DIFFERENCES BETWEEN STUDENT PERCEPTIONS OF THE ACTUAL AND THE PREFERRED SCIENCE LABORATORY CLASSROOM LEARNING ENVIRONMENTS AT A SOUTH AFRICAN COLLEGE OF EDUCATION

by

William Edward Adams

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ABSTRACT

This preliminary research study aimed to investigate, with the aid of the **Science Laboratory Environment Inventory (SLEI)**, the actual and the preferred laboratory environments as perceived by 264 first, second and third year college Science and Biology students in Cape Town, South Africa.

This investigation sought to answer the following main questions:

* Are the English and the Afrikaans versions of the **SLEI** valid and reliable for use as perceptive instruments in a South African context?
* What are the relationships between variables such as class membership, the year level of study, the type or level of the science subject studied, the particular lecturer concerned, home language and gender and the students' perceptions of their science laboratory classroom environments?
* Do appreciable differences occur between the actual and the preferred environments as perceived by the students?
* Are the findings of the present investigation consistent with the results of parallel investigations undertaken overseas?

The data was collected by means of standard answer sheets, and analysed by comparison of the mean scores, standard deviations, discriminant validities and the alpha reliabilities of the various scales of **SLEI**.

The evidence derived by the investigation suggests that:

* both the English and the Afrikaans versions of the **SLEI** are valid and reliable for use as instruments for assessing the students' perceptions of their science laboratory classroom environments in a South African setting;
* variables such as class membership, the year level of study, the type or level of the science subject studied, and the particular lecturer are statistically significant factors in accounting for variation in the learning environment perceptions of students. Non-significant variables are the gender and the home language of the students;
* there are appreciable measured differences between the actual and the preferred environments as perceived by the students;
* certain findings of the present investigation are consistent with the findings of previous and current research undertaken overseas, corroborating the significant variables.

Recommendations are made as follows:

* that teachers and lecturers could begin to use classroom environment instruments like **SLEI**, together with all the other measures that they use in formative evaluations, to alter or improve the effectiveness of their teaching strategies;

* that more laboratory activities should be encouraged which emphasize an open-ended, divergent, individualized approach to experimentation;
* that the **SLEI** be used to assist in the measurement and evaluation of the effectiveness of innovations in science laboratory teaching, and to guide systematic attempts to improve the laboratory learning environments to harmonise the actual environment more closely with the preferred environment, as perceived by the students, since there is a demonstrated correlation between students' academic performance scores worldwide and their classroom environment;
* that the **SLEI** be used in cross-cultural studies in a wider South African context.

CHAPTER 1: ORIGIN AND CONTEXT OF THE RESEARCH STUDY

1.1 Origin and Background of the Problem

The origin of this problem lies in the cultural diversity of college institutions preparing South African science teachers for a wide range of educationally and socio-economically different schools.

The background to the problem is that in more than one sense South Africa is still partly a developed country and partly a developing country. South Africa is also a politically divided country, based on race, colour and creed. It is only since February 1990, with the release of some political prisoners and the unbanning of political organisations of the people, that South Africa is on the road to democracy, justice and attempts are being made to normalise the South African society, also in the educational sphere. However this process is a very slow one because it is hamstrung by enormous problems.

Although there has been movement in the educational sphere i.e. the establishment of the so-called open schools and the Model C schools, the poor economic climate is hampering this process and there remain deep-rooted divisions in the educational systems of South Africa. These divisions are manifested in the various educational departments, which cater for the various racial and ethnic groups with different perceptions and cultural preferences, both actual and preferred.

1.2 The Nature, Delimitation and the Importance of the Problem

The problem may be ascribed to increasingly intensified perceived differences and preferences among science teachers and their pupils and students in culture, socio-economic status, political status and educational status which have occurred during the last four decades of enforced separation.

The South African education system is to a large extent divided on a racial basis. Therefore one might expect some significant perceived differences and preferences across the racial divide.

The pupils and students of the disadvantaged sectors of the South African population might necessarily perceive the science laboratory environments in the schools and colleges differently from the pupils and students of the advantaged sector. This might also be clearly noticeable in their preferences in terms of the science laboratory environment.

These differences might be further accentuated by the level of qualification of the teachers, the availability of science laboratory space and apparatus.

The investigation was restricted to the first, second and third year science and biology students, studying full-time at the **Hewat College of Education**, Athlone, Cape Town, where the writer lectures in science and biology.

These students form part of the disadvantaged sectors of the South African population and they come from varying backgrounds in terms of socio-economic and political status, and language traditions.

The importance of the problem is that it could have some practical application in facilitating improvements in science classrooms (Schibeci, Rideng and Fraser 1987). It may encourage college science lecturers to implement classroom strategies aimed at harmonising the actual science environment more closely with the students' preferred science environment (Schibeci, Rideng and Fraser 1987), where important and significant discrepancies can be shown to occur.

1.3 The Purpose of the Investigation

The purpose of the research is to measure the actual and preferred science laboratory classroom environments as perceived by college science education students in 1990 at the Hewat College of Education, and to attempt to account for any appreciable differences.

The investigation will attempt to measure a sample of the spectrum of development between the two dimensions of South Africa being a partly developed country and a partly developing country, with particular reference to the diversity of current learning environments offered by lecturers in the laboratories at the Hewat College of Education, and to explain the differences where possible.

The research is partly exploratory because an extensive literature search by the writer has so far revealed very little research of this nature carried out in Africa, except in the Sudan (Harty and Hassan 1983) and Nigeria (Fraser, Giddings and McRobbie 1990, 1991, 1992). Indeed, it is only since 1984 that research at the tertiary level has been undertaken (Fraser and Fisher 1984; Fraser 1986b; Fraser and Treagust 1986; Fraser, Treagust, Williamson and Tobin 1987; Fraser and Giddings 1989; Giddings and Fraser 1989; McRobbie, Giddings and Fraser 1990, 1991; Fraser, Giddings and McRobbie 1992).

The investigation is a comparative study because it will involve accounting for student perceptions of the actual and the preferred science laboratory classroom environments, and the students' perceptions and preferences of science laboratory classroom environments when compared according to home language, year level of study, the type of science subject studied, the particular lecturer involved and the gender of the student.

The results of this research study can also be compared with the results of research studies with tertiary students carried out in Australia by Barry J Fraser and Darrell L Fisher (1984), Fraser and David F Treagust (1986), Geoff Giddings and Fraser (1989), Fraser, Giddings and McRobbie (1990, 1991, 1992), as well as with samples of American students.

1.4 Clarification of Terms: Definitions

This research study is based on the work undertaken by Barry J Fraser, Darrell L Fisher, David F Treagust, Geoffrey J Giddings and Campbell J McRobbie in Australia and as such makes use of the terminology used by these researchers.

The **actual** laboratory classroom environment is what the students perceive the laboratory actually to be like (Fraser 1986a; Giddings and Fraser 1989). The actual laboratory environment was rated by the students responding to the actual form of the instrument, the **Science Laboratory Environment Inventory (SLEI)**, developed by Fraser and Giddings (1989).

The **preferred** laboratory classroom environment is what the students would prefer the laboratory to be like (Fraser 1986a; Giddings and Fraser 1989). The preferred laboratory environment was rated by the students responding to the preferred form of the **SLEI**.

The actual and preferred forms of the **SLEI** are discussed in more detail in **Chapter 3**.

Other prominent researchers, notably Rudolf H Moos and Edward Trickett, who developed the **Classroom Environment Scale (CES)**, use the term **real** environment, instead of the actual environment, and the term **ideal** environment, instead of the preferred environment (Trickett and Moos 1973; Moos and Moos 1978; Fraser and Fisher 1984; Moos 1986; Fraser 1986a).

A closer scrutiny of the literature on the assessment of classroom psychosocial environments reveals that Fraser et al also sometimes use real and ideal in brackets after actual and preferred. This is also true of Moos and Trickett in the reversed manner.

1.5 Hypotheses and Research Questions

1.5.1 The following **null hypotheses (Ho's)** were formulated to investigate the research problems:

> **There is no significant difference between the measured perceptions of the Hewat students of their actual and preferred science laboratory classroom environments. (Ho 1)**

There is no statistically significant difference between the Hewat students' perceptions of the science laboratory classroom environments when compared according to:

* the class group that they belong to. (Ho 2)
* home language, namely English and Afrikaans. (Ho 3)
* the year level of study. (Ho 4)
* the specific science subject that they study, namely Science Higher and Science Elementary for first year students, and Biology for second and third year students. (Ho 5)
* the gender of the individual. (Ho 6)
* the particular lecturer who lectures them. (Ho 7)

1.5.2 This research study proposes and investigates answers to the following research questions:

* Do the 1990 Hewat students prefer a science laboratory classroom environment significantly different from the actual science laboratory classroom environment as preferred by them?
* Are there significant differences in the perceptions of the students which are related to:

  class membership;
  the year level of study;

the home language of the students;
the type of the science subject studied;
the specific lecturer who lectures to them?

* Are the Afrikaans translated versions of SLEI also valid and reliable instruments for assessing classroom psychosocial environments in South African higher education?

* Are the English versions of SLEI valid for use as instruments for assessing classroom psychosocial environments in South African higher education?

* Do the results of this study corroborate or contradict results obtained elsewhere in the world?

1.6 Procedure for the Treatment and the Analysis of the Data

ANOVAS (Analyses of variance) will be employed to differentiate between the effects of different science laboratory classroom environments (after Giddings and Fraser 1989), and also with particular reference to the home language, the year level of study, the specific science subject, the particular lecturer and the gender of the student.

1.7 Importance of the Study

One of the aims of this research study is to make this exciting research tradition, i.e. of making use of classroom environment instruments, more accessible to wider audiences (Fraser 1986b).

The importance of the study is that it could have some practical application in facilitating improvements in science laboratory classrooms (Schibeci, Rideng and Fraser 1987; Giddings and Fraser 1989; Fraser, Giddings and McRobbie 1990, 1991, 1992).

It may encourage lecturers to implement classroom strategies aimed at harmonising the actual science environment in the laboratory more closely with the students' preferred science laboratory environment (Fraser and Giddings 1989; Giddings and Fraser 1989; McRobbie, Giddings and Fraser 1990, 1991; Fraser, Giddings and McRobbie 1992), where important discrepancies can be shown to occur.

It is crucial that researchers, teachers and lecturers begin to include classroom environment instruments with those measures used in school evaluations and school effectiveness studies (Fraser 1986b).

1.8 The Organization of the Remainder of the Thesis

A review of relevant literature and related studies is recorded in **Chapter 2**. This provides a theoretical foundation for the empirical investigation, an account of which is given in **Chapters 4** and **5**.

In **Chapter 2** the historical development of the assessment of classroom psychological environments, the different classroom environment instruments, their statistical validation and their uses are described.

In **Chapter 3** the experimental design of this investigation is discussed. An explanation is given of the methodology of the empirical study which involved the administration of the instrument, the **Science Laboratory Environment Inventory (SLEI)** to 264 science and biology college students to measure their perceptions of the actual and the preferred science laboratory classroom learning environments at the Hewat College of Education in Athlone, Cape Town, South Africa.

Chapter 4 consists of an analysis of the data obtained, the findings of the empirical study are reported in the form of tables presenting the means, standard deviations, internal consistencies and the discriminant validities of the variables investigated. **ANOVAS** are presented to establish the existence of any significant differences. The rejection or the support of the hypotheses is described and answers to the research questions are offered.

In **Chapter 5** these results are discussed in detail with additional four statistical tables in support. An attempt is made to account for the significant differences obtained among the variables and to suggest explanations for the outcomes of the tested null hypotheses and the research questions.

Chapter 6 provides a summary of the study as a whole. An attempt is made to relate the findings of this study to those of previous investigations, and to draw conclusions and to make recommendations for further research.

1.9 Chapter Summary

The origin, background, nature and the importance of the problem; and the purpose of the investigation have been described in this chapter. The null hypotheses and the research questions have been formulated, the terms and definitions have been clarified and the procedure for the treatment and the analysis of the data have been described. A review of related literature which forms the theoretical framework for this research study follows in **Chapter 2**.

CHAPTER 2: REVIEW OF RELATED LITERATURE

A review of relevant literature and related studies is presented below. This provides a theoretical foundation for the empirical investigation, an account of which follows in **Chapters 4 and 5**.

2.1 Historical Development of the Assessment of Classroom Psychosocial Environments

Traditionally school evaluations and the assessment of instructional effectiveness have relied heavily, and sometimes exclusively, on the assessment of academic achievement. However, these measures cannot give a complete picture of the educational process (Fraser 1986b). Pupils and students have a large stake in what happens to them at school or college. Their reactions to and perceptions of their school and college experiences are important.

During the past two decades considerable interest has been shown in the conceptualization, measurement, and investigation of perceptions of psychosocial characteristics of the learning environment in primary and secondary schools (Fraser and Treagust 1986).

Recent key publications by Walberg (1969), Haertel, Walberg and Haertel (1981),Fraser (1981a & b; 1982; 1984; 1986a & b), Lawrenz (1976 a & b; 1987), Fraser and Fisher (1984;1986), Moos (1986), Fraser, Treagust, Williamson and Tobin (1987), Giddings and Fraser (1989), McRobbie, Giddings and Fraser 1990, 1991; Fraser, Giddings and McRobbie (1992) and others have firmly established classroom environment as an active field of study.

The research for these publications employed an instrument for assessing classroom psychosocial environment. It defines classroom environment in terms of the shared perceptions of the students and the teachers in that environment (Fraser and Treagust 1986). This approach has the dual advantage of characterizing the class through the eyes of the actual participants and capturing data which the observer could miss or consider unimportant.

2.2 Distinction between School-level and Classroom-level Environment

Studies in the fields of classroom-level and school-level environment have remained independent, despite their simultaneous development and logical linkages. Workers in the one field commonly have little cognizance of the other field. Different theoretical and conceptual foundations have also been used to underpin the two areas (Fraser 1986b).

Classroom climate might involve relationships between the teacher and his/her students or among students, whereas school climate might involve relationships between teachers and their teaching colleagues, head of department, and school principal. Classroom environment is usually measured in terms of either student or teacher perceptions, while school environment is usually, but not exclusively, assessed in terms of teacher perceptions (Fraser 1986b).

Fraser (1986b; 1989) argues that it would be desirable to break away from the existing tradition of independence of the two fields of school and classroom environment and for there to be a confluence of the two fields. This argument is supported by Fraser, Giddings and McRobbie (1992).

2.3 Instruments for assessing Classroom Environment

This discussion clarifies the background and nature of several instruments commonly used in prior research to assess perceptions of classroom learning environment.

The following instruments are considered below: the **Learning Environment Inventory (LEI)**, the **Classroom Environment Scale (CES)**, the **Individualized Classroom Environment Questionnaire (ICEQ)**, **My Class Inventory (MCI)**, the **College and University Classroom Environment Inventory (CUCEI)**, and the **Science Laboratory Environment Inventory (SLEI)**.

Each instrument is suitable for convenient group administration, can be scored either by hand or computer, and has been shown to be reliable in extensive field trials (Fraser 1986b). Also, all of these instruments, except the **LEI** are available in economical short forms (Fraser 1982). Typical scales included in the above instruments are Competition, Formality, Difficulty, Rule Clarity, Personalization and Investigation (Fraser and Treagust 1986).

Surprisingly little work has been conducted in tertiary institutions, simply due to the unavailability of suitable, reliable, and practical instruments for use in tertiary classrooms (Fraser and Fisher 1984; Fraser and Treagust 1986; Giddings and Fraser 1989). The investigation undertaken by DeYoung (1977), using the ICEQ with university students is one exception.

To fill this void, Fraser & Treagust (1986) developed and described the validity and use of the **College and University Classroom Environment Inventory (CUCEI)**, suitable for small higher education classes often referred to as seminars.

Most recently Fraser & Giddings (1989) developed another new instrument, the **Science Laboratory Environment Inventory (SLEI)**, suitable for assessing science laboratory classroom environments at the senior high school level or the higher education level. They have forwarded a copy of **SLEI** to the writer for use in the present investigation. A copy of the letter from Professor Barry J Fraser, giving permission is attached in **Appendix A**.

Table 2.1 provides an overview of the scales contained in **LEI**, **CES**, **ICEQ**, **MCI**, **CUCEI** and **SLEI**. The table summarizes the level for which each instrument is suited, the number of items contained in each scale, and the classification of each scale according to Moos' scheme for classifying human environments (Moos and Trickett 1974; Moos 1986).

Table 2.1: **Overview of scales contained in six classroom environment instruments.**

			Scales classified according to Moos' scheme		
Instrument	Level	Items per scale	Relationship dimensions	Personal development dimensions	System maintenance and system change dimensions
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material environment Goal direction Disorganization Democracy
Classroom Environment Scale (CES)	Secondary	10	Involvement Affiliation Teacher support	Task orientation Competition	Order and organization Rule clarity Teacher control Innovation
Individualized Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalization Participation	Independence Investigation	Differentiation
My Class Inventory (MCI)	Primary, lower secondary	6–9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
College and University Classroom Environment Inventory (CUCEI)	Higher education	7	Personalization Involvement Student cohesiveness Satisfaction	Task orientation	Innovation Individualization
Science Laboratory Environment Inventory (SLEI)	Senior secondary, highe- education	7	Teacher supportiveness Involvement Student cohesiveness	Open-endedness Integration	Organization Rule clarity Material environment

Source: Fraser (1989)

Most of these instruments have four distinct forms which purport to measure (a) student or pupil perceptions of actual classroom environment, (b) student or pupil perceptions of preferred classroom environment, (c) teacher perceptions of actual classroom environment, and (d) teacher perceptions of preferred classroom environment (Giddings and Fraser 1989). The preferred forms are concerned with goals and value orientations, and they aim to measure perceptions of the classroom environment ideally liked or preferred (Fraser and Treagust 1986; Giddings and Fraser 1989).

2.4 Specific Information about the Classroom Environment Instruments

2.4.1 Learning Environment Inventory (LEI)

The initial development and validation of a preliminary version of the **LEI** began in the late 1960's (Fraser and Fisher 1984). The final version of the **LEI**, as developed by Anderson and Walberg in 1971, contains 15 different scales and a total of 105 statements, (seven per scale) descriptive of typical classes.

Each item of the **LEI** has four response choices on a four-point scale (i.e. 4, 3, 2, and 1) for alternatives of Strongly Disagree, Agree, Agree and Strongly Agree. The scoring direction is reversed for some items. Omitted or invalid responses are scored two and a half (Fraser and Fisher 1984; Lawrenz 1987).

A typical item contained in the Cohesiveness scale is: "All students know each other very well".

2.4.2 Classroom Environment Scale (CES)

The **CES** was developed by Rudolf Moos at Stanford University (Trickett and Moos 1973; Moos and Trickett 1974). Moos and Trickett's final version of the **CES** contains nine scales with ten items of the true-false response format in each scale (Fraser and Fisher 1984; Fraser 1986 a & b).

Typical items in the **CES** are: "The teacher takes a personal interest in the students" (Teacher Support) and "There is a clear set of rules for students to follow" (Rule Clarity) (Fraser 1986b).

2.4.3 Individualized Classroom Environment Questionnaire (ICEQ)

The **ICEQ**, developed by Fraser & Fisher, assesses those dimensions (namely, Personalization, Participation, Independence, Investigation, and Differentiation) which distinguish individualized classrooms from conventional ones (Fraser and Fisher 1984). The final published version of the **ICEQ's** long form contains 50 items altogether, with an equal number of items belonging to each of the five scales (10 per scale) (Fraser 1986b).

Each item is responded to on a five-point scale with the alternatives of Almost Never, Seldom, Sometimes, Often and Very Often. The scoring direction is reversed for many of the items.

Typical items are: "The teacher considers students' feelings" (Personalization) and "Different students use different books, equipment, and materials (Differentiation) (Fraser 1986b).

2.4.4 My Class Inventory (MCI)

The **LEI** has been simplified to form the **MCI** which is suitable for children in the 8 to 12 years age range (Fisher and Fraser 1981a; Fraser, Anderson and Walberg 1982; Fraser 1986 a & b). **MCI** has also been used with students in the junior high school, especially those who might experience reading difficulties with the **LEI** (Fraser and Fisher 1984; Fraser 1986b).

The final version of the **MCI** as adapted from the **LEI** by Anderson (1971), and modified by Fisher and Fraser (1981) contains 38 items altogether (six for Cohesiveness, eight for Friction, eight for Difficulty, nine for Satisfaction, and seven for Competitiveness) (Fraser 1986b).

Typical items contained in the **MCI** are: "Children are always fighting with each other" (Friction) and "Children seem to like the class" (Satisfaction) (Fraser 1986b).

2.4.5 College and University Classroom Environment Inventory (CUCEI)

The **CUCEI** assesses students' or instructors' perceptions of the following seven psychosocial dimensions of actual or preferred classroom environment: Personalization, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation, and Individualization (Fraser and Treagust 1986).

The final version of the **CUCEI** contains 49 items altogether, with an equal number of items belonging to each of the seven scales. Each item is responded to on a four-point scale with the alternatives of Strongly Agree, Agree, Disagree, and Strongly Disagree. The scoring direction is reversed for approximately half of the items. Omitted or invalidly answered items are scored 3 (after Fraser and Treagust 1986).

