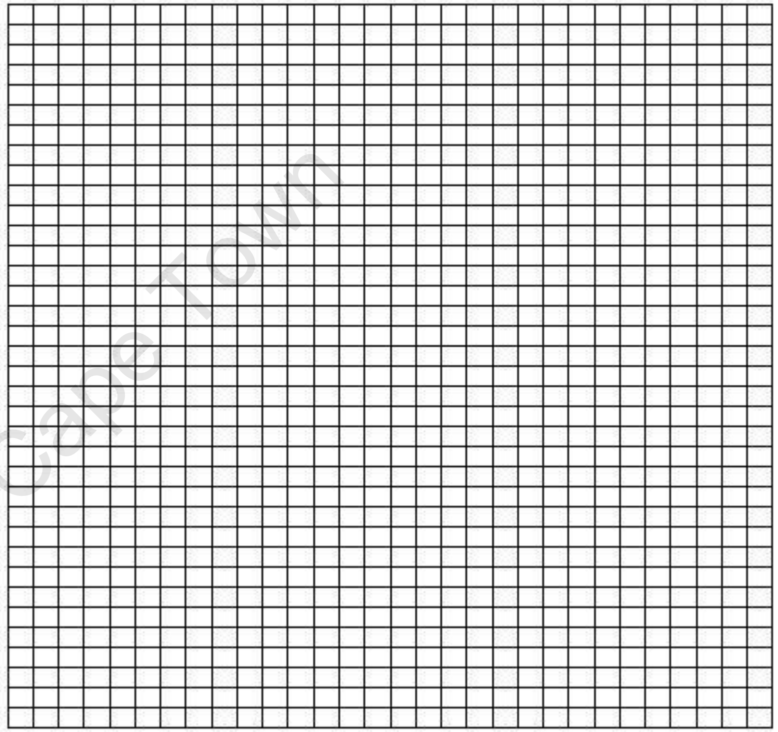
2. Find the value of X in the table above. (2)

3. Describe ***in your own words*** what this line graph shows? (2)

Lees die volgende paragraaf en antwoord die vrae wat daarop volg in die gegewe ruimtes.

Thandi maak tee tuis. Sy probeer ´n experiment om te sien hoe lank dit neem om die water in ´n ketel te laat kook. Sy het verskillende hoeveelhede water gebruik om die volgende resultate in die tabel hieronder te verkry.

Getal koppies water in die ketel.	1	2	3	4	5	6
Tyd wat dit neem om die ketel te laat kook in sekondes	60	120	180	240	300	X



<u>Vrae</u>:

1. Teken ´n graphiek deur Thandi se resultate op die grafiekpapier. (11)

2. Bepaal die waarde van X in die tabel hierbo. (2)

3. Beskryf in u eie woorde wat hierdie grafiek bewys ? (2)

Funda esi sicatshulwa silandelayo uze uphendule imibuzo kwizikhewu ozinikiweyo apha ngezantsi.

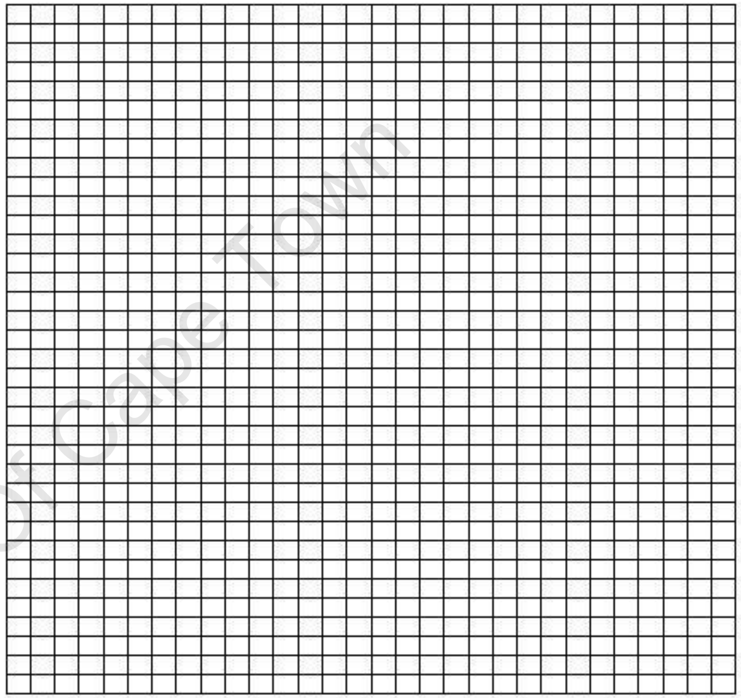
UThandi ebesenza iti ekhaya. Ubekhe wazama i-eksperimenti ukuze abone ukuba kuthabatha ixesha elingakanani na ukubilisa iketile ukwenza iti. Uzebenzise imiyinge yamanzi eyahlukeneyo ukuze afumane ezi ziphumo zibonakaliswe apha ngezantsi.

Inani leekomityi zamanzi aseketileni	1	2	3	4	5	6
Ixesha lokubila kweketile ngokwemizuzwana	60	120	180	240	300	X

<u>**Imibuzo**</u>:

1. Zoba igrafu yomgca yeziphumo zikaThandi kule gridi yegrafu ilapha ngezantsi. (11)

2. Fumanisa ukuba u-X ungakanani na kule-table ingasentla. (2)



3. Chaza ***ngawakho amazwi*** ukuba ibonisa ntoni na le grafu yomgca? (2)

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