Typical items in the **CUCEI** are: "Activities in this class are clearly and carefully planned" (Task Orientation) and "Teaching approaches allow students to proceed at their own pace" (Individualization).

2.4.6 Science Laboratory Environment Inventory (SLEI)

The **LEI**, **CES** and **ICEQ** are not well-suited for use in the laboratory class (Giddings and Hofstein 1980). Consequently, to fill this gap Fraser and Giddings (1989) developed a new questionnaire, called the **Science Laboratory Environment Inventory (SLEI)**, which is suitable for use either at the senior high school level or the higher educational level.

Separate actual and preferred forms were developed. The unrefined **SLEI** has 72 items altogether, with nine items assessing each of the following eight scales: Teacher Supportiveness, Involvement, Student Cohesiveness, Open-Endedness, Integration, Organization, Rule Clarity and Material Environment (Fraser and Giddings 1989).

Typical items in **SLEI** are: "The teacher/instructor goes out of his/her way to help students" (Teacher Supportiveness) in the actual form. In the preferred form the item is reworded to read: "The teacher/instructor would go out of his/her way to help students" (Giddings and Fraser 1989).

2.5 Statistical Validation of these Instruments in Previous Studies

2.5.1 LEI

Table 2.2 provides the names of the 15 different scales of LEI, scale means and standard deviations for individuals and classes in Montreal, Canada (Fraser and Fisher 1984).

Table 2.2: LEI Scale Means and Standard Deviations for Individuals and Classes

Scale	Individuals[a]		Class Means[b]	
	Mean	Standard Deviation	Mean	Standard Deviation
Cohesiveness	17.71	3.14	17.68	1.70
Diversity	20.23	2.32	20.36	0.75
Formality	18.00	3.44	17.67	2.05
Speed	17.33	3.41	17.63	1.63
Material Environment	16.77	3.06	16.51	1.50
Friction	16.82	3.33	17.16	1.79
Goal Direction	17.96	3.80	17.92	1.55
Favoritism	14.18	3.81	14.48	1.83
Difficulty	18.72	2.80	18.98	1.10
Apathy	17.80	3.74	17.96	1.84
Democracy	17.53	3.16	17.35	1.25
Cliqueness	19.33	2.94	19.56	1.30
Satisfaction	16.77	3.65	16.44	1.97
Disorganization	16.43	4.18	16.84	2.58
Competitiveness	17.04	3.33	16.96	1.32

[a]Based on 1,048 individual students in 64 classes with various subject areas in Montreal (1969 data)

[b]Based on 61 class means for the same sample (1969 data)

Source: Fraser and Fisher (1984)

Table 2.3 provides the Individual and Group Reliabilities of LEI scales for a North American sample of 464 students (Fraser and Fisher 1984).

Table 2.3: Individual and Group Reliabilities of LEI Scales

Scale	Alpha Coefficient for Individuals (N=464)	(N=1048)	Intraclass Correlation for Groups (N=29)	(N=64)	Test-Retest Reliability for Individuals (N=139)
Cohesiveness	0.78	0.69	0.82	0.85	0.52
Diversity	0.58	0.54	0.43	0.31	0.43
Formality	0.64	0.76	0.82	0.92	0.55
Speed	0.77	0.70	0.71	0.81	0.51
Máterial Environment	0.65	0.56	0.76	0.81	0.64
Friction	0.78	0.72	0.77	0.83	0.73
Goal Direction	0.86	0.85	0.71	0.75	0.65
Favoritism	0.77	0.78	0.53	0.76	0.64
Difficulty	0.66	0.64	0.84	0.78	0.46
Apathy	0.83	0.82	0.79	0.74	0.61
Democracy	0.67	0.67	0.54	0.67	0.69
Cliqueness	0.74	0.65	0.77	0.71	0.68
Satisfaction	0.80	0.79	0.74	0.84	0.71
Disorganization	0.81	0.82	0.82	0.92	0.72
Competitiveness	0.78	0.78	-	0.56	-

All reliability estimates are based on samples of senior high school students in North America. Alpha coefficients have been estimated for a sample of 464 students in 1967 and a sample of 1,048 students in 1969. Intraclass correlations were calculated on a sample of 29 classes in 1967 and of 64 classes in 1969. Test-retest data were collected in 1970 from a sample of 139 individuals.

Source: Fraser and Fisher (1984)

2.5.2 CES

Tables 2.4, 2.5 and 2.6 provide the names of the nine different scales as well as statistical properties of the CES obtained with Australian junior high school pupils (Fraser and Fisher 1984).

Table 2.4: Means and Standard Deviations for each Form of CES using Junior High School pupils in Australia

Scale	Mean[a]			Standard Deviation For Individuals			Standard Deviation For Class Means	
	Student actual (N=1083)	Student preferred (N=1092)	Teacher actual (N=56)	Student actual (N=1083)	Student preferred (N=1092)	Teacher actual (N=56)	Student actual (N=116)	Student preferred (N=116)
Involvement	20.6	23.1	24.8	5.0	5.2	4.6	2.7	2.7
Affiliation	23.8	25.1	25.1	4.0	3.9	3.9	1.9	1.8
Teacher Support	21.3	23.1	25.3	5.0	4.6	3.3	2.9	2.4
Task Orientation	24.8	23.7	25.7	3.6	3.7	3.8	1.8	1.6
Competition[b]	17.4	17.3	16.8	3.1	3.1	3.7	1.4	1.2
Order & Organization	21.7	23.2	25.2	5.2	4.9	4.5	3.3	2.8
Rule Clarity	23.4	24.3	27.0	4.3	4.1	3.7	2.1	1.8
Teacher Control	22.0	21.7	22.1	4.3	4.1	4.0	2.2	1.9
Innovation[c]	17.9	20.3	18.5	3.7	4.2	4.2	2.0	2.0

a Means were approximately the same for both the student and the class as the unit of analysis.

b Competition scale contains 8 items only.

c Innovation scale contains 9 items only.

Source: Fraser and Fisher (1984)

Table 2.5: Internal Consistency Reliability (Alpha Coefficient) and Discriminant Validity (Mean Correlation with Other Eight Scales) for Three Forms of CES for Two Units of Analysis

Scale	Unit of Analysis	Alpha Reliability			Mean Correlation with Other Scales		
		Student actual (N=1083 or 116)	Student preferred (N=1092 or 116)	Teacher actual (N=56)	Student actual (N=1083 or 116)	Student preferred (N=1092 or 116)	Teacher actual (N=56)
Involvement	Indiv.	0.70	0.75	0.76	0.40	0.39	0.32
	Class	0.81	0.84		0.42	0.43	
Affiliation	Indiv.	0.60	0.63	0.65	0.24	0.32	0.31
	Class	0.71	0.70		0.29	0.39	
Teacher Support	Indiv.	0.72	0.67	0.63	0.29	0.37	0.25
	Class	0.85	0.80		0.38	0.39	
Task Orientation	Indiv.	0.58	0.58	0.68	0.23	0.22	0.30
	Class	0.72	0.65		0.31	0.24	
Competition	Indiv.	0.51	0.50	0.62	0.09	0.08	0.23
	Class	0.60	0.60		0.08	0.16	
Order and Organization	Indiv.	0.75	0.73	0.77	0.29	0.37	0.31
	Class	0.90	0.86		0.40	0.38	
Rule Clarity	Indiv.	0.63	0.60	0.70	0.29	0.34	0.17
	Class	0.76	0.69		0.36	0.39	
Teacher Control	Indiv.	0.60	0.55	0.57	0.16	0.18	0.17
	Class	0.71	0.67		0.23	0.32	
Innovation	Indiv.	0.52	0.63	0.66	0.19	0.37	0.22
	Class	0.71	0.73		0.29	0.38	

The sample of junior high school science classes in Australia involved 1,083 students in 116 classes responding to the actual form, 1,092 students in 116 classes responding to the preferred form, and 56 teachers responding to the acutal form.

In the present study, all scales contained 10 items except for Competition (8 items) and Innovation (9 items).

Source: Fraser and Fisher (1984)

Table 2.6: ANOVA Results for Class Membership Differences in Student Perceptions on the Actual Form of CES

Scale	MS Between	MS Within	df	F	Eta^2
Involvement	63.8	18.9	115, 967	3.4*	0.29
Affiliation	30.2	13.9	115, 967	2.2*	0.21
Teacher Support	79.8	18.2	115, 967	4.4*	0.34
Task Orientation	29.6	10.5	115, 967	2.8*	0.25
Competition	17.0	9.1	115, 967	1.9*	0.18
Order & Organization	108.1	17.2	115, 967	6.3*	0.43
Rule Clarity	35.3	15.9	115, 967	2.2*	0.21
Teacher Control	46.8	15.2	115, 967	3.1*	0.27
Innovation	32.8	11.1	115, 967	3.0*	0.26

*$p < 0.001$

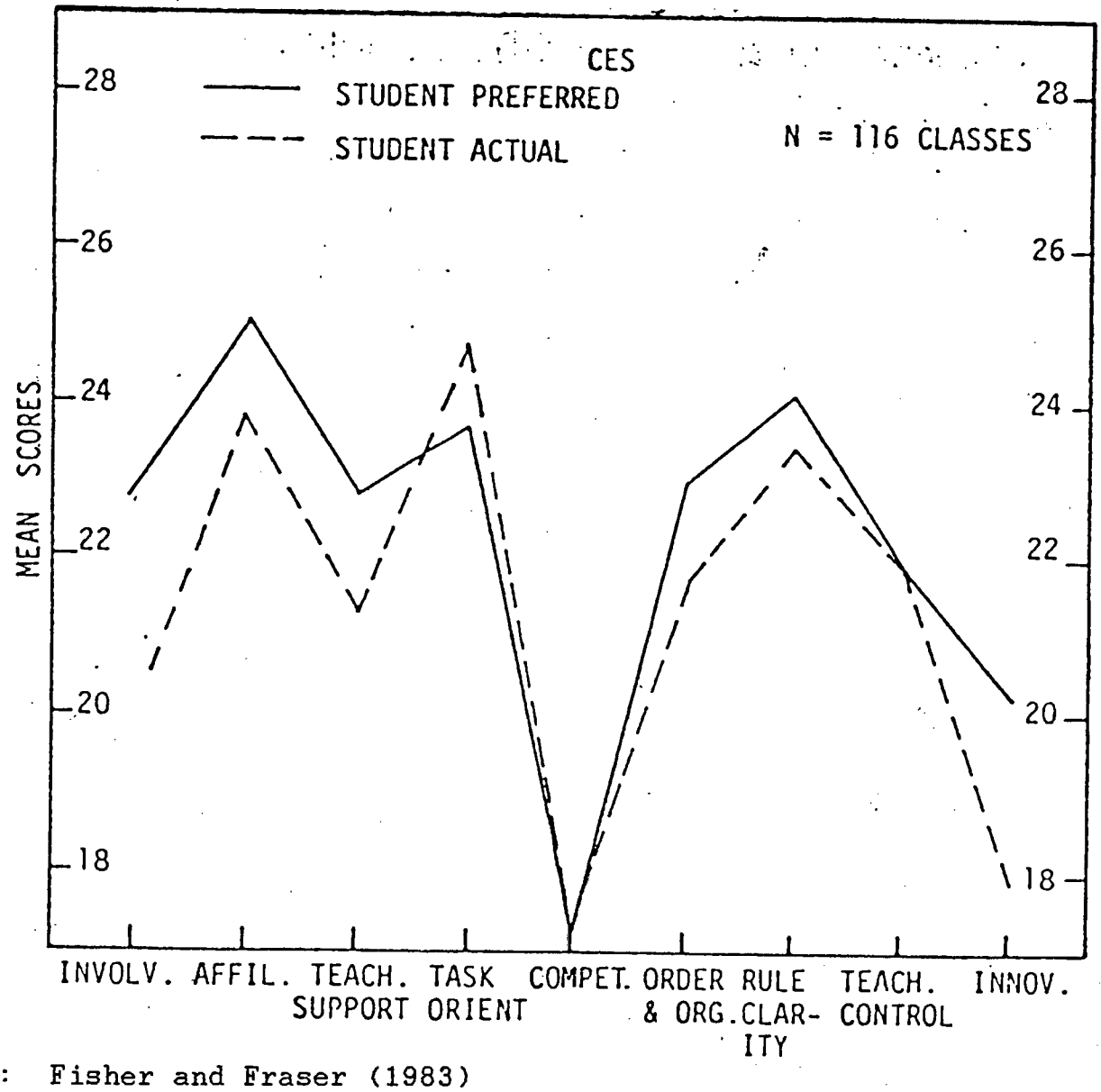
Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by class membership.

Sample size was 1083 junior high school Australian students in 116 classes.

Source: Fraser and Fisher (1984)

Figure 2.1 shows that differences between pupil actual and pupil preferred scores were statistically significant for six of the nine environmental scales of the **CES** ($p < 0.05$). Pupils preferred a more positive environment in terms of a greater emphasis on classroom Involvement, Affiliation, Teacher Support, Order and Organization, Rule Clarity, and Innovation (Fisher and Fraser 1983).

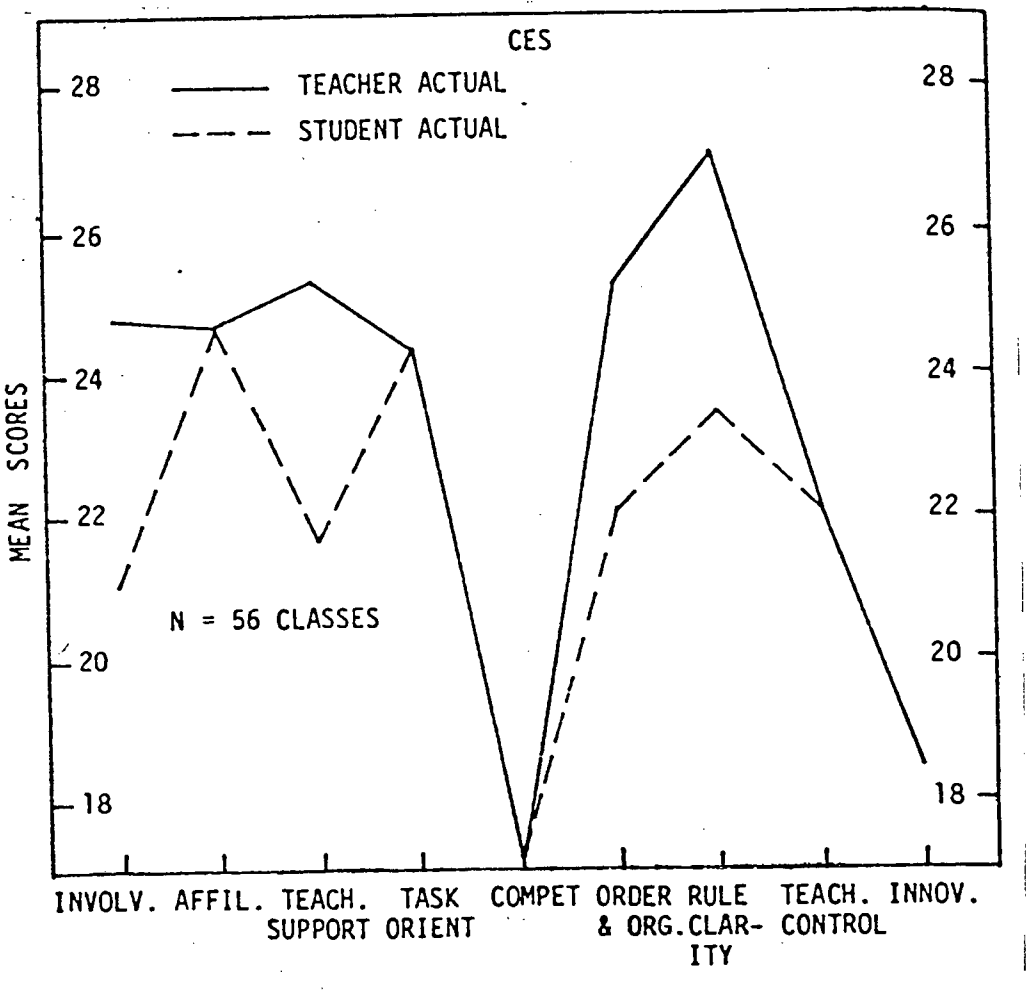
Figure 2.1: Simplified Plot of Significant Differences between Student Preferred and Student Actual Responses using the **CES** in 116 classes



Source: Fisher and Fraser (1983)

Figure 2.2 indicates that significant differences existed between pupil and teacher perceptions of the actual environment of the same classrooms on four of the nine environmental scales of the **CES** ($p < 0.05$). In all the four cases, teachers' scores were appreciably higher than students' scores. Thus teachers perceived their classrooms in terms of a significantly greater emphasis upon Involvement, Teacher Support, Order & Organization, and Rule Clarity (Fisher and Fraser 1983).

Figure 2.2: Simplified Plot of Significant Differences between Teacher Actual and Student Actual Responses using the **CES** in 56 classes



Source: Fisher and Fraser (1983)

2.5.3 ICEQ

Tables 2.7, 2.8 and 2.9 present the names of the five different scales as well as statistical properties of the **ICEQ** (Fraser and Fisher 1984).

Table 2.7: Means and Standard Deviations for each Form of the Long Version of **ICEQ** for a Sample of Australian and Tasmanian High School Students

Scale	Mean				Standard Deviation for Individuals				Standard Deviation for Class Means	
	Student actual (N=1849 or 150)[a]	Student pref. (N=1858 or 150)[a]	Teacher actual (N=90)	Teacher pref. (N=34)	Student actual (N=1849)	Student pref. (N=1858)	Teacher actual (N=90)	Teacher pref. (N=34)	Student actual (N=150)	Student pref. (N=150)
Personalization	32.7	37.2	37.9	42.9	6.7	6.4	5.0	3.5	3.4	3.0
Participation	33.9	36.7	36.5	41.0	5.3	5.4	4.7	4.0	2.5	2.3
Independence	27.8	29.8	26.2	25.7	6.0	6.1	6.0	5.9	3.3	2.7
Investigation	30.1	33.2	31.8	38.7	5.4	5.9	5.5	6.0	2.3	2.7
Differentiation	23.5	25.7	25.0	28.4	6.0	6.6	6.0	5.4	3.9	3.8

[a] Means were approximately the same whether the individual student or the class was used as the unit of analysis.

Source: Fraser and Fisher (1984)

Table 2.8: Internal Consistency (Alpha Reliability) and Discriminant Validity (Mean Correlation of a Scale with Other Four Scales) for each Form of the Long Version of ICEQ for Two Units of Analysis for a Sample of Australian and Tasmanian Students

Scale	Unit of Analysis	Alpha Reliability				Mean Correlation with Other Scales			
		Student actual (N=1849 & 150)[a]	Student pref. (N=1858 & 150)[a]	Teacher actual (N=90)	Teacher pref. (N=34)	Student actual (N=150)	Student pref. (N=150)	Teacher actual (N=90)	Teacher pref. (N=34)
Personalization	Individual	0.79	0.74	0.79	0.74	0.28	0.31	0.32	0.29
	Class	0.90	0.86			0.31	0.35		
Participation	Individual	0.70	0.67	0.79	0.82	0.27	0.29	0.39	0.34
	Class	0.80	0.75			0.32	0.32		
Independence	Individual	0.68	0.70	0.83	0.86	0.07	0.12	0.23	0.25
	Class	0.78	0.79			0.16	0.17		
Investigation	Individual	0.71	0.75	0.80	0.90	0.21	0.27	0.34	0.33
	Class	0.77	0.83			0.29	0.31		
Differentiation	Individual	0.76	0.75	0.85	0.81	0.10	0.16	0.29	0.16
	Class	0.91	0.92			0.19	0.20		

[a] The sample sizes shown are the number of individual students and classes, respectively.

Source: Fraser and Fisher (1984)

Table 2.9: ANOVA Results for Class Membership Differences in Student perceptions on the Actual Form of the Long Version of ICEQ

Scale	MS Between	MS Within	df	F	Eta^2
Personalization	169.4	33.3	149, 1699	5.1*	0.31
Participation	70.4	23.4	149, 1699	3.1*	0.21
Independence	107.8	22.2	149, 1699	4.9*	0.30
Investigation	73.6	26.0	149, 1699	2.8*	0.20
Differentiation	154.8	17.4	149, 1699	8.9*	0.43

* $p<0.001$

Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by class membership.

Sample size was 1849 students in 150 classes.

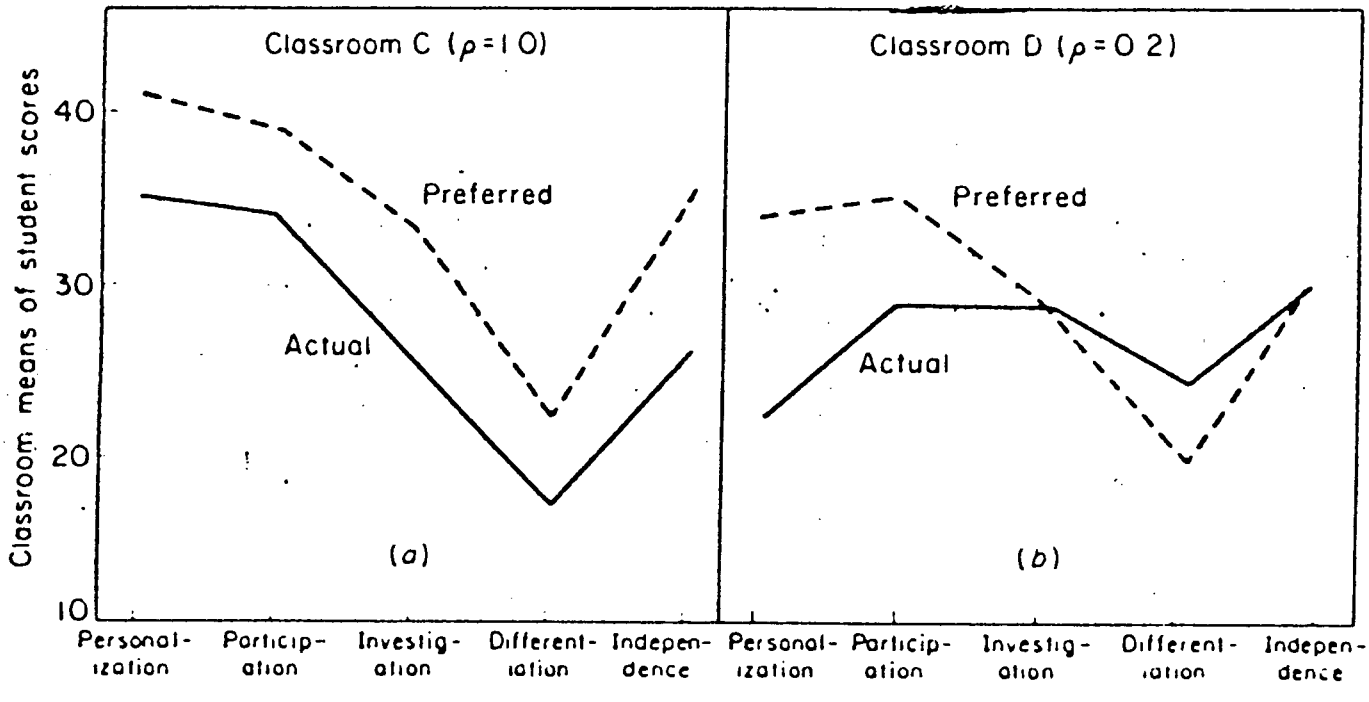
Footnote: The Australian sample was made up of approximately equal numbers of boys and girls, science and social science classes, and schools located in Sydney suburbs and country areas of New South Wales. Thirteen classes were at the Grade 7 level, fourteen were at the Grade 8 level, and seven were at the Grade 9 level.

The Tasmanian sample consisted of Grade 8 and 9 students in 116 classes, each with a different teacher, in 33 schools. Approximately equal numbers of schools were in country and suburban areas, and approximately equal numbers of boys and girls and of Grade 8 and 9 classes made up the sample.

Source: Fraser and Fisher (1984)

Figures 2.3 (a) and (b) indicate that each of the five **ICEQ** scales differentiated significantly ($p < 0.001$) between the perceptions of two different sets of pupils in different classrooms (Fraser 1981b)

Figure 2.3: **(a) and (b)** Simplified Plots of Significant Differences between the Perceptions of two different sets of pupils in different classrooms using the **ICEQ**



Source: Fraser (1981b)

Figure 2.4 shows that differences between pupil actual and pupil preferred scores were statistically significant for all five scales of the **ICEQ** ($p < 0.05$). Pupils tended to prefer a more positive environment in terms of a greater emphasis on classroom Personalization, Participation, Independence, Investigation, and Differentiation (Fisher and Fraser 1983).

Figure 2.4: Simplified Plot of Significant Differences between Student Preferred and Student Actual using the ICEQ in 116 Tasmanian classes

Figure 2.5: Simplified Plot of Significant Differences between Teacher Actual and Student Actual Responses using the ICEQ in 56 Tasmanian classes.

Figure 2.4

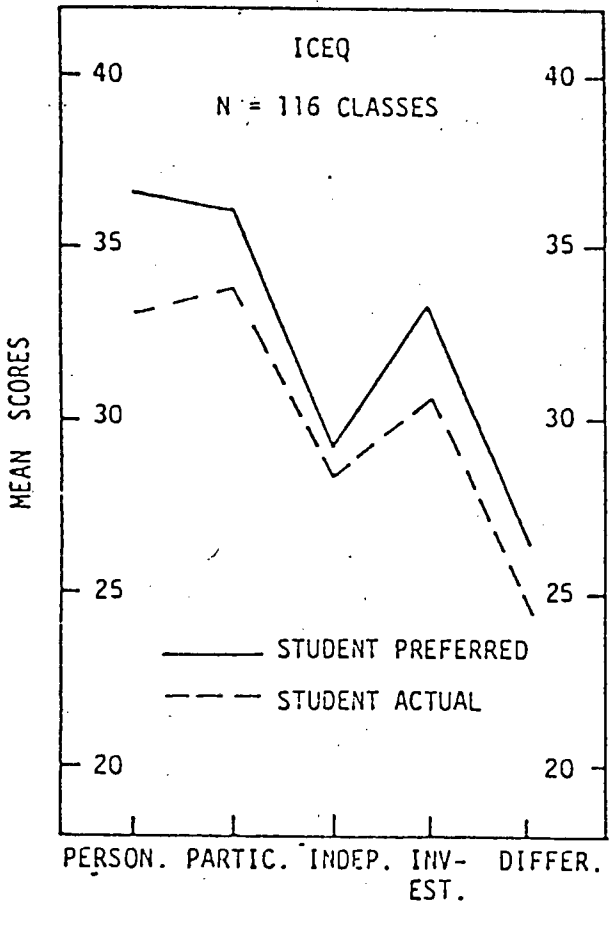
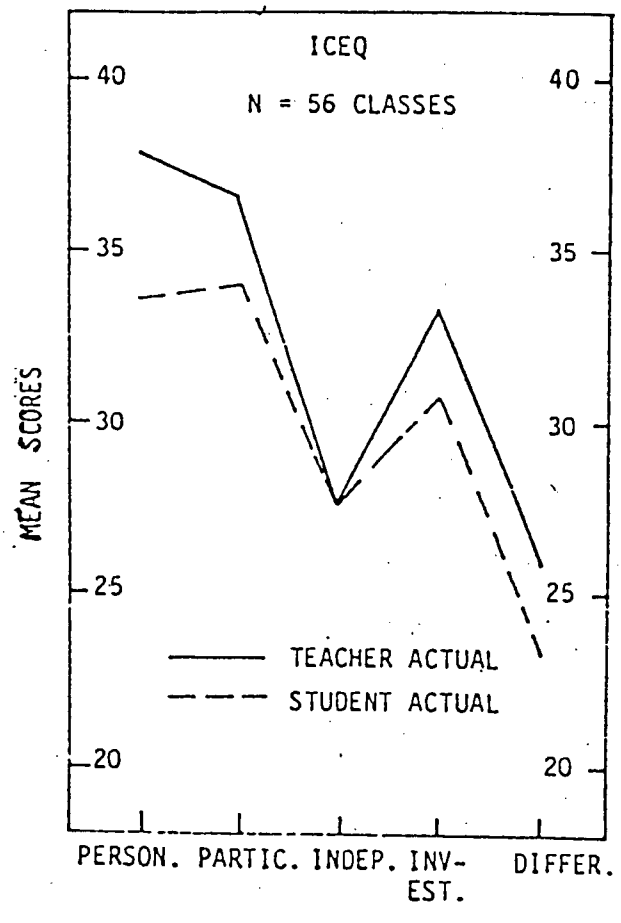


Figure 2.5



Source: Fraser and Fisher (1983)

Figure 2.5 shows that significant differences existed between pupil and teacher perceptions of the actual environment of the same classrooms on four of the five scales in the **ICEQ** ($p < 0.05$). In all of these four cases, teachers' scores were higher than pupils' scores. Thus, teachers perceived their classrooms more positively than the pupils in the same classrooms in terms of a greater emphasis on Personalization, Participation, Investigation, and Differentiation (Fisher and Fraser 1983).

Table 2.10: Means, Standard Deviations, Reliabilities, and Intercorrelations for MCI Scales obtained with a Sample of Australian and Tasmanian Students

Scale	Mean[a]	Standard Deviation		Alpha Reliability		Scale Intercorrelations (N=100)					Mean Correl. with other scales
		Students (N=2305)	Classes (N=100)	Students (N=2305)	Classes (N=100)	Coh	Fri	Dif	Sat	Comp	
Cohesiveness	14.01	3.12	1.41	0.67	0.80	-					0.27
Friction	18.23	3.81	1.92	0.67	0.75	-.41	-				0.30
Difficulty	12.31	3.40	1.44	0.62	0.73	-.17	.17	-			0.20
Satisfaction	18.87	5.08	2.77	0.78	0.88	.36	-.41	-.31	-		0.28
Competitiveness	16.20	3.62	1.51	0.71	0.81	-.13	.20	-.13	.05	-	0.13

[a]Means were approximately the same for both the student and the class as the unit of analysis.

Footnote: The sample consisted of 2305 seventh grade students in 100 science classes in 30 schools throughout Tasmania and Australia.

Source: Fraser and Fisher (1984)

2.5.4 MCI

Table 2.10 presents a set of the statistical parameters and intercorrelations for the **MCI** scales obtained with a sample of 2305 Australian pupils (Fraser and Fisher 1984).

2.5.5 CUCEI

Table 2.11 shows that, for the four forms of the instrument, the values obtained for the alpha coefficient ranged from 0.53 to 0.90 with the individual as the unit of analysis and from 0.78 to 0.96 with the class as the unit of analysis. These data together suggest that each **CUCEI** scale has adequate internal consistency, especially for scales containing only seven items each, in both its actual and preferred forms, for both students and instructors, and with either the individual or the class mean as the unit of analysis (Fraser and Treagust 1986; Fraser, Treagust, Williamson and Tobin 1987).

Table 2.11 also reports data on the discriminant validity (using the mean correlation of a scale with the other six scales as a convenient index) for each of the four forms of the **CUCEI** using the individual and the class as the unit of analysis. These values are acceptable and suggest that each **CUCEI** scale has adequate discriminant validity for use in its actual and preferred forms, with students and instructors, and for two units of analysis.

It appears that the **CUCEI** measures distinct - although somewhat overlapping - aspects of classroom environment; but, the conceptual distinctions among scales are important enough to retain the seven dimensions within the instrument (Fraser, Treagust, Williamson and Tobin 1987).

The ANOVA results in **Table 2.11** also indicate that each scale differentiated significantly ($p < 0.001$) between classroom environments. The eta -statistic, which is the ratio of between to total sums of squares, was calculated as an estimate of the amount of variance in **CUCEI** scores related to class membership. The proportion of variance accounted for by class membership ranged fromn 0.32 for Satisfaction to 0.47 for Student Cohesiveness (Fraser, Treagust, Williamson and Tobin 1987).

Table 2.12 presents further cross-validition data for the **CUCEI**, an evaluation study done by Williamson, Tobin and Fraser (1986) involving a sample of 742 adolescent and adult learners in 62 classes in alternative high schools, conventional high schools, and adult education classes at evening technical colleges in Perth, Western Australia (Fraser, Treagust, Williamson and Tobin 1987).

Table 2.11: CUCEI Internal Consistency Reliability (Alpha Coefficient) and Discriminant Validity for Two Units of Analysis and ANOVA Results for Class Membership Differences

Scale	Unit of Analysis	Alpha Reliability				Mean Correlation with Other Scales				ANOVA Results	
		Student actual	Student pref.	Instr. actual	Instr. pref.	Student actual	Student pref.	Instr. actual	Instr. pref.	Student actual F	Eta²
Personal-ization	Indiv.	0.75	0.68	0.60	0.67	0.46	0.42	0.28	0.32	5.5*	0.35
	Class	0.85	0.81			0.53	0.50				
Involvement	Indiv.	0.70	0.65	0.54	0.76	0.47	0.41	0.34	0.44	6.9*	0.40
	Class	0.81	0.79			0.56	0.55				
Student Cohesiveness	Indiv.	0.90	0.78	0.83	0.70	0.45	0.39	0.29	0.38	9.2*	0.47
	Class	0.95	0.90			0.48	0.44				
Satisfaction	Indiv.	0.88	0.82	0.53	0.82	0.45	0.40	0.14	0.25	4.7*	0.32
	Class	0.96	0.90			0.53	0.57				
Task Orien-tation	Indiv.	0.75	0.63	0.74	0.77	0.38	0.33	0.40	0.26	7.6*	0.43
	Class	0.85	0.78			0.41	0.38				
Innovation	Indiv.	0.81	0.70	0.55	0.55	0.46	0.41	0.24	0.15	7.1*	0.41
	Class	0.93	0.82			0.53	0.50				
Individuali-zation	Indiv.	0.78	0.67	0.83	0.82	0.34	0.32	0.35	0.25	8.9*	0.46
	Class	0.89	0.80			0.36	0.36				

* $p < 0.001$

Source: Fraser, Treagust, Williamson and Tobin (1987)

Footnote: The 372 student sample was made up of, first, 307 students in 30 postgraduate and undergraduate classes in a variety of disciplines (including education, biology, mathematics, communications, and psychology) in two multi-purpose higher education institutions in Perth, Western Australia and, second, 65 postgarduate and undergraduate students in four education classes in university in Illinois, USA. The group of instructors consisted of a subsample of 20 of the 30 different teachers (16 Australian and 4 American) teaching these 34 classes.

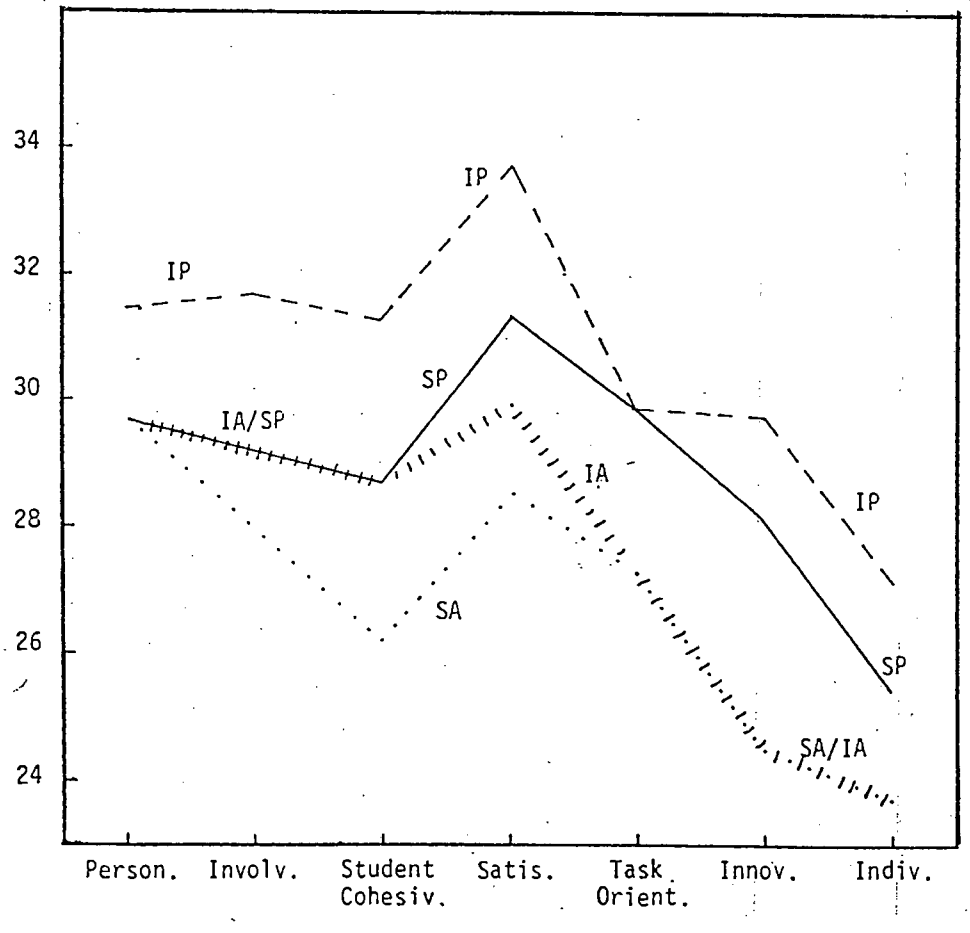
Table 2.12: Internal Consistency and Discriminant Validity for Actual and Preferred Forms of CUCEI for a different sample (N = 742)

Scale	Form	Alpha Reliability	Mean Correlation with Other Scales
Personalization	Actual	0.80	0.49
	Pref.	0.72	0.47
Involvement	Actual	0.70	0.47
	Pref.	0.64	0.46
Student Cohesiveness	Actual	0.84	0.23
	Pref.	0.80	0.45
Satisfaction	Actual	0.87	0.49
	Pref.	0.82	0.48
Task Orient-ation	Actual	0.70	0.40
	Pref.	0.71	0.43
Innovation	Actual	0.72	0.46
	Pref.	0.73	0.40
Individualization	Actual	0.74	0.35
	Pref.	0.73	0.30

Source: Fraser, Treagust, Williamson and Tobin (1987)

Figure 2.6 provides the simplified plots of statistically significant differences between the various forms of the **CUCEI** which involved a sample of 20 instructors and the 20 classes taught by these instructors (Fraser 1989).

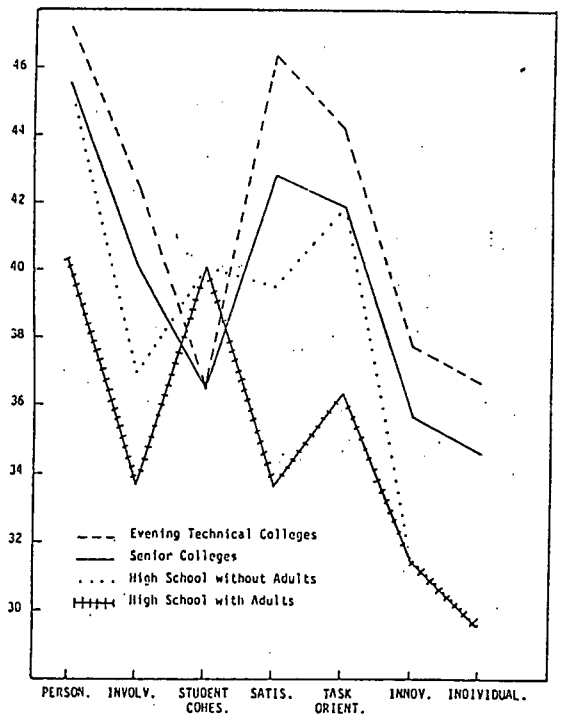
Figure 2.6: Simplified Plot of Significant Differences between Student Actual (SA), Student Preferred (SP), Instructor Actual (IA), and Instructor Preferred (IP) perceptions using the **CUCEI**



Source: Fraser (1989)

Figure 2.7 shows the classroom environment profiles for four types of schools (Fraser, Treagust, Williamson and Tobin 1987).

Figure 2.7: Simplified Plot of the Classroom Environment Profiles for Four Types of Schools using the CUCEI



Footnote: The sample of senior college students (adult learners) in Perth, Western Australia was 536 students in 45 classes. The first control group consisted of 87 students in 11 classes in two technical colleges which offer evening courses which adult students can attend out of personal interest. The second control group consisted of 62 students in three Grade 11 or 12 classes in a conventional high school in which adult students were enrolled but integrated into the classes containing adolescent learners. The third control group consisted of 57 students in three Grade 11 or 12 classes at a conventional high school catering only for adolescents.

Source: Fraser, Treagust, Williamson and Tobin (1987)

The most favourable environments were evident in the evening technical colleges; the next most favourable environments were found in the senior colleges; the third most favourable environment emerged in the conventional high schools catering only for adolescents; and the least favourable environment occurred in the conventional high school which integrated adults with adolescents within the same classes.

The only exception to this overall trend emerged on the Student Cohesiveness dimension in that cohesiveness was higher in the conventional high schools than in either the evening technical colleges or the senior colleges (Fraser, Treagust, Williamson and Tobin 1987).

2.5.6 SLEI

The unrefined version of the **SLEI** contained 72 items altogether, with nine items belonging to each of the eight scales (Giddings and Fraser 1989). After item analysis, the refined version of the **SLEI** contained 56 items altogether, with seven items belonging to each of the eight scales (Fraser 1989).

Validation data for the **SLEI** are provided for the Australian and the USA samples only (Giddings and Fraser 1989). **Table 2.13** shows that, for the sample of Australian school students, the values obtained for the alpha coefficient ranged from 0.56 to 0.85 for the actual form and from 0.55 to 0.71 for the preferred form.

Data for the other samples, namely, the American university students and the American school students, compared favourably with the Australian values (Giddings and Fraser 1989).

Discriminant validity data indicate the scale indices ranged from 0.24 to 0.49 for the actual form for the sample of 293 Australian school students. Comparable values were obtained for the other two samples (Giddings and Fraser 1989).

Table 2.13: Cronbach Alpha Reliability Coefficients for Actual and Preferred Forms of SLEI for Three Different Samples

		Alpha Reliability		
Scale	Form	USA school students (N=902)	USA university students (N=583)	Australian school students (N=293)
Teacher Supportiveness	Actual	0.83	0.84	0.77
	Pref.	0.78	0.78	0.61
Involvement	Actual	0.66	0.50	0.66
	Pref.	0.61	0.65	0.55
Student Cohesiveness	Actual	0.82	0.75	0.81
	Pref.	0.77	0.75	0.66
Open-Endedness	Actual	0.69	0.43	0.56
	Pref.	0.63	0.56	0.57
Integration	Actual	0.83	0.88	0.85
	Pref.	0.80	0.81	0.71
Organization	Actual	0.82	0.79	0.82
	Pref.	0.78	0.80	0.70
Rule Clarity	Actual	0.79	0.75	0.70
	Pref.	0.74	0.72	0.63
Material Environment	Actual	0.76	0.74	0.80
	Pref.	0.77	0.76	0.70

Source: Giddings and Fraser (1989)

The ability of the SLEI to differentiate between classroom environments was indicated by the findings that each scale differentiated significantly ($p < 0.001$) between classrooms for each sample of students (Giddings and Fraser 1989).

2.6 Uses of the Different Instruments

2.6.1 LEI

The strongest tradition with the **LEI** in prior research has involved investigation of appreciable associations between student learning outcomes and their perceptions of classroom environment in the USA (Walberg 1969, 1972; Lawrenz 1976 (a) and (b), 1987), Canada (Walberg and Anderson 1972), Australia (Fraser 1979; Power and Tisher 1979), Israel (Hofstein et al 1979) and India (Walberg, Singh and Rasher 1977).

In other studies the **LEI** has been used for curriculum evaluation purposes (Anderson, Walberg and Welch 1969; Fraser 1979; Levin 1980), or to relate classroom environment significantly to other variables including teacher personality (Walberg 1968), class size (Walberg 1969; Anderson and Walberg 1972), grade level (Welch 1979), subject matter (Anderson 1971; Kuert 1979) and type of school (Hofstein et al 1980; Sharon and Yaakobi 1981), attitudes (Lin and Crawley 1987).

2.6.2 CES

Several studies using the **CES** have established associations between students' outcomes such as satisfaction and mood criteria, absences and grades, achievement, attitudes and their perceptions of classroom environment as measured by Trickett and Moos 1973; Moos and Moos 1978; and Fisher and Fraser 1983.

Other studies have used the **CES** to investigate differences between students and teachers in their perceptions of classroom environment (Fisher and Fraser 1983), relationships between subject matter and classroom environment (Hearn and Moos 1978), differences in the classroom environment of different types of school (Trickett 1978), and whether students achieve significantly better when in their preferred classroom environment (Fraser and Fisher 1983).

2.6.3 ICEQ

Several studies using the **ICEQ** have established associations between pupils' outcomes and their perceptions of classroom environment (Rentoul and Fraser 1980; Fraser 1981a; Fraser and Butts 1982; Fraser, Pearse and Azmi 1982). Other studies have used the **ICEQ** to investigate the differences between scores on various forms of the **ICEQ** (Fraser 1982; Fisher and Fraser 1983), evaluation of educational innovations (Fraser 1981b), person-environment fit studies (Fraser and Rentoul 1980; Rentoul and Fraser 1980), and practical attempts to improve classroom environments (Fraser 1981; Fraser, Seddon and Eagleson 1982; Fraser and Deer 1983; Fraser and Fisher 1986).

2.6.4 MCI

Fraser and Deer (1983) reported the successful use of a preferred form of the short version of the **MCI**. Published reports include investigations of outcome-environment relationships (Talmage and Walberg 1978; Boulanger 1980; Fraser and Fisher 1982; MacAulay 1990), a curriculum evaluation study (Talmage and Hart 1977) and a practical attempt to improve classroom environments (Fraser and Deer 1983).

2.6.5 CUCEI

Fraser, Treagust, Williamson and Tobin (1987) successfully reported the research applications of the **CUCEI**, which are an investigation of associations between student outcomes and the nature of the classroom environment, a study of differences between students and instructors in their perceptions of actual and preferred classroom environment, and an evaluation of some alternative high schools.

The first of these studies provided some evidence that the nature of the classroom environment affects students' academic outcomes.

The second study suggested that both students and instructors preferred a more favourable classroom environment than the one actually present, and that instructors viewed classroom environments more favourably than did their students in the same classrooms.

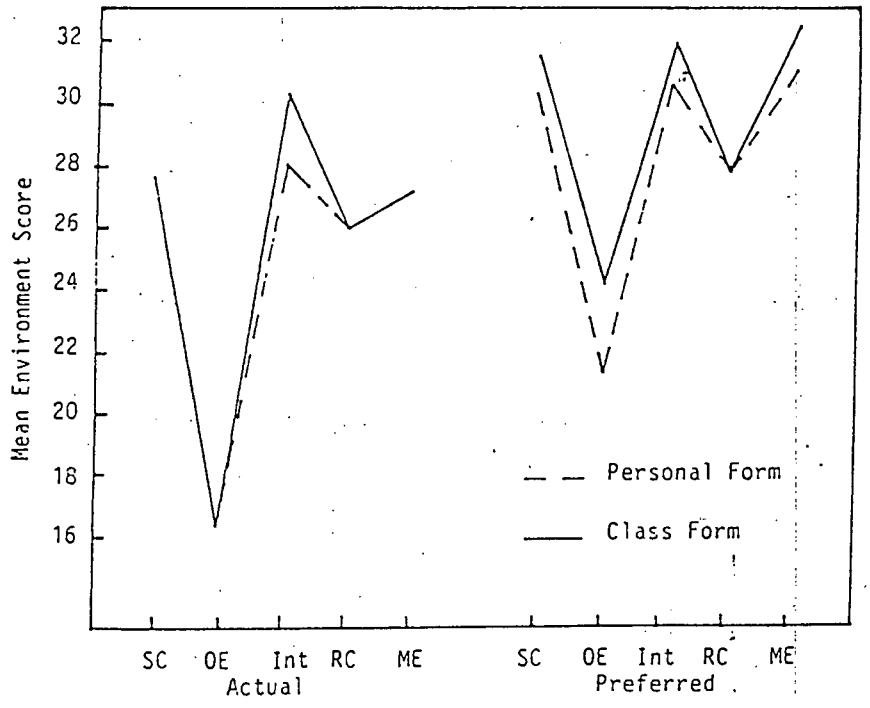
The third study attested to the usefulness of the **CUCEI** in evaluation studies in that revealing differences were detected in the classroom environments of alternative and conventional high schools (Fraser, Treagust, Williamson and Tobin 1987).

2.6.6 SLEI

Fraser, Giddings and McRobbie (March 1992), successfully reported on the applications of the **SLEI** for the cross-validation sample of 516 students in 56 classes. First, their finding replicates past research which has highlighted that closed-ended laboratory exercises dominate much of science education to the exclusion of more desirable open-ended activities (e.g. Hodson 1988; Lumpe and Scharmann 1991 in Fraser, Giddings and McRobbie 1992). The very low mean scores on the actual version of the Open-Endedness scale in **Figure 2.8** confirmed this. A further check on the level of open-endedness prevalent in science laboratory classrooms is the six-countries sample of school and university students. Again the mean score on the actual version of the Open- Endedness scale was extremely low relative to the **SLEI's** other dimensions, in all six countries and at both the school and university levels.

Students seem to have a more positive view of the environment as it applies to the class as a whole (Class Form) than when the focus is on the student's own role within that classroom environment (Personal Form), which is consistent with the fact that teachers perceive classrooms more favourably than their students. This pattern becomes more pronounced for the preferred version than for the actual version (see **Figure 2.8**).

Figure 2.8: Simplified Plot of Significant Differences in the Scale Means for the Personal and Class Forms of SLEI



Source: Fraser, Giddings and McRobbie (1992)

Their results in terms of gender differences in perceptions of science laboratory classrooms replicate previous research findings which have shown that females tend to hold more favourable perceptions of classroom environments than do males (Lawrenz 1987; McRobbie, Giddings and Fraser 1990, 1991; Fraser, Giddings and McRobbie 1992).

2.7 Chapter Summary

The historical development of the assessment of classroom psychosocial environments, the difference between school-level and classroom-level environment, the different classroom environment instruments, their statistical validation and their uses have been described in this chapter. The experimental design of this investigation follows in **Chapter 3.**

CHAPTER 3: EXPERIMENTAL DESIGN

3.1 The Setting for the Investigation

This research study investigates the perceptions of the actual and the preferred science laboratory classroom learning environments at the **Hewat College of Education** in Athlone, Cape Town, South Africa where the writer lectures in Science and in Biology to first, second and third year tertiary education students.

3.2 The Sample Selected

In September 1990 the **SLEI** was administered to more than 264 science and biology college students in sixteen classes, taught by a team of three bilingual male lecturers.

Table 3.1 describes the characteristics of the sample and presents the spread of science subjects to include Science Higher Grade; and Science Elementary Grade for first year students; and Biology for second and third year students. The second and third year Biology students were tertiary students in three different course levels, namely the Junior Primary course (levels 1 to 3, pupil age range 7 to 9 years), the Senior Primary course (levels 4 to 6, pupil age range 10 to 13 years), and the Practical Specialization course.

Table 3.1: Description of the Sample

	Code	Abs. Freq.	Rel. Freq. (%)
Lecturer	1	85	32.2
	2	101	38.3
	3	78	29.5
Total		264	100.0

	Code	Abs. Freq.	Rel. Freq. (%)
Year Level	1	86	32.6
	2	136	51.5
	3	42	15.9
Total		264	100.0

	Code	Abs. Freq.	Rel. Freq. (%)
Gender	M	118	44.7
	F	146	55.3
Total		264	100.0

	Code	Abs. Freq.	Rel. Freq. (%)
Language	Eng	148	56.1
	Afr	116	43.9
Total		264	100.0

Year Level	Subject	Abs. Freq.	Rel. Freq.(%)
1	Science HG	34	12.9
	Science EG	52	19.7
2	Biology	136	51.5
3	Biology	42	15.9
Total		264	100.0

Year Level	No of Classes	Rel. Freq. (%)
1	6	37.5
2	8	50.0
3	2	12.5
Total	16	100.0

The sample consisted of 44.7% male students (N = 118) and 53.3% female students (N = 146); 56.1 % English language medium students (N= 148) and 43.9 % Afrikaans language medium students (N = 116). Six of the classes were at the first year level (N =86), eight were at the second year level (N = 136) and two were at the third year level (N = 42); 39.5 % of the first year students studied Science Higher Grade (N = 34) and 60.5 % studied Science Elementary Grade (N = 52).

3.3 Selection of Research Method

Permission was obtained from the Department of Education and Culture in the House of Representatives to carry out this investigation with college students. A copy of the letter of approval from the Department is attached in **Appendix B**.

SLEI was translated from English into Afrikaans and the accuracy was checked by experts fluent in both languages using the back-translation technique.

Each of the three different lecturers involved in the research study administered the **SLEI**, both actual and preferred forms, to his students during normal lecturing time, after a thorough briefing session with the writer. The directions for responding were also supplied to the lecturers with the **SLEI** questionnaires.

A separate answer sheet was handed to each student. Students who did not respond to both actual and preferred forms of SLEI were excluded from the final sample of 264 students and their scores were omitted from the statistical analysis of results.

The actual and preferred forms of SLEI were administered two weeks apart, because of time-table constraints and in the order of first the actual form and then the preferred form with all classes.

3.4 Selection of the Instrument, its Validation and Refinement to suit local conditions

The **Science Laboratory Environment Inventory (SLEI)** was developed in Australia by Barry J Fraser and Geoff Giddings (1989). The **SLEI** is suitable for use at the senior high school level and the higher education level (Fraser and Giddings 1989; Giddings and Fraser 1989). It has been field-tested in its unrefined version and in its various stages of validation and refinement with students in six different countries, namely, Australia, the U.S.A., Canada, England, Israel and Nigeria (Giddings and Fraser 1989; McRobbie, Giddings and Fraser 1990; McRobbie, Giddings and Fraser 1991; Fraser, Giddings and McRobbie 1992).

Fraser and Giddings have forwarded a copy of the unrefined version of **SLEI** to the writer, and have given permission for the use of **SLEI** in the present investigation (see **Appendix A**). A copy of the actual form of **SLEI** and its Afrikaans version are attached in **Appendices C** and **D**.

The present research study was implemented by the writer using the unrefined **SLEI** 72-item version. Thus it may be viewed as a preliminary study to extend the validation and refinement of **SLEI**. For the first time the validity and reliability of Afrikaans versions are being assessed. These results can also corroborate the previous research work undertaken by Giddings and Fraser 1989; McRobbie, Giddings and Fraser 1990, 1991; Fraser, Giddings and McRobbie 1992) in a cross- national study with tertiary students from the six countries, mentioned above. South Africa has become the seventh pioneering country in this cross-national study, with great potential for further investigation due to its closely knitted geographical distribution of languages and cultures.

3.5 Properties of the Instrument and its Scales

Descriptive information for each scale in the actual form of the **SLEI** as well as sample items appear in **Table 3.2** (Giddings and Fraser 1989).

Table 3.2: Descriptive Information for Each Scale in the Science Laboratory Environment Inventory (SLEI)

Scale Name	Moos Category	Description	Sample Item
Teacher Supportiveness	R	Extent to which the teacher/ instructor is helpful and shows concern for all students.	The teacher is concerned about students' safety laboratory sessions. (+)
Involvement	R	Extent to which students participate actively and attentively in laboratory activities and discussions.	During laboratory group work students leave it to their partners to do all the work. (-)
Student Cohesiveness	R	Extent to which students know, help and are supportive of one another.	Students in this laboratory class get along well as a group. (+)
Open-Endedness	P	Extent to which the laboratory activities emphasize an open-ended, divergent, individualized approach to experimentation.	We know the results that we are supposed to get before we commence a laboratory activity. (-)
Integration	P	Extent to which the laboratory activities are integrated with non-laboratory and theory classes.	We use the theory from our regular science class sessions during laboratory activities. (+)
Organization	S	Extent to which the laboratory activities are clearly defined and well organized.	There is confusion during laboratory classes. (-)
Rule Clarity	S	Extent to which behaviour in the laboratory is guided by formal rules.	There is a recognised way of doing things safely in this laboratory. (+)
Material Environment	S	Extent to which the laboratory equipment and materials are adequate.	The laboratory is too crowded when we are doing experiments. (-)

R: Relationship Dimension; P: Personal Development Dimension; S: System Maintenance and System Change Dimension

Items designated (+) are scored 1, 2, 3, 4, and 5 respectively for the responses Almost Never, Seldom, Sometimes, Often and Very Often. Items designated (-) are scored in the reverse manner. Omitted or invalid responses are scored 3.

Source: Giddings and Fraser (1989)

Table 3.2 clarifies the meaning of each **SLEI** scale by providing its classification according to Moos' scheme, a scale description and sample items and scoring instructions and directions. The unrefined **SLEI** comprises 72 items, with nine items assessing responses to each of the eight scales.

The wording of the preferred form is almost identical except for the use of words such as "would". For example, the item "The teacher/instructor goes out of his way to help students" in the actual form is reworded in the preferred form to read "The teacher/instructor would go out of his/her way to help students." Copies of the preferred form of **SLEI**, together with its translated Afrikaans version are attached in **Appendices E** and **F**.

Items in the instruments are arranged in cyclic order so that the first, second, third, fourth, fifth, sixth, seventh and eighth items respectively, in each block, measure Teacher Supportiveness, Involvement, Student Cohesiveness, Open-Endedness, Integration, Organization, Rule Clarity and Material Environment.

Items whose item numbers are not underlined are scored 1, 2, 3, 4 and 5, respectively, for the responses Almost Never, Seldom, Sometimes, Often and Very Often. Underlined items are scored in the reverse manner (i.e. 5, 4, 3, 2 and 1 respectively for Almost Never, Seldom, Sometimes, Often and Very Often). Omitted or invalidly answered items are scored 3 (after Giddings and Fraser 1989).

3.6 Procedure for the Administration of the Instruments, and Data Collation

In September 1990, first the actual and then, two weeks later, the preferred form of **SLEI** were administered by the three different lecturers to more than 264 students. Each lecturer administered both the actual and the preferred forms of **SLEI** to his students during normal lecturing time, after a thorough briefing session with the writer. Directions for responding were also supplied to the lecturers. The answer sheets facilitated ready hand scoring because students had to respond to the items of **SLEI** by circling a number on their answer sheets corresponding to the alternatives (see **Appendices G** and **H**).

The scores of those students who responded to only one of the two forms of **SLEI** were omitted from the statistical analysis of this study.

The units of analysis are the individual student means and the class means, since these have been used in past research studies with which the present study compares (Haertel, Walberg and Haertel 1981; Fraser and Fisher 1982, 1983, 1984, 1986; Fraser and Butts 1982; Fraser, Pearse and Azmi 1982; Fraser 1986 a & b; Fraser and Treagust 1986; Schibeci, Rideng and Fraser 1987; Fraser and Giddings 1989; McRobbie, Giddings and Fraser 1990, 1991; Fraser, Giddings and McRobbie 1992).

The choice of unit of analysis is of utmost importance for a number of reasons. First, measures having the same operational definition can have different substantive interpretations with different levels of aggregation. Second, it is possible that relationships obtained using one unit of analysis could differ in magnitude and even in sign from relationships obtained using another unit. Third, the use of certain units of analysis (e.g., individuals when classes are the primary sampling units) violates the requirement of independence of observations and calls into question the results of any statistical significance tests because an unjustifiably small of the sampling error is used. One solution to this dilemma followed in recent research is to use the individual as the unit of analysis but to employ the Jack-knife technique or the Bootstrap technique to adjust significance levels to allow for non-independence of observations. Fourth, the use of different units of analysis involves the testing of conceptually different hypotheses (Fraser 1986b; Fraser, Giddings and McRobbie 1992).

The means and standard deviations of each scale of both the actual and preferred forms of **SLEI** will be calculated for the student samples. The alpha reliability to determine the internal consistency and the discriminant validity for each form of **SLEI**, both actual and preferred, will be calculated for the two units of analysis. ANOVAS will also be employed to establish the existence of significant differences among various groups.

3.7 Format of the Statistical Analyses

The statistical data and results will be displayed in tables and in simple plots depicting the signifcant differences between mean scores. Data will also be analysed and interpreted to support or refute the seven hypotheses and to answer the various research questions posed.

3.8 Chapter Summary

The experimental design for this research study and methodology have been described in this chapter and the research instruments discussed. The findings of the research study are presented in **Chapter 4**.

CHAPTER 4: PRESENTAION AND ANALYSIS OF THE DATA - RESULTS

4.1 Introduction

This chapter reports the findings of the empirical study undertaken to examine differences between student perceptions of the actual and the preferred science laboratory classroom learning environments at a South African College of Education. The selected College of Education is the Hewat College of Education, in Cape Town where the writer lectures in Science and in Biology to first, second and third year students.

First, the units of analysis and the properties of the instrument used, together with its scales, are discussed. Then, the statistical analyses testing the hypotheses detailed in **Chapter 1**, are presented. A discussion of the results contained in this chapter, and an attempt to provide answers to the research questions posed at the beginning of the investigation will follow in **Chapter 5**. A discussion of the implications of the results, as well as a summary, conclusions and recommendations follow in **Chapter 6**.

4.2 Units of Analysis

The units of analysis are the individual student and the **SLEI** class means, as these have been used commonly in past research studies (Haertel, Walberg and Haertel 1981; Fraser and Fisher 1982, 1983, 1984, 1986; Fraser and Butts 1982; Fraser, Pearse and Azmi 1982; Fraser and Treagust 1986; Schibeci, Rideng and Fraser 1987; Giddings and Fraser 1989; McRobbie, Giddings and Fraser 1990, 1991; Fraser, Giddings and McRobbie 1992).

The importance and consequences of the choice of these units of analysis are acknowledged by a growing body of literature. There are a number of reasons for this, of which the testing of conceptually different hypotheses is one of the main reasons.

For example, use of the individual as the unit of analysis (i.e., a between-student analysis) involves questions about whether students who score higher on environment measures also score higher on outcome measures when class membership is disregarded, and use of the class mean as the unit of analysis (i.e., a between-class analysis) asks whether classes higher than average on environment scores also achieve higher than average on outcome measures (Fraser, Giddings and McRobbie 1992).

4.3 Profile of the Sample

The sample as presented in **Table 3.1**, in **Chapter 3**, consisted of 264 college education students in 16 classes at the Hewat College of Education in Athlone, Cape Town. The spread of science subjects includes Science Higher Grade and Science Elementary for first year students; and Biology for second and third year students. The sixteen classes were taught by a team of three male lecturers.

4.4 South African Parameters and Properties of SLEI

4.4.1 Means and Standard Deviations

Preliminary means for the actual and preferred forms of the **SLEI** are presented here for the unrefined version of the scales. **Table 4.1** presents the scale means and standard deviations obtained for individuals and classes for both forms of **SLEI**.

As anticipated from **Figure 4.1** and **Figure 4.2**, the means for the preferred scales for both units of analysis are higher than the means for the actual scales. The means for the actual scales ranged from 23.57 for Open-Endedness to 37.58 for Teacher Supportiveness using the individual as the unit of analysis. The means for the preferred scales ranged from 30.84 for Open-Endedness to 39.77 for Teacher Supportiveness using the individual as the unit of analysis.

Table 4.1: Scale Means and Standard Deviations for South African Individual Students and College Classes for both Forms of SLEI

		Individuals (N = 264)		Classes (N = 16)	
Scale	Form	Mean	SD	Mean	SD
Teacher Supportiveness	Act.	37.58	4.71	37.91	4.04
	Pref.	39.77	4.49	39.94	3.75
Involvement	Act.	33.12	5.19	33.07	4.68
	Pref.	36.69	4.15	36.66	3.77
Student Cohesiveness	Act.	36.25	4.61	36.34	4.20
	Pref.	39.29	5.04	39.63	4.26
Open-Endedness	Act.	23.57	4.59	23.69	4.19
	Pref.	30.84	5.56	30.90	4.40
Integration	Act.	35.04	6.67	35.19	6.30
	Pref.	37.23	4.59	37.28	4.15
Organization	Act.	33.81	5.75	34.06	4.99
	Pref.	37.31	5.59	37.51	4.59
Rule Clarity	Act.	30.19	6.56	30.34	5.51
	Pref.	35.65	3.97	35.58	3.43
Material Environment	Act.	33.82	6.10	34.07	5.28
	Pref.	39.41	4.09	39.47	3.44

Figure 4.1

Simplified Plot of Significant Differences between the Forms (Actual and Preferred) of SLEI for South African College Students' Perceptions with the Individual as the Unit of Analysis using the Mean Scores

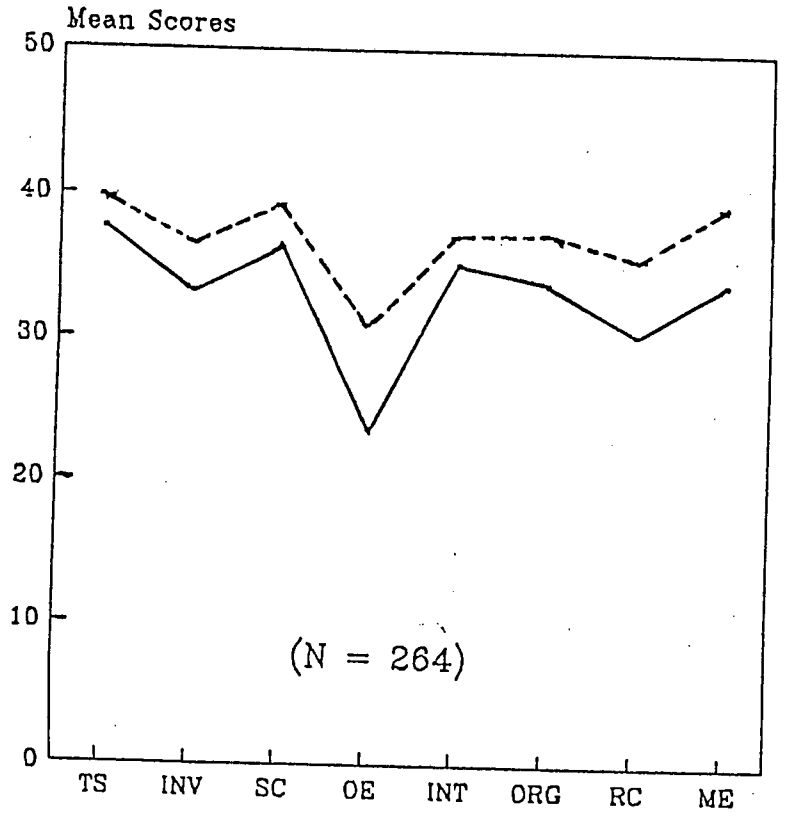
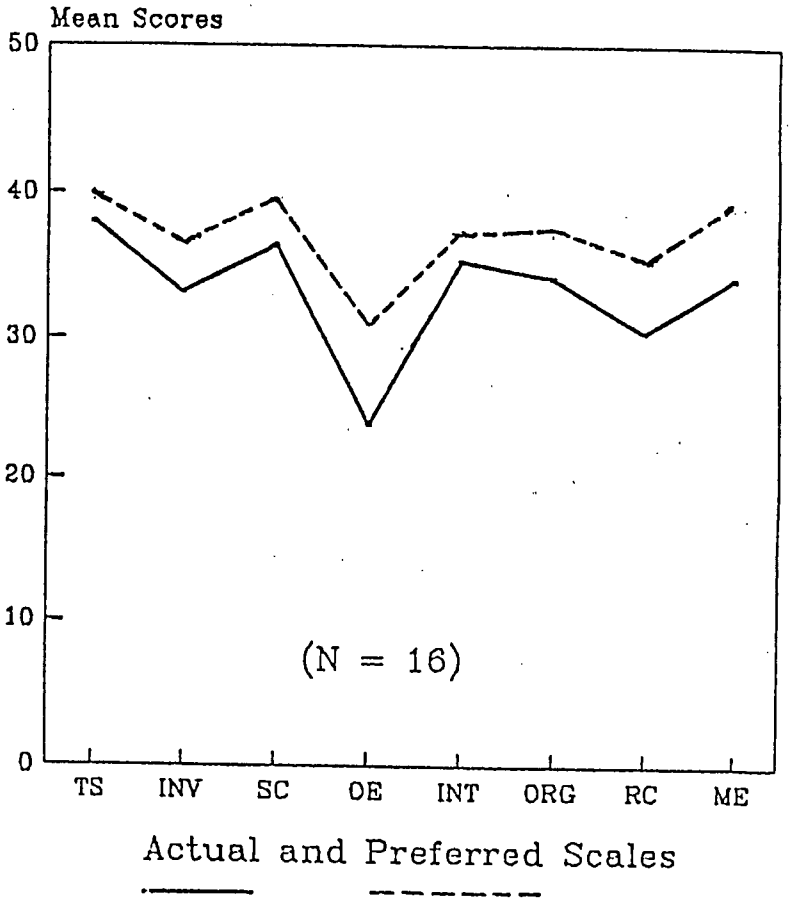


Figure 4.2

Simplified Plot of Significant Differences between the Forms (Actual and Preferred) of SLEI for South African College Students' Perceptions with the Class as the Unit of Analysis using the Mean Scores



The standard deviations are smaller for class means as the unit of analysis than for the means based on individual scores in both actual and preferred scales. The data reported in **Table 4.1** and indicated by **Figures 4.1** and **4.2** are consistent with and corroborate data obtained in previous research studies, such as the means, standard deviations and actual-preferred differences (Fraser, Pearse and Azmi 1982; Fraser 1982; Fisher and Fraser 1983; Fraser and Fisher 1984; Fraser and Treagust 1986; Giddings and Fraser 1989; McRobbie, Giddings and Fraser 1990, 1991; Fraser, Giddings and McRobbie 1992).

4.4.2 Internal Consistency Reliability (Alpha Reliability)

The first index of validity reported is the scale reliability in **Table 4.2**. Estimates of the internal consistency of the actual and preferred forms of each **SLEI** scale were calculated using Cronbach's alpha coefficient formula. Data are reported separately for the actual and preferred forms using the individual as the unit of analysis.

Also, because the class mean has been commonly used as the unit of analysis in past classroom environment research, alpha reliability estimates are reported for class means for the group of 16 classes. Class estimates of internal consistency were made by using the variance of class means on each item in conjunction with the conventional alpha formula (Fraser and Fisher 1983; Fraser and Treagust 1986; McRobbie, Giddings and Fraser 1990, 1991).

Table 4.2 shows that the values obtained for the alpha coeffients range from 0.42 for Open-Endedness in the actual form to 0.75 for Teacher Supportiveness in the preferred form, using the individual as the unit of analysis; and from 0.36 for Open-Endedness in the actual form to 0.66 for Integration in the actual form, using the class as the unit of analysis.

Table 4.2: Internal Consistency (Alpha Reliability) for the Two Units of Analysis for each Form of SLEI with South African College Students

Scale	Unit of Analysis	Alpha Reliability: Student Actual (N = 264 & 16)@	Alpha Reliability: Student Pref. (N = 264 & 16)@
Teacher Supportiveness	Indiv.	0.73	0.75
	Class	0.61	0.59
Involvement	Indiv.	0.53	0.64
	Class	0.43	0.37
Student Cohesiveness	Indiv.	0.66	0.68
	Class	0.53	0.51
Open-Endedness	Indiv.	0.42	0.60
	Class	0.36	0.42
Integration	Indiv.	0.69	0.68
	Class	0.66	0.59
Organization	Indiv.	0.74	0.73
	Class	0.62	0.59
Rule Clarity	Indiv.	0.66	0.64
	Class	0.48	0.48
Material Environment	Indiv.	0.66	0.74
	Class	0.53	0.57

@ The sample sizes shown are the number of individual students and number of classes, respectively.

The reliabilities for class means generally are noticably lower than those for individuals, which is unexpected and inconsistent with recent research undertaken by Fraser et al with instruments such as the **College and University Classroom Environment Inventory (CUCEI)**, which is suitable for small higher education classes often referred to as seminars (Fraser and Treagust 1986).

However, together these data suggest that each **SLEI** scale has acceptable internal consistency, especially for scales containing only nine items each, in both its actual and preferred forms (Giddings and Fraser 1989), and with either the individual or the class mean as the unit of analysis.

The values obtained for the alpha coeffients range from 0.42 to 0.74 for the actual form and from 0.60 to 0.75 for the preferred form, which compare favourably with values obtained by Giddings and Fraser (1989) with Australian school students and values obtained with American school students and American university students, as presented in **Table 2.13**.

Data presented in **Table 4.3** (the alpha reliability for class sessions conducted by each of the three lecturers) and **Table 4.4** (the alpha reliability for classroom sessions conducted at each of the three year levels), also suggest that each **SLEI** scale has adequate internal consistency for both its actual and preferred forms, with the individual as the units of analysis.

Table 4.3: Internal Consistencies (Alpha Reliabilities) for Learning Environments conducted by Three South African College Lecturers for each Form of SLEI using the Individual Student as the Unit of Analysis

		Alpha Reliability		
Scale	Form	Lecturer 1	Lecturer 2	Lecturer 3
Teacher Supportiveness	Act.	0.72	0.59	0.70
	Pref.	0.79	0.64	0.69
Involvement	Act.	0.51	0.49	0.62
	Pref.	0.57	0.67	0.67
Student Cohesiveness	Act.	0.64	0.62	0.69
	Pref.	0.77	0.58	0.64
Open-Endedness	Act.	0.47	0.41	0.36
	Pref.	0.49	0.57	0.62
Integration	Act.	0.68	0.69	0.69
	Pref.	0.74	0.62	0.63
Organization	Act.	0.74	0.66	0.67
	Pref.	0.76	0.64	0.61
Rule Clarity	Act.	0.61	0.52	0.61
	Pref.	0.67	0.54	0.61
Material Environment	Act.	0.62	0.67	0.72
	Pref.	0.79	0.72	0.54

Lecturer 1 N = 85 students

Lecturer 2 N = 101 students

Lecturer 3 N = 78 students

Table 4.4: Internal Consistencies (Alpha Reliabilities) for the Three South African Year Levels for each Form of SLEI using the Individual Student as the Unit of Analysis

Scale	Form	Alpha Reliability		
		Year Level 1 (N = 86)	Year Level 2 (N = 136)	Year Level 3 (N = 42)
Teacher Supportiveness	Act.	0.68	0.73	0.65
	Pref.	0.58	0.78	0.67
Involvement	Act.	0.46	0.54	0.58
	Pref.	0.69	0.59	0.74
Student Cohesiveness	Act.	0.51	0.71	0.69
	Pref.	0.55	0.71	0.73
Open-Endedness	Act.	0.43	0.48	0.28
	Pref.	0.61	0.41	0.55
Integration	Act.	0.71	0.69	0.66
	Pref.	0.66	0.69	0.58
Organization	Act.	0.69	0.76	0.69
	Pref.	0.68	0.76	0.61
Rule Clarity	Act.	0.64	0.64	0.60
	Pref.	0.59	0.64	0.60
Material Environment	Act.	0.60	0.67	0.77
	Pref.	0.61	0.79	0.43

4.4.3 Discriminant Validity

Table 4.5 presents discriminant validity data (using the mean correlation of a scale with the other seven scales as a convenient index) for both the actual and preferred form of **SLEI**, using the individual as the unit of analysis. The discriminant validity for the class as a unit of analysis was omitted because the significance of the indices is questionable due to the very small number of classes in the sample and the few individuals per class.

The discriminant validity indices range from 0.14 for Open-Endedness to 0.41 for Organization in the actual form; and from 0.17 for Open-Endedness to 0.46 for both Integration and Organization ($p < 0.05$) in the preferred form. These discriminant validity indices compare favourably with the indices for the Australian school students, which ranged from 0.24 to 0.49 for the actual form (Giddings and Fraser 1989). Comparable values were also obtained for the other two American samples (Giddings and Fraser 1989).

Although only arbitrary criteria exist, generally these values can be regarded as small enough to suggest that each **SLEI** scale has adequate discriminant validity for use in its actual and preferred forms with the individual as the unit of analysis.

Table 4.5: Discriminant Validities (Mean Correlations of a Scale with Other Seven Scales) for each Form of SLEI using the Individual as the Unit of Analysis with a Sample of South African College Students

Scale	Form	Discriminant Validity (Mean Correlation with Other Scales) (N = 264)
Teacher Supportiveness	Act.	0.34*
	Pref.	0.43***
Involvement	Act.	0.25
	Pref.	0.26
Student Cohesiveness	Act.	0.27***
	Pref.	0.41***
Open-Endedness	Act.	0.14
	Pref.	0.17
Integration	Act.	0.31
	Pref.	0.46***
Organization	Act.	0.41
	Pref.	0.46*
Rule Clarity	Act.	0.34**
	Pref.	0.35
Material Environment	Act.	0.32*
	Pref.	0.38*

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

It appears that the **SLEI** measures distinct although somewhat overlapping aspects of the science laboratory classroom environment; but, the conceptual distinctions among scales are important enough to retain the eight dimensions within the instrument (Fraser and Treagust 1986; Giddings and Fraser 1989).

Data presented in **Table 4.6** (discriminant validity for the learning environments of the three lecturers) and in **Table 4.7** (discriminant validity for each of the three year levels) also suggest that each **SLEI** scale has adequate discriminant validity for use in its actual and preferred forms with the individual as the unit of analysis.

Table 4.6: Discriminant Validities (Mean Correlations of a Scale with Other Seven Scales) for each Form of SLEI for the Classroom Learning Environments of the Three South African College Lecturers using the Individual as the Unit of Analysis

		Discriminant Validity		
Scale	Form	Lecturer 1	Lecturer 2	Lecturer 3
Teacher Supportiveness	Act.	0.42**	0.29*	0.34**
	Pref.	0.52**	0.44**	0.31
Involvement	Act.	0.13	0.39***	0.26
	Pref.	0.17*	0.53***	0.07*
Student Cohesiveness	Act.	0.27*	0.29*	0.30
	Pref.	0.45	0.49***	0.21
Open-Endedness	Act.	0.28*	0.08	0.14
	Pref.	0.26	0.29**	0.09
Integration	Act.	0.39*	0.36**	0.18
	Pref.	0.47***	0.55***	0.34
Organization	Act.	0.52**	0.37*	0.28
	Pref.	0.46**	0.50**	0.36
Rule Clarity	Act.	0.39	0.29	0.26*
	Pref.	0.27	0.49***	0.34*
Material Environment	Act.	0.39	0.25*	0.27*
	Pref.	0.36	0.48***	0.28*

* $p < 0.05$ Lecturer 1 N = 85 students

** $p < 0.01$ Lecturer 2 N = 101 students

*** $p < 0.001$ Lecturer 3 N = 78 students

Table 4.7: Discriminant Validities (Mean Correlations of a Scale with Other Seven Scales) for each Form of SLEI for the Three South African College Year Levels using the Individual as the Unit of Analysis

Scale	Form	Discriminant Validity		
		Level 1 (N = 86)	Level 2 (N = 136)	Level 3 (N = 42)
Teacher Supportiveness	Act.	0.33*	0.36*	0.29
	Pref.	0.39**	0.49***	0.28
Involvement	Act.	0.39**	0.22	0.16
	Pref.	0.48***	0.23	0.07*
Student Cohesiveness	Act.	0.30**	0.28*	0.23
	Pref.	0.45***	0.43	0.30
Open-Endedness	Act.	0.14	0.18	0.04
	Pref.	0.27*	0.24	-0.004
Integration	Act.	0.28	0.40*	0.07*
	Pref.	0.52***	0.47***	0.26*
Organization	Act.	0.41*	0.46**	0.19
	Pref.	0.47*	0.48	0.24*
Rule Clarity	Act.	0.29*	0.38	0.15
	Pref.	0.45**	0.33*	0.20
Material Environment	Act.	0.25*	0.37*	0.22
	Pref.	0.45***	0.38	0.26

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

4.5 Analysis of Variance (ANOVA) and the Confirmation or Refutation of the Hypotheses

4.5.1 Null Hypotheses

Null hypotheses were formulated in seven categories namely:

* concerning the difference in perceptions of the actual and preferred science laboratory classroom environments for individual students;
* the effect for class membership;
* the effect for home language;
* the effect for the year level;
* the effect for the type of science subject studied;
* the effect for gender; and
* the effect for the different lecturers.

Analyses of variance (ANOVAS) have been calculated to discover any significant differences between the students' perceptions of the actual and preferred science laboratory classroom environments using the individual as the unit of analysis.

Simplified plots are presented to depict graphically any significant differences using the mean scores obtained with the individual as the unit of analysis.

Ho 1: There is no significant difference between the measured perceptions of the Hewat College of Education students of their actual and preferred science laboratory classroom environments.

Table 4.1 and **Figure 4.1** show that this hypothesis is rejected. The means for all the preferred scales are significantly higher than the means for the actual scales using the individual as the unit of analysis, indicating that students tended to prefer a more favourable classroom environment than they perceived as being actually present. These results are of educational significance and are consistent with previous research results (Fisher and Fraser 1983; Fraser 1984,1986 a & b, 1989; Fraser and Treagust 1986; Giddings and Fraser 1989; McRobbie, Giddings and Fraser 1990, 1991).

Ho 2: There is no statistically significant difference between the students' perceptions of the science laboratory classroom environments when compared according to the class group that they belong to.

Table 4.8, presenting the ANOVA results with class membership as the main effect and using the individual as the unit of analysis shows that this hypothesis is rejected. The ANOVA results in **Table 4.8** indicate that each of the eight scales (for both actual and preferred scores), except for Involvement and Integration in the actual form, differentiated significantly ($p < 0.05$) between the perceptions of students in different classrooms.

The eta statistics, which provide an estimate of the amount of variance in classroom environment scores attributable to class membership, ranged from 0.05 for Involvement to 0.25 for Teacher Supportiveness in the actual form; and 0.11 for Integration to 0.21 for Rule Clarity in the preferred form.

Table 4.8: ANOVA Results for Class Membership Differences in South African College Student Perceptions using the Individual as the Unit of Analysis

Scale	Form	MS Between	MS Within	df	F	Eta^2
Teacher Supportiveness	Act.	98.23	17.59	15, 248	5.58***	0.34
	Pref.	56.99	17.99	15, 248	3.17***	0.19
Involvement	Act.	22.42	27.21	15, 248	0.82	0.05
	Pref.	35.05	16.15	15, 248	2.17**	0.12
Student Cohesiveness	Act.	38.93	20.21	15, 248	1.93*	0.12
	Pref.	62.32	23.16	15, 248	2.69***	0.16
Open-Endedness	Act.	57.09	18.93	15, 248	3.02**	0.18
	Pref.	100.84	26.73	15, 248	3.77***	0.23
Integration	Act.	63.61	43.35	15, 248	1.47	0.09
	Pref.	41.75	19.87	15, 248	2.10*	0.13
Organization	Act.	115.64	28.11	15, 248	4.11***	0.25
	Pref.	77.87	28.52	15, 248	2.73***	0.17
Rule Clarity	Act.	154.55	36.33	15, 248	4.25***	0.26
	Pref.	57.01	13.24	15, 248	4.31***	0.26
Material Environment	Act.	96.05	33.66	15, 248	2.85***	0.17
	Pref.	48.19	14.79	15, 248	3.26***	0.19

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by class membership.

Sample size was 264 students in 16 classes.

Ho 3: There is no statistically significant difference between the students' perceptions of the science laboratory classroom environments when compared according to home language, namely English and Afrikaans.

Table 4.9 and Figue 4.3 show that the null hypothesis is supported for all the scales both actual and preferred, except for Rule Clarity in the actual form where there is a noticable difference with the Afrikaans-speaking students (N = 116) scoring 31.78 as a mean, as opposed to 28.95 for the English-speaking students (N = 148). For all the other scales, both actual and preferred, only marginal differences, that are not significant were obtained. These preliminary results raise possibilities for further research involving other home languages within the South African context, as well as internationally.

Figure 4.3: Simplified Plot of Significant Differences between the Forms (Actual and Preferred) of SLEI for the Perceptions of English- and Afrikaans-Speaking Students with the Individual as the Unit of Analysis using the Mean Scores

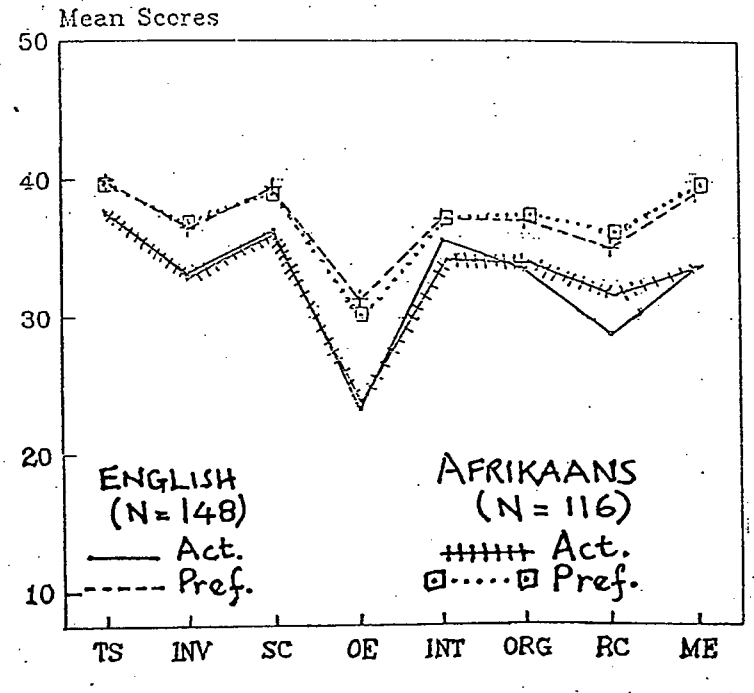


Table 4.9: SLEI Scale Means and Standard Deviations for English- and Afrikaans-Speaking South African College Students using the Individual as the Unit of Analysis

		English Students (N = 148)		Afrikaans Students (N = 116)	
Scale	Form	Mean	SD	Mean	SD
Teacher Supportiveness	Act.	37.53	5.06	37.63	4.26
	Pref.	39.89	5.16	39.64	3.52
Involvement	Act.	33.20	5.78	33.04	4.37
	Pref.	36.54	4.47	36.91	3.72
Student Cohesiveness	Act.	36.33	4.69	36.16	4.54
	Pref.	39.52	5.85	39.00	3.81
Open-Endedness	Act.	23.37	4.58	23.87	4.61
	Pref.	31.37	6.42	30.23	4.16
Integration	Act.	35.64	7.38	34.33	5.60
	Pref.	37.23	4.78	37.26	4.38
Organization	Act.	33.55	6.24	34.12	5.11
	Pref.	37.16	6.69	37.49	3.84
Rule Clarity	Act.	28.95	7.45	31.78	4.84
	Pref.	35.20	4.07	36.26	3.76
Material Environment	Act.	33.76	6.67	33.91	5.35
	Pref.	39.18	3.86	39.69	4.38

Table 4.10: ANOVA Results for Languages (English/Afrikaans) Differences in South African College Student Perceptions using the Individual as the Unit of Analysis

Scale	Form	MS Between	MS Within	df	F	Eta^2
Teacher Supportiveness	Act.	0.63	22.26	1, 262	0.03	0.0001
	Pref.	4.38	20.27	1, 262	0.22	0.0009
Involvement	Act.	1.68	26.98	1, 262	0.06	0.0004
	Pref.	9.19	17.21	1, 262	0.53	0.003
Student Cohesiveness	Act.	1.86	21.35	1, 262	0.09	0.0009
	Pref.	17.79	25.48	1, 262	0.69	0.003
Open-Endedness	Act.	15.99	21.07	1, 262	0.76	0.003
	Pref.	83.46	30.69	1, 262	2.72	0.01
Integration	Act.	111.58	44.28	1, 262	2.52	0.01
	Pref.	0.05	21.15	1, 262	0.002	0.00
Organization	Act.	21.04	33.26	1, 262	0.63	0.003
	Pref.	7.27	31.46	1, 262	0.23	0.001
Rule Clarity	Act.	520.04	41.37	1, 262	12.57***	0.05
	Pref	72.10	15.50	1, 262	4.65*	0.02
Material Environment	Act.	1.63	37.49	1, 262	0.04	0.0002
	Pref.	17.63	16.76	1, 262	1.05	0.004

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by language.

English N = 148 Afrikaans N = 116

Table 4.10 presents the ANOVA results with language (English/Afrikaans) as the main effect and using the individual as the unit of analysis. The values of F and p clearly show that the hypothesis fails to be rejected for all the scales both actual and preferred, except for Rule Clarity in the actual form.

Ho 4: There is no statistically significant difference between the students' perceptions of the science laboratory classroom environments when compared according to the year level of study.

Table 4.11 presents the ANOVA results with the year level of study as the main effect and using the individual as the unit of analysis; **Table 4.12** for the first year science students; **Table 4.13** for the second and third year biology students; and **Figure 4.4** show that this hypothesis is rejected for the following seven scales: Teacher Supportiveness, Organization and Rule Clarity in the actual form; and Teacher Supportiveness, Open-Endedness, Integration and Rule Clarity in the preferred form as there are significant differences between the year levels at the 0.05 level as indicated by the **Addendum** to **Table 4.11**.

The null hypothesis fails to be rejected for the following nine scales: Involvement, Student Cohesiveness, Open-Endedness, Integration, Material Environment in the actual form; and Involvement , Student Cohesiveness, Organization and Material Environment in the preferred form since no two year levels are significantly different at the 0.05 level as indicated by the Addendum to **Table 4.11**. The eta statistics, which provide an estimate of variance in classroom environment scores attributable to the year level of study, range from 0.004 for Integration to 0.10 for Teacher Supportiveness in the actual form; and from 0.002 for Student Cohesiveness to 0.09 for Open-Endedness in the preferred form.

Table 4.11: ANOVA Results for the Three South African College Year Levels in Student Perceptions using the Individual as the Unit of Analysis

Scale	Form	MS Between	MS Within	df	F	Eta^2
Teacher Supportiveness	Act.	295.73	20.10	2, 261	14.71***	0.11
	Pref.	78.35	19.78	2, 261	3.96*	0.03
Involvement	Act.	19.83	26.99	2, 261	0.74	0.01
	Pref.	50.49	16.97	2, 261	2.98	0.02
Student Cohesiveness	Act.	41.23	21.12	2, 261	1.95	0.02
	Pref.	7.04	25.53	2, 261	0.28	0.002
Open-Endedness	Act.	14.16	21.16	2, 261	0.67	0.01
	Pref.	366.09	28.39	2, 261	12.89***	0.09
Integration	Act.	21.18	44.69	2, 261	0.47	0.004
	Pref.	91.15	20.58	2, 261	4.43*	0.03
Organization	Act.	118.50	32.45	2, 261	3.65*	0.03
	Pref.	26.98	31.37	2, 261	0.86	0.01
Rule Clarity	Act.	297.86	41.12	2, 261	7.24***	0.06
	Pref.	91.44	15.16	2, 261	6.03**	0.05
Material Environment	Act.	64.47	37.01	2, 261	1.74	0.01
	Pref.	44.39	16.49	2, 261	2.69	0.02

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by year level.

Sample size was 264 students in the three year levels, N = 86, N = 136, and N = 42.

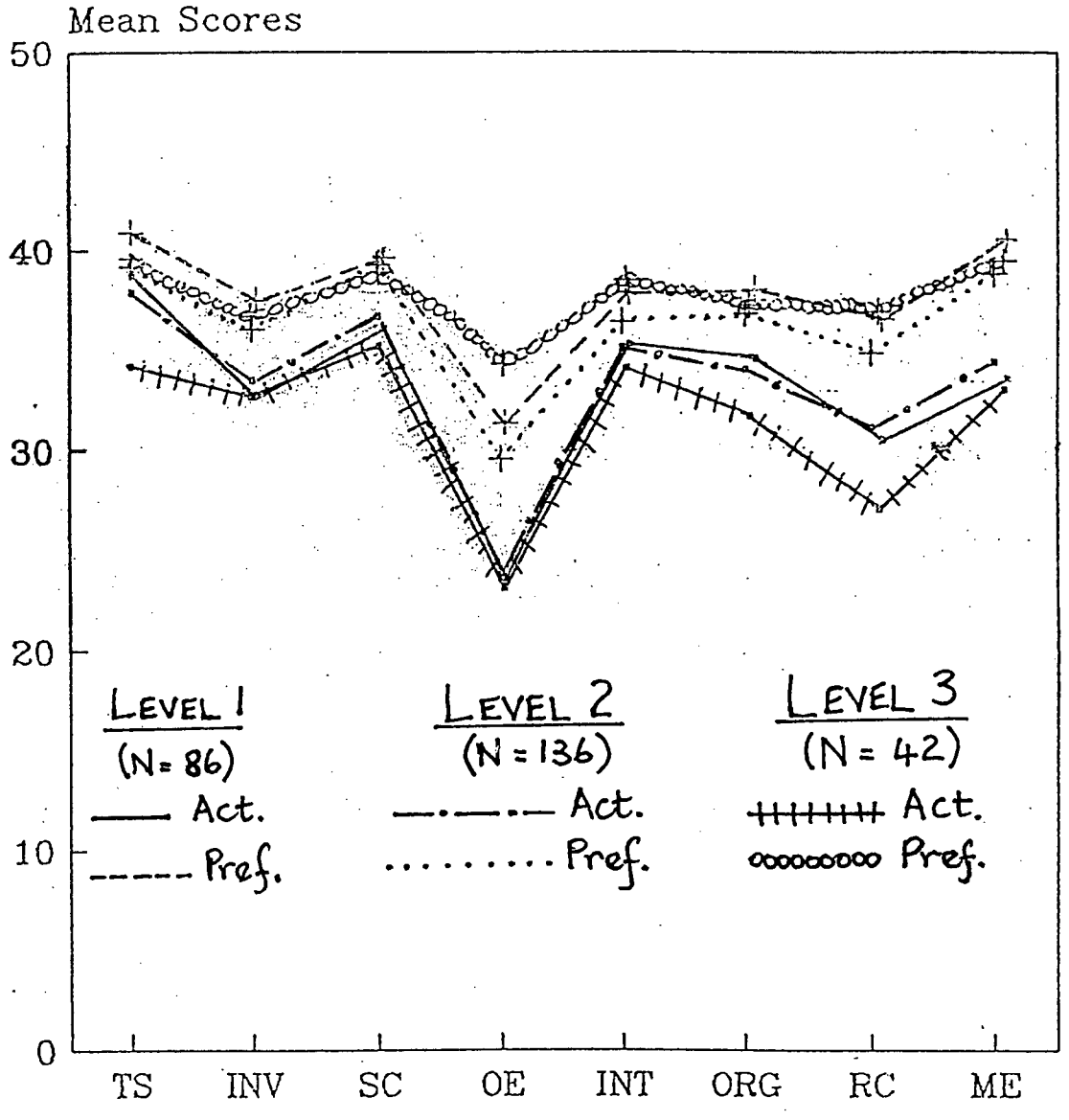
Table 4.12: SLEI Scale Means and Standard Deviations for South African College First Year Science Students using the Individual as the Unit of Analysis

Scale	Form	Science Higher (N = 34) Mean	SD	Science Elem (N = 52) Mean	SD
Teacher Supportiveness	Act.	37.22	4.67	39.85	3.44
	Pref.	40.36	2.87	41.19	2.79
Involvement	Act.	31.72	3.49	33.40	4.09
	Pref.	37.47	2.89	37.50	4.35
Student Cohesiveness	Act.	36.03	4.29	36.09	3.61
	Pref.	40.06	3.05	39.35	3.02
Open-Endedness	Act.	23.28	3.98	23.35	4.29
	Pref.	30.92	3.02	31.23	4.48
Integration	Act.	34.75	5.10	35.35	5.48
	Pref.	37.19	4.31	38.21	3.93
Organization	Act.	32.69	4.61	35.59	3.82
	Pref.	36.67	3.42	38.85	3.55
Rule Clarity	Act.	27.25	5.19	32.23	4.51
	Pref.	35.08	3.18	37.12	3.83
Material Environment	Act.	33.83	4.19	33.08	5.54
	Pref.	40.14	2.85	40.31	3.24

Table 4.13: SLEI Scale Means and Standard Deviations for South African College Biology Students using the Individual as the Unit of Analysis

		Second Year Biol (N = 136)		Third Year Biol (N = 42)	
Scale	Form	Mean	SD	Mean	SD
Teacher Supportiveness	Act.	37.85	4.63	34.24	4.60
	Pref.	39.13	4.79	39.57	5.84
Involvement	Act.	33.52	4.93	32.67	7.75
	Pref.	36.14	4.42	36.74	3.74
Student Cohesiveness	Act.	36.70	4.85	35.21	5.12
	Pref.	39.22	6.38	38.86	3.31
Open-Endedness	Act.	23.90	4.75	23.05	4.99
	Pref.	29.59	6.57	34.29	2.92
Integration	Act.	35.28	7.46	34.12	6.63
	Pref.	36.46	4.79	38.52	4.60
Organization	Act.	34.09	6.02	31.64	6.95
	Pref.	36.91	6.92	37.21	4.05
Rule Clarity	Act.	31.22	7.42	26.91	4.69
	Pref.	34.87	4.41	36.83	2.11
Material Environment	Act.	34.44	5.77	32.76	8.63
	Pref.	38.89	4.99	39.31	1.96

Figure 4.4: Simplified Plot of the Differences between the Forms (Actual and Preferred) of SLEI for the Perceptions of the Three Year Levels with a Sample of South African College Students using the Mean Scores and the Individual as the Unit of Analysis



Ho 5: There is no statistically significant difference between the students' perceptions of the science laboratory classroom environments when compared according to the specific science subject that they study, namely Science Higher and Science Elementary for first year students, and Biology for second and third year year students.

Table 4.14: ANOVA Results for the Perceptions of the First Year South African College Science Students using the Individual as the Unit of Analysis

Scale	Form	MS Between	MS Within	df	F	Eta^2
Teacher Supportiveness	Act.	146.46	15.92	1, 84	9.20*	0.11
	Pref.	14.69	7.98	1, 84	1.84	0.02
Involvement	Act.	60.16	14.93	1, 84	4.03*	0.05
	Pref.	0.02	14.63	1, 84	0.001	0.00001
Student Cohesiveness	Act.	0.10	15.25	1, 84	0.007	0.0001
	Pref.	10.71	9.18	1, 84	1.17	0.01
Open-Endedness	Act.	0.10	17.36	1, 84	0.006	0.0001
	Pref.	2.09	15.63	1, 84	0.134	0.002
Integration	Act.	7.56	28.42	1, 84	0.27	0.003
	Pref.	22.01	16.72	1, 84	1.32	0.02
Organization	Act.	179.12	17.30	1, 84	10.35**	0.12
	Pref.	101.05	12.22	1, 84	8.27**	0.09
Rule Clarity	Act.	527.74	23.05	1, 84	22.89***	0.27
	Pref.	87.84	12.81	1, 84	6.86*	0.08
Material Environment	Act.	12.17	25.31	1, 84	0.48	0.006
	Pref.	0.61	9.53	1, 84	0.06	0.001

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by level of subject grade.

Science Higher = 34; Science Elementary = 52 (N = 86)

Table 4.15: ANOVA Results for the Perceptions of the South African Second Year and Third Year Biology College Students using the Individual as the Unit of Analysis

Scale	Form	MS Between	MS Within	df	F	Eta^2
Teacher Supportiveness	Act.	417.34	21.37	1, 176	19.53***	0.11
	Pref.	6.32	25.62	1, 176	0.25	0.001
Involvement	Act.	23.42	32.74	1, 176	0.72	0.004
	Pref.	11.37	18.26	1, 176	0.62	0.004
Student Cohesiveness	Act.	70.73	24.19	1, 176	2.92	0.02
	Pref.	4.13	33.67	1, 176	0.12	0.001
Open-Endedness	Act.	23.39	23.14	1, 176	1.01	0.01
	Pref.	705.22	34.95	1, 176	20.18***	0.11
Integration	Act.	43.37	52.93	1, 176	0.82	0.005
	Pref.	136.83	22.49	1, 176	6.08*	0.03
Organization	Act.	192.59	39.08	1, 176	4.93*	0.03
	Pref.	2.95	40.41	1, 176	0.07	0.0004
Rule Clarity	Act.	594.47	47.27	1, 176	12.58***	0.07
	Pref.	123.81	15.94	1, 176	7.77**	0.04
Material Environment	Act.	90.08	43.02	1, 176	2.09	0.01
	Pref.	5.48	19.97	1, 176	0.27	0.002

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by subject year level.

Second Year = 136 Third Year = 42

Figure 4.5: (a) and (b) Simplified Plots of Significant Differences between the Forms (Actual and Preferred) of SLEI for the Perceptions of the First Year Science Students; and the Second and Third Year Biology Students with the Individual as the Unit of Analysis using the Mean Scores of a South African Sample of College Students

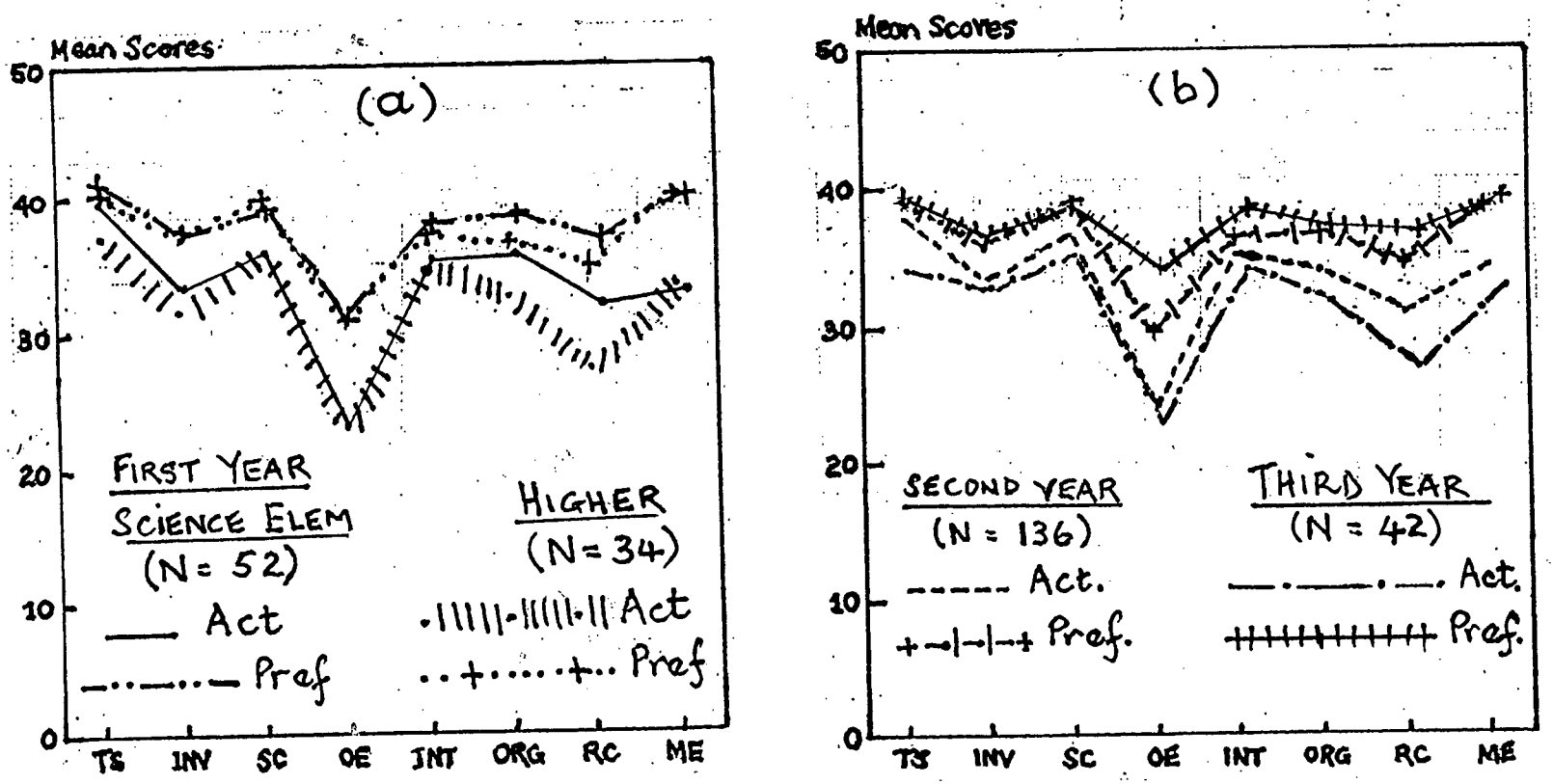


Table 4.14 and **Table 4.15** show that this hypothesis is rejected. The rejection of the hypothesis is evident in the very low eta -scores for all the scales except for Organization (eta = 11%, $F = 10.35$, $p < 0.01$) and Rule Clarity (eta = 21%, $F = 22.89$, $p < 0.001$), both in the actual version (**Table 4.14** for first year students). The low eta -scores can also be due to the relatively low number of students (science Higher = 34; Science Elementary = 52).

Very low eta -scores were also obtained for the second (N = 136) and third (N = 42) year students. Here only Teacher Supportiveness and Rule Clarity in the actual version, and Open-Endedness in the preferred version differed significantly ($p < 0.001$) with acceptable F-values and eta -scores.

The eta statistics, which provide an estimate of the amount of variance in classroom environment scores attributable to the specific science subject studied, range from 0.0001 for Student Cohesiveness and Open-Endedness to 0.21 for Rule Clarity ($p < 0.001$) in the actual form; and from 0.00001 for Involvement to 0.09 for Organization in the preferred form for the first year science students. The eta statistics for the second year and third year biology students, range from 0.004 for Involvement and Integration to 0.10 for Teacher Supportiveness ($p < 0.001$) in the actual form; and from 0.0004 for Organization to 0.10 for Open-Endedness ($p < 0.001$) in the preferred form.

Table 4.12 and **Table 4.13** present the means and standard deviations for first year science (higher and elementary) students, and for second and third year biology students. **Figure 4.5** presents these results graphically using the mean scores for all the scales in both forms with the individual as the unit of analysis. The significant influence of the type and/or level and nature of the subject on the perceptions of the students is commented on in **Chapter 5**.

Ho 6: There is no statistically significant difference between the students' perceptions of the science laboratory classroom environments when compared according to the gender of the individual.

Table 4.16 and **Figure 4.6** show that the null hypothesis fails to be rejected since male and female students view the environments in their science laboratory similarly. These preliminary results are interesting if one takes the findings of Lawrenz (1987), McRobbie, Giddings and Fraser (1990, 1991), and Fraser, Giddings and McRobbie (1992) into account, where the findings reported that there are gender-related differences in students' perceptions of the classroom psychosocial environment.

Table 4.17 presents the ANOVA results with gender as the main effect and using the individual as the unit of analysis. The values of F and p clearly show that the hypothesis is supported.

Figure 4.6: Simplified Plot of Significant Differences between the Forms (Actual and Preferred) of SLEI for the Perceptions of the Male and Female Students with the Individual as the Unit of Analysis using the Mean Scores of a South African Sample of College Students

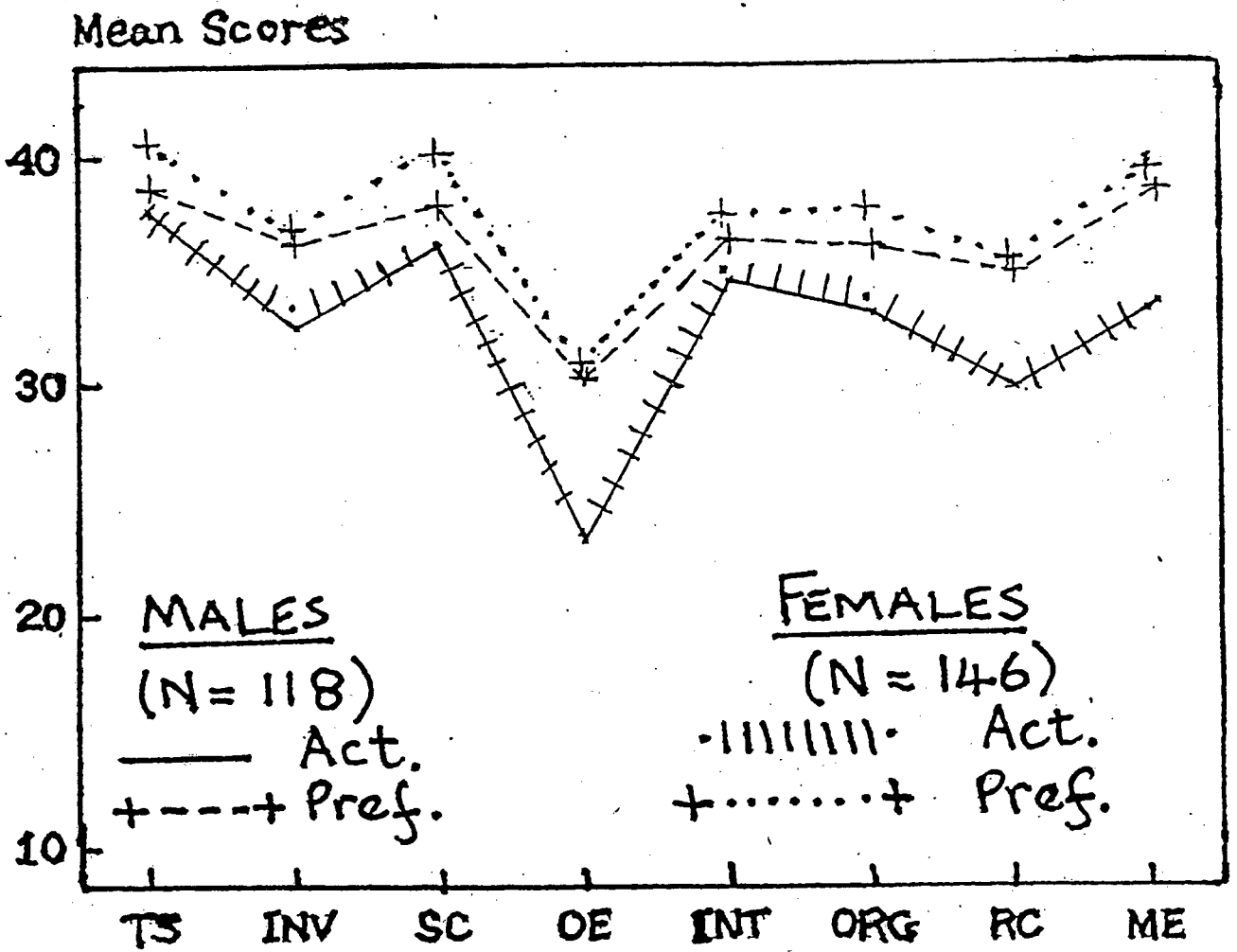


Table 4. 17: ANOVA Results for Gender Differences in South African College Student Perceptions using the Individual as the Unit of Analysis

Scale	Form	MS Between	MS Within	df	F	Eta^2
Teacher Supportiveness	Act.	1.48	22.28	1, 262	0.07	0.0004
	Pref.	263.70	19.29	1, 262	13.67***	0.05
Involvement	Act.	49.54	26.85	1, 262	1.85	0.006
	Pref.	24.39	17.20	1, 262	1.42	0.005
Student Cohesiveness	Act.	0.38	21.36	1, 262	0.02	0.0001
	Pref.	314.72	24.29	1, 262	12.96***	0.003
Open-Endedness	Act.	5.82	21.16	1, 262	0.28	0.001
	Pref.	23.58	30.98	1, 262	0.76	0.003
Integration	Act.	11.56	44.63	1, 262	0.26	0.001
	Pref.	67.29	20.94	1, 262	3.21	0.012
Organization	Act.	25.32	33.13	1, 262	0.76	0.003
	Pref.	163.22	30.84	1, 262	5.29*	0.02
Rule Clarity	Act.	0.08	43.24	1, 262	0.002	0.00
	Pref	16.57	15.74	1, 262	1.05	0.004
Material Environment	Act.	7.42	37.33	1, 262	0.19	0.001
	Pref.	46.82	16.58	1, 262	2.82	0.01

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by gender.

Male N = 118 Female N = 146

Ho 7: There is no statistically significant differences between the students' perceptions of the various science laboratory classroom environments when compared according to the particular lecturer who lectures them.

Table 4.18 presents the ANOVA results, with the particular lecturer as the main effect, and using the individual as the unit of analysis; and **Figure 4.7** show how this hypothesis is partially rejected.

The ANOVA results in **Table 4.18** indicate that the null hypothesis is rejected for the following nine scales: Teacher Supportiveness, Organization, Rule Clarity in the actual form; and Teacher Supportivesness, Open-Endedness, Integration, Organization, Rule Clarity and Material Environment in the preferred form since there are significant differences between the students of the various lecturers at the 0.05 level as indicated by the **Addendum** to **Table 4.18**.

The null hypothesis fails to be rejected for the following seven scales: Involvement, Student Cohesiveness, Open-Endedness, Integration and Material Environment in the actual form; and Involvement and Student Cohesiveness in the preferred form since no two groups of students from all three lecturers are significantly different at the 0.05 level.

Table 4.18: ANOVA Results for the Perceptions of the Three Lecturers' Learning Environments using the Individual as the Unit of Analysis with a Sample of South African College Students

Scale	Form	MS Between	MS Within	df	F	Eta^2
Teacher Supportiveness	Act.	514.18	18.43	2, 261	27.90***	0.21
	Pref.	114.51	19.49	2, 261	5.87**	0.05
Involvement	Act.	58.38	26.69	2, 261	2.19	0.02
	Pref.	26.47	17.16	2, 261	1.54	0.01
Student Cohesiveness	Act.	48.55	21.07	2, 261	2.30	0.02
	Pref.	3.54	25.57	2, 261	0.14	0.001
Open-Endedness	Act.	69.45	20.73	2, 261	3.35*	0.03
	Pref.	199.69	29.66	2, 261	6.73*	0.05
Integration	Act.	11.53	44.76	2, 261	0.26	0.002
	Pref.	85.12	20.62	2, 261	4.13*	0.03
Organization	Act.	448.73	29.92	2, 261	14.99***	0.11
	Pref.	249.93	29.66	2, 261	8.43***	0.06
Rule Clarity	Act.	610.27	38.73	2, 261	15.76***	0.12
	Pref.	221.59	14.16	1, 261	15.65***	0.12
Material Environment	Act.	95.42	36.77	2, 261	2.59	0.02
	Pref.	136.19	15.78	2, 261	8.63***	0.07

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Eta^2 is the ratio of between to total sums of squares and indicates proportion of variance explained by the difference in lecturer.

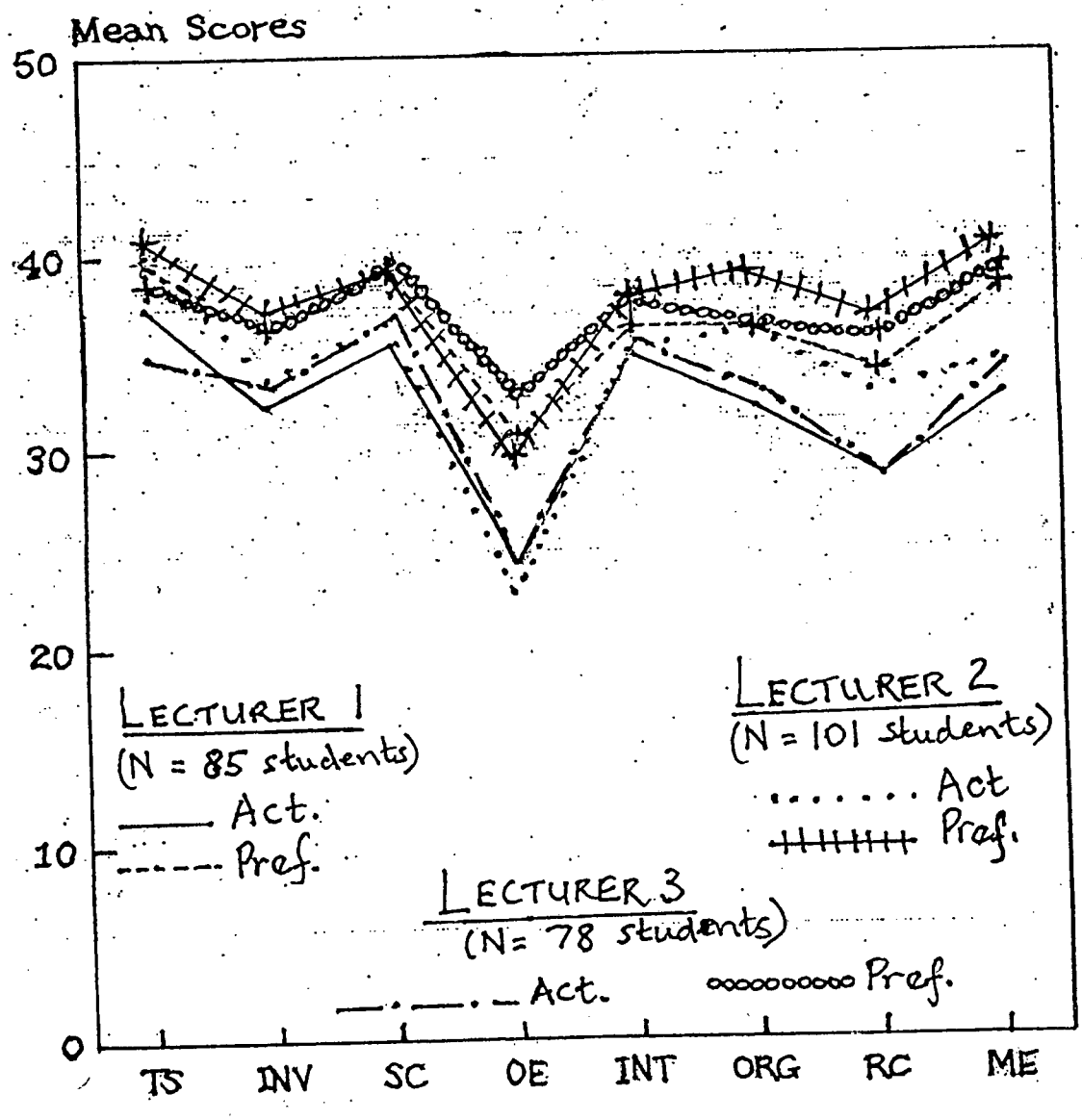
Sample size was 264 students with three different lecturers.

Lecturer 1 = 85 students

Lecturer 2 = 101 students

Lecturer 3 = 78 students

Figure 4.7: Simplified Plot of the Differences between the Forms (Actual and Preferred) of SLEI for the Perceptions of the Three Lecturers' Learning Environments, with a Sample of South African College Students, using the Mean Scores and the Individual as the Unit of Analysis



4.6 Answers to the Research Questions

This research study proposed to investigate and to answer the following research questions:

4.6.1 Do college education students prefer a science laboratory classroom environment significantly different from the actual science laboratory classroom environment as perceived by them?

This research question was answered affirmatively as the discussion in **Chapter 5** indicates.

4.6.2 Are there significant differences in the perceptions of the students which are related to class membership?

This research question was answered affirmatively as the discussion in **Chapter 5** indicates.

4.6.3 Are there significant differences in the perceptions of the students which are related to gender, the year level of study and the home language of the students?

This research question was not affirmed as the discussion in **Chapter 5** indicates.

4.6.4 Are there significant differences in the perceptions of the students which may be related to the type of science subject studied and/or the specific lecturer who lectures to them?

This research question was answered affirmatively as the discussion in **Chapter 5** indicates.

4.6.5 Are the Afrikaans translated versions of SLEI valid and reliable for use as instruments for assessing classroom psychosocial environment in higher education?

This research question was answered affirmatively as the discussion in **Chapter 5** indicates.

4.6.6 Are the English versions of SLEI reliable for use as instruments for assessing classroom psychosocial environment in higher education in a South African setting?

This research question was answered affirmatively as the discussion in **Chapter 5** indicates.

4.6.7 Do the results of this research study corroborate the results obtained elsewhere in the world?

This research question was answered affirmatively as the discussion in **Chapter 5** indicates.

4.7 Chapter Summary

In **Chapter 4** the results of the research investigation, the support or rejection of the hypotheses have been described and answers to the research questions have been arrived at. In **Chapter 5** these results are discussed in detail.

CHAPTER 5: DISCUSSION OF RESULTS

5.1 Introduction

This chapter deals with the discussion of the empirical results reported in **Chapter 4**, and an attempt is made to account for any significant differences obtained among the variables which were investigated. An attempt is also made in this chapter to suggest explanations for the outcomes of the tested null hypotheses as formulated under point 4.5.1 of **Chapter 4** and the research questions as formulated under point 4.6 of **Chapter 4**.

5.2 Explanations for the Outcomes of the Tested Null Hypotheses

The outcomes of the tested null hypotheses may be explained as follows:

5.2.1 The Hewat students do prefer a more favourable laboratory classroom environment than they perceived as being actually present (see **Table 4.1** and **Figure 4.1**). The very low means recorded for the actual version for both units of analysis i.e. individual and class, on the Open-Endedness scale are indicative that the laboratory classes in the present sample have a very low level of open-endedness. The relatively low means for the preferred version for both units of analysis i.e. individual and class, of the Open-Endedness scale are evidence that the students prefer that the laboratory classes be closed-ended in nature.

This can be ascribed partially to the fact that the syllabi of the colleges of education are examination-orientated towards rote (non-discovery) learning.

5.2.2 The results presented in **Table 5.1** show that **SLEI** is capable of differentiating between the perceptions of students in different classrooms (see **Figure 4.2**). In other words, students within the same class should perceive **SLEI** dimensions relatively similarly, while mean within-class perceptions vary from classroom to classroom.

Table 5.1: The Mean Scores for the Actual and Preferred Scales of SLEI of the Sixteen South African College Classes

Clas	N	TSA	TSP	INVA	INVP	SCA	SCP	OEA	OEP	INTA	INTP	ORA	ORP	RCA	RCP	MEA	MEP
01	10	37.3	40.5	32.5	38.1	35.5	40.8	26.1	32.3	35.0	38.0	34.4	36.5	27.9	34.0	35.5	40.7
02	11	36.3	40.3	31.6	37.8	36.4	40.6	22.3	30.5	33.7	37.6	31.0	36.8	25.9	35.6	32.1	39.7
03	15	37.9	40.3	31.3	36.8	36.1	39.2	22.1	30.3	35.3	36.3	32.8	36.7	27.8	35.4	34.0	40.1
04	10	41.8	44.8	32.8	35.9	34.7	46.0	25.9	36.1	41.2	37.6	34.9	42.1	32.8	32.7	36.1	37.2
05	28	36.1	38.3	32.0	36.1	33.9	36.6	22.9	28.8	32.6	35.5	28.9	33.8	27.5	32.9	29.3	37.1
06	12	36.9	36.8	33.1	32.7	37.8	37.2	27.2	27.9	33.7	32.8	34.7	34.3	30.7	33.1	33.6	34.9
07	18	38.5	40.7	33.7	37.9	37.2	40.5	25.8	30.9	36.4	38.2	35.1	38.2	34.0	37.9	34.6	41.2
08	20	40.2	41.3	33.5	36.5	35.8	38.4	21.8	30.2	33.8	37.6	35.4	39.0	30.2	35.7	30.9	39.2
09	14	41.1	41.8	32.9	38.5	35.1	39.3	22.4	33.1	36.3	39.1	36.5	39.5	32.9	38.1	34.2	40.7
10	07	41.1	39.9	34.1	35.6	36.9	38.9	20.6	26.9	32.7	38.6	36.4	39.3	33.1	36.1	34.7	41.4
11	22	38.9	39.3	34.3	35.6	36.2	37.6	23.2	27.7	35.3	36.5	36.2	38.3	32.9	35.9	36.0	39.3
12	20	39.9	41.7	33.9	39.2	37.9	40.6	21.4	29.5	35.1	38.9	37.1	40.1	35.1	38.4	36.2	41.9
13	16	34.4	36.9	33.7	35.9	38.9	40.9	26.3	30.9	38.1	37.4	34.6	36.3	29.5	35.2	36.2	40.3
14	19	37.1	37.6	34.7	36.4	38.7	39.8	24.9	30.6	35.9	35.5	34.1	35.1	30.9	34.4	36.3	39.2
15	23	34.8	39.9	34.0	35.8	35.4	38.8	22.4	33.4	34.9	38.7	33.4	37.9	25.1	36.0	34.1	39.6
16	19	33.6	39.1	31.0	37.8	35.1	38.9	23.8	35.4	33.1	38.3	29.5	36.5	29.1	37.8	31.1	38.9

TSA/TSP = Teacher Supportiveness actual/preferred

INVA/INVP = Involvement actual/preferred

SCA/SCP = Student Cohesiveness actual/preferred

OEA/OEP = Open-Endedness actual/preferred

INTA/INTP = Integration actual/preferred

ORA/ORP = Organization actual/preferred

RCA/RCP = Rule Clarity actual/preferred

MEA/MEP = Material Environment actual/preferred

Each of the sixteen scales, except for Involvement and Integration in the actual form, differentiated significantly ($p < 0.05$) between the perceptions of the students in different classrooms.

5.2.3 The results show that for all the scales, both actual and preferred, except for Rule Clarity in the actual form, only marginal differences, that are not significant were obtained, when the home language is the variable. The means for Rule Clarity in the actual form for the Afrikaans-speaking students (N = 116) is 31.78 as opposed to 28.95 for the English-speaking students (N = 148) (see **Table 4.9** and **Figure 4.3**).

One reason for this could possibly be that the Afrikaans-speaking students are more conservatively brought up and are more orthodox in outlook than their English-speaking counterparts, hence the clear understanding of the rules and the observance of the rules. The writer has observed the English-speaking students to be more outward-looking in their approach, possibly due to their relatively liberal upbringing. Also, the fact is that a sizeable portion of the Afrikaans-speaking students are from the outlying rural areas as far afield as Malmesbury, Paarl, Upington, Springbok and Namibia, where the general outlook is conservative in comparison with the urban areas such as Cape Town.

5.2.4 To a degree, the year level of study does have a significant influence on the perceptions of the students of their laboratory environment (see **Tables 4.10, 4.11, 4.12** and **Figure 4.4**). There are significant differences between the year levels at the 0.05 level in the following scales: Teacher Supportiveness, Organization and Rule Clarity in the actual form; and Teacher Supportiveness, Open-Endedness, Integration and Rule Clarity in the preferred form, as presented in **Table 5.2.**

Table 5.2: The Mean Scores for the Actual and Preferred Scales of SLEI of the Three Year Levels for the South African Sample of College Students

N	TSA	TSP	INVA	INVP	SCA	SCP	OEA	OEP	INTA	INTP	ORA	ORP	RCA	RCP	MEA	MEP
86	38.7	40.9	32.7	37.5	36.0	39.6	23.4	31.2	35.2	37.8	34.4	37.9	30.2	36.3	33.3	40.2
136	37.9	39.2	33.5	36.1	36.7	39.3	23.9	29.6	35.2	36.5	34.1	36.9	31.2	34.9	34.5	38.9
42	34.2	39.6	32.7	36.7	35.2	38.9	23.1	34.3	34.1	38.5	31.6	37.2	26.9	36.8	32.8	39.3

TSA/TSP = Teacher Supportiveness actual/preferred

INVA/INVP = Involvement actual/preferred

SCA/SCP = Student Cohesiveness actual/preferred

OEA/OEP = Open-Endedness actual/preferred

INTA/INTP = Integration actual/preferred

ORA/ORP = Organization actual/preferred

RCA/RCP = Rule Clarity actual/preferred

MEA/MEP = Material Environment actual/preferred

First Year students receive, and also prefer, a high level of lecturer support, which is to be expected. At the other end of the scale, third year students receive and also prefer a lower level of lecturer support, which is also to be expected.

5.2.5 The level and nature of the science subject studied have a significant influence on the students' perceptions of their laboratory environment (see **Figure 4.5**).

First year Science Elementary students viewed their laboratory classroom more favourably in seven out of eight actual scales than the Science Higher students. Only in Material Environment in the actual form do the Science Higher students view their laboratory classroom marginally more favourable than the Science Elementary students. These findings exclude the possiblities when the lecturers are held constant.

Science Elementary students view their science laboratory classroom more favourably in seven out of the eight preferred scales than the Science Higher students. Only in Student Cohesiveness in the preferred form do Science Higher students view their laboratory classroom marginally more favourable than the Science Elementary students.

Science Elementary students scored significantly higher than the Science Higher students in Teacher Supportiveness for both actual and preferred forms. Given the nature of the Science Elementary syllabus, this is to be expected.

These students need the support of the lecturer, since they may not have passed Biology in Matriculation and they most definitely did not study Physical Science in their final school years.

Organization and Rule Clarity, both in the actual and preferred forms, also show significant differences in favour of the Science Elementary students. The fact that all the Science Elementary students are lectured by the same lecturer, and the Science Higher students by a different lecturer, might account for these significant differences.

Second year Biology students, as a group entity (N = 136), view their laboratory classroom environment significantly more favourably than do the third year Biology students, as a group entity (N = 42), in all the actual scales especially in Teacher Supportiveness, Organization and Rule Clarity. But the third year students, as a group, preferred a more favourable laboratory classroom environment than the second year students, as a group, in all the preferred scales (except for Student Cohesiveness), especially in Open-Endedness and Integration. The fact that all the third year students are taught by the same lecturer might account for these significant differences. The teaching style of this lecturer might differ in these two scales from the teaching styles of the other two lecturers. Or being third year students, they might show a greater affinity for open-ended and integrated laboratory environments. Maybe the topics of the syllabus allow for this to a greater extent.

5.2.6 Female students view their laboratory classroom marginally more favourably than do male students in seven of the eight actual scales, except in Material Environment (see **Figure 4.6**). However, these differences are not statistically significant, which finding is in conflict with the findings of Lawrenz (1987), and McRobbie, Giddings and Fraser (1990;1991), and Fraser, Giddings and McRobbie (1992).

Lawrenz (1987) administered the **LEI** to a random sample of fourth grade students, seventh grade students and high school students in Arizona and found that there are gender related differences in their perceptions of the classroom psychosocial environment. According to her results, although she admitted that her research study had certain limitations, these differences become more appreciable as the students get older.

Giddings and Fraser (1990) (in Fraser, Giddings and McRobbie 1992) also reported that females tend to hold more favourable perceptions of classroom environments than do males. These results were replicated and supported by the most recent research undertaken by Fraser, Giddings and McRobbie (1992), using the refined **SLEI** 35-item version in a cross-national study of science laboratory classroom environments at schools and universities in six different countries.

It could be argued that the present research study by the writer had certain limitations, such as being a preliminary research study with a random group of education students studying at the same college of education. Thus, there is much scope for further research in this regard on a wider scale to investigate gender-related differences at tertiary level.

Table 5.3: The Mean Scores for the Actual and Preferred Scales of SLEI of the Three different South African College Science Lecturers

rer	N	TSA	TSP	INVA	INVP	SCA	SCP	OEA	OEP	INTA	INTP	ORA	ORP	RCA	RCP	MEA	MEP
	85	37.3	39.7	32.2	36.2	35.4	39.2	24.1	30.5	34.7	36.1	31.9	36.0	28.5	33.9	32.6	38.1
	101	39.8	40.8	33.7	37.2	36.5	39.2	22.7	29.7	34.9	37.9	36.1	39.0	32.9	36.9	34.4	40.5
	78	34.9	38.5	33.4	36.5	36.9	39.6	24.2	32.7	35.5	37.6	32.9	36.5	28.5	35.9	34.4	39.5

TSA/TSP = Teacher Supportiveness actual/preferred

INVA/INVP = Involvement actual/preferred

SCA/SCP = Student Cohesiveness actual/preferred

OEA/OEP = Open-Endedness actual/preferred

INTA/INTP = Integration actual/preferred

ORA/ORP = Organization actual/preferred

RCA/RCP = Rule Clarity actual/preferred

MEA/MEP = Material Environment actual/preferred

5.2.7 For the following scales: Teacher Supportiveness, Organization, Rule Clarity in the actual form, and Teacher Supportiveness, Open-Endedness, Integration, Organization, Rule Clarity and Material Environment in the preferred form there are significant differences between the students of the various lecturers at the 0.05 level, as presented in **Table 5.3** and the post hoc test.

It is interesting to note that while the students of a particular lecturer scored considerably higher for Teacher Supportiveness, Organization and Rule Clarity in the actual form than the students of the other two lecturers, they scored considerably lower for Open-Endedness in the actual form than the students of the other two lecturers (see **Figure 4.7**).

These results seem to suggest that there might be a correlation between the actual teacher support given, the organization within the laboratory and the clarity of the rules, on the one hand, and the actual level of open-endedness of the laboratory activities, on the other hand.

With lecturers where there are relatively lower mean scores on the actual teacher support given, the open-endedness of the laboratory activities is somewhat higher, whereas the mean scores on the organization within the laboratory and the clarity of the rules are lower.

5.3 Explanations for the Answers to the Research Questions

5.3.1 The research findings suggest that the Hewat students do tend to prefer a more favourable science laboratory classroom environment than they perceive as being actually present. These findings are consistent with previous research results with various assessment instruments such as the **LEI**, **ICEQ**, **CES** and **CUCEI** undertaken by Trickett and Moos (1973); Lawrenz (1976); Moos and Moos (1978); Fraser and Walberg (1981); Haertel, Walberg and Haertel (1981); Fraser, Pearse and Azmi (1982); Fraser and Fisher (1983); Fraser and Treagust (1986); Giddings and Fraser (1989).

5.3.2 The research findings suggest that **SLEI** is capable of differentiating between the perceptions of students in different classrooms. These results are consistent with previous research findings with various assessment instruments such as the **ICEQ**, **CES**, **CUCEI** undertaken by Fraser and others (see **Table 5.1**).

5.3.3 The research findings suggest that there are no statistically significant differences between the perceptions of male students and female students because they view their science laboratory environments similarly. This is an unexpected result and there is considerable scope to replicate and to validate this work.

Figure 8 in **Chapter 4**, however, shows that the preferred scores are appreciably higher than the actual scores for both males and females, as has been found in previous studies undertaken by Fisher and Fraser (1983).

5.3.4 The year level of study, in other words, to a certain extent the age of the student, does have a significant influence on the students' perceptions of the science laboratory environment. The results presented in **Table 4.11** and **Figure 4.4** indicate, as expected, that first year students actually receive and prefer lecturer support more than the second and third year students. Third year students, on the other hand, score considerably lower in both Organization and Rule Clarity in the actual form, but do not necessarily prefer a more favourable science laboratory environment on these two scales than the first and second year students. Third year students also prefer a more favourable science laboratory environment on the scales of Open-Endedness and Integration than the first year and second year students (see **Table 5.2**).

5.3.5 The research results suggest that there are no statistically significant differences between the perceptions of English-speaking and Afrikaans-speaking students for all the scales, actual and preferred, except for Rule Clarity in the actual form, where the mean score for the Afrikaans-speaking students is 31.78 as opposed to the mean score of 28.95 for the English-speaking students. This preliminary result paves the way for further research to include up to a dozen other South African languages as well.

Since this is a preliminary research investigation the findings need to be further researched to validate the results, maybe in conjunction with other indigenous South African languages, such as Zulu, Sotho, Tswana, Xhosa, Venda, Pedi and others.

5.3.6 The research results suggest that there are statistically significant differences in the perceptions of the students which are related to the nature and/or level and type of the science subjects studied. The differences appear to reflect the varying backgrounds of the students in terms of the subjects studied.

5.3.7 The research findings suggest that there are statistically significant differences in the perceptions of the students in nine of the sixteen scales of the two different forms of **SLEI**, which are related to the specific lecturer who lectures the students. The nine scales are Teacher Supportiveness, Organization and Rule Clarity in the actual form; and Teacher Supportiveness, Open-Endedness, Integration, Organization, Rule Clarity and Material Environment in the preferred form. For the other seven scales namely Involvement, Student Cohesiveness, Open-Endedness, Integration and Material Environment in the actual form; and Involvement and Student Cohesiveness in the preferred form there are no statistically significant differences.

5.3.8 The research findings suggest more evidence that both the English and the Afrikaans versions of **SLEI**, both in the actual and the preferred forms, are valid and reliable for use as instruments for asssessing some aspects of classroom psychosocial environment in higher education.

Table 5.4: Internal Consistencies (Alpha Reliabilities) for each Form of the English and Afrikaans Versions of **SLEI** using the Individual as the Unit of Analysis for a South African Sample of College Students

		Alpha Reliability	
Scale	Form	English Version (N = 148 students)	Afrikaans Version (N = 116 students)
Teacher Supportiveness	Act.	0.77	0.67
	Pref.	0.79	0.69
Involvement	Act.	0.60	0.49
	Pref.	0.68	0.59
Student Cohesiveness	Act.	0.64	0.65
	Pref.	0.69	0.68
Open-Endedness	Act.	0.44	0.49
	Pref.	0.62	0.61
Integration	Act.	0.71	0.69
	Pref.	0.69	0.67
Organization	Act.	0.73	0.76
	Pref.	0.76	0.69
Rule Clarity	Act.	0.65	0.61
	Pref.	0.66	0.61
Material Environment	Act.	0.66	0.67
	Pref.	0.62	0.83

Table 5.4 presents the internal consistencies for each form, actual and preferred of **SLEI** for the Afrikaans versions, using the individual as the unit of analysis. Generally, these results suggest that each scale in the **SLEI** possesses adequate internal consistency for use in science laboratory classes of colleges of education in its actual and preferred forms. Alpha reliability coefficients range from 0.49 for Open-Endedness and Involvement to 0.76 for Organization in the actual form; and from 0.59 for Involvement to 0.83 for Material Environment in the preferred form.

The discriminant validity of the Afrikaans versions is also acceptable if the discriminant validity for the total sample (N = 264) is taken into consideration. The values of the mean correlation with other scales range from 0.14 for Open-Endedness to 0.41 for Organization in the actual form; and from 0.17 for Open-Endedness to 0.46 for Integration and Organization in the preferred form (see **Table 4.5**).

Table 5.4 also presents the internal consistencies for each form, actual and preferred of **SLEI** for the original English versions, with the individual as the unit of analysis. Generally, these results suggest that each scale in the **SLEI**, both actual and preferred, possesses adequate internal consistency for use in science laboratory classes of a college of education in a South African setting.

Alpha reliability coefficients range from 0.44 for Open-Endedness to 0.77 for Teacher Supportiveness in the actual form; and from 0.62 for Open-Endedness and Material Environment to 0.79 for Teacher Supportiveness in the preferred form, which are comparable with reliablity coefficients obtained overseas.

The discriminant validity of the English versions is also acceptable if the discriminant validity for the total sample (N = 264) is taken into consideration. The values of the mean correlation with other scales range from 0.14 for Open-Endedness to 0.41 for Organization in the actual form; and from 0.17 for Open-Endedness to 0.46 for Integration and Organization in the preferred form (see **Table 4.5**).

5.4 Comparison of Local and Overseas Results

5.4.1 The discriminant validity indices and the internal consistency (alpha reliability) coefficients of **SLEI** compare favourably with the corresponding indices obtained for the Australian school students and for two other American samples, derived by Giddings and Fraser (1989), and as presented in **Table 2.1**3, except that, among the South African college students, gender-related differences were found to be negligible; and language-related differences were found to be negligible except for Rule Clarity in the actual form which was more pronounced among Afrikaans-speaking students.

5.4.2 The fact that students preferred a more favourable science laboratory environment than was actually present, is also consistent with previous research findings overseas.

5.4.3 Past research has highlighted that closed-ended laboratory exercises dominate much of science education to the exclusion of more desirable open-ended activities (Fraser, Giddings and McRobbie 1992). A cursory glance at **Table 4.1** and **Figures 4.1** and **4. 2** - which present and depict the mean scores obtained on each scale in the actual and preferred versions for both units of analysis - corroborate this research. The very low means for the actual version of the Open-Endedness scale, for both units of analysis, confirm the impression that science laboratory classes in the present sample typically have a very low level of open-endedness.

Using the refined **SLEI** in a cross-national study of six countries on the level of open-endedness at both school and university levels, Fraser, Giddings and McRobbie (1992) found that the mean score on the actual version of the Open-Endedness scale was extremely low relative to the **SLEI's** other dimensions. Therefore, the results reported here on the level of Open-Endedness at tertiary level also support past research results and reinforce an international pattern of findings in which science laboratory classes in school, colleges and universities are dominated by a perception of closed-ended activities.

5.4.4 Gender Differences

The findings reported here on gender-related differences in perceptions of science laboratory classroom environments are not consistent with findings reported by Lawrenz (1987), McRobbie, Giddings and Fraser (1990; 1991) and Fraser, Giddings and McRobbie (1992).

Table 4.15 and **Figure 4.6** show that the male and female students at Hewat College of Education view the actual environment in their science laboratory approximately similarly, although female students tend slightly to prefer a more favourable science laboratory environment than do male students, especially in Teacher Supportiveness (mean for males 38.66; female 40.28) and Student Cohesiveness (males 38.08; female 40.28) and Organization (males 36.43; females 38.01) which is consistent with previous results reported by Fisher and Fraser (1983), Lawrenz (1987), McRobbie, Giddings and Fraser (1990; 1991), and Fraser, Giddings and McRobbie (1992). However, male students tend to perceive the actual science laboratory environment marginally but not significantly more favourably than female students in Material Environment in the actual version (males 34.01; females 33.67).

Fraser, Giddings and McRobbie (1992) employed the refined version of **SLEI**, and reported that gender differences are statistically significant ($p < 0.05$) for all **SLEI** scales except Open-Endedness and Rule Clarity for the Personal actual form, for all scales except Open-Endedness for the Personal preferred form, for two scales for the Class actual form (Student Cohesiveness and Integration), and for all scales except Open-Endedness for the Class preferred form.

5.5 Critique of the Instrument Used

The **Science Laboratory Environment Inventory (SLEI)** was developed in Australia by Barry Fraser and Geoff Giddings (1989) and is designed for use at the higher education level.

SLEI is in the form of a questionnaire and a separate actual form (what the laboratory is actually like) and preferred form (what students would prefer the laboratory to be like) have been developed.

The unrefined form of **SLEI**, which was used in this research study, has 72 items with nine items assessing each of the following eight areas: Teacher Supportiveness, Involvement, Student Cohesiveness, Open-Endedness, Integration, Organization, Rule Clarity and Material Environment (Fraser and Giddings 1989). Dimensions for the **SLEI** were chosen to include scales in each of Moos' three general categories for conceptualizing all human environments.

These three general categories are: (i) **Relationship Dimensions**, (ii) **Personal Development Dimensions** and (iii) **System Maintenance and System Change Dimensions** (Table 3.2).

Meanwhile **SLEI** has been further refined to contain 56 items initially, and then 52 items (Fraser 1989).

In a letter dated 21 August 1992, addressed to the writer, Professor Barry J Fraser wrote the following: "A lot has happened at this end since last we were in contact. Enclosed is a 1992 conference paper which summarises the state of play at the moment. You will note that we have further refined the **SLEI** so that it now has only 5 scales with 7 items in each (i.e. a total of 35 items altogether)." (see **Appendix I**).

The five scales in the final refined **SLEI** 35-item version are Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment.

Fraser and Tobin (1991) pointed out a major problem with nearly all existing classroom environment instruments. The problem is that items are worded in such a way that they elicit an individual student's perceptions of the class as a whole, as distinct from the student's perceptions of his/her own role within the classroom. For example, items in the traditional Class Form of classroom environment instruments might seek students' opinions about whether "the work of the class is difficult" or whether "the teacher is friendly towards the class."

In contrast, a Personal Form of the same items would seek opinions about whether "I find the work of the class difficult" or whether "the teacher is friendly towards me." (Fraser, Giddings and McRobbie 1992).

Thus there was a need for a new generation of classroom environment instruments which are better capable of detecting the differences in perceptions between individuals or subgroups within the class. (Fraser, Giddings and McRobbie 1992). This problem could be avoided if use were made of a Personal Form which elicits each student's view of his/her own situation within the class.

The development of a Personal Form of the SLEI is also in harmony with the constructivist theory of knowledge (von Glaserfeld 1989) (in Fraser, Giddings and McRobbie 1992) which is influential in science education today. According to the constructivist theory, learners personally construct their own knowledge of the world, rather then absorb it from external sources. In harmony with constructivist thinking, a classroom environment would be something individually perceived or constructed by each student in a class. That is, in contrast to traditional class instruments which treat differences in perceptions among students within a class as "error", the Personal Form of an instrument recognizes as legitimate and meaningful the differences between different students' perceptions (Fraser, Giddings and McRobbie 1992).

5.6 Critique of the Methodology Employed

In 1989 Fraser and Giddings forwarded a copy of the original unrefined **SLEI** to the writer for use in the present research study, a copy of which was submitted to the Department of Education and Culture accompanied by a letter to seek approval and permission for use in the investigation.

SLEI was translated from English into Afrikaans and the accuracy was checked reversibly by experts fluent in both languages. The present research study can thus be viewed as a pilot study on African soil, or a preliminary study. The statistical data reported here on the means and standard deviations of the different scales, the internal consistency (reliablilty), discriminant validity and the ability to differentiate between science laboratory classrooms appear to be satisfactory.

Each of the three different lecturers involved in the research study administered the **SLEI**, in both actual and preferred forms, to his students during normal lecturing time, after a thorough briefing session with the writer. The directions for assessment were also supplied to the lecturers with the **SLEI** questionnaires. The lecturers were very co-operative and motivated their students to participate in this research study. Although hampered by constraints related to the time-table and the syllabus, the lecturers and students supported the writer admirably.

A separate answer sheet was handed to each student. The answer sheet facilitated ready hand scoring (see **Appendices G** and **H**).

The students were required to respond to the items of **SLEI** by circling a number on their answer sheet corresponding to the responses: Almost Never, Seldom, Sometimes, Often and Very Often. Items not underlined on the answer sheet were scored 1, 2, 3, 4 and 5 respectively for the afore-mentioned responses. Underlined items on the answer sheet were scored in the reverse manner by allocating 5, 4, 3, 2 and 1 respectively for the afore-mentioned responses. Omitted or invalidly answered items were scored 3 (after Giddings and Fraser 1989). Very low percentage of omitted or spoilt responses occurred, although some of the students were apprehensive about the research project. The absence of a research culture at the selected college of education may account for this statement. The absence of a research culture at the college can be ascribed to the syllabi which are examination-orientated.

The scores of students who did not respond to both actual and preferred forms of **SLEI** were excluded from the analysis of results reported here.

The actual and preferred forms of **SLEI** were administered two weeks apart, due to time-table constraints and in the order of first the actual form and then the preferred form with all classes.

The writer is aware that, from a methodological point of view, the reverse order could have been employed elsewhere with three samples at another college. The results and findings could then have been compared with the results and findings of this study. Consequently, there is much scope for future research investigations to identify any educationally significant and statistically significant differences, such as actual-preferred scores, means and standard deviations etc., should the reverse order of assessment be employed.

Confidentiality of responses and anonymity of respondents were assured by the writer and all students and lecturers were assured that they were not being assessed personally.

The two units of analysis, namely the individual student and the class means were used, as has been the case in past research by Fraser and others.

The lecturers and students were very amenable to the report back on the findings of the study. In general, they were in agreemment that the activities in the laboratory classes were too closed-ended. Suggestions were made by the lecturers, among others:

* that team-teaching be instituted;
* that evaluation be done on the modular system; and
* that practical work be more student-centred.

The low eta -square scores in **Table 4.8** could be due to the very low number of students per class, which range from 7 to 28 (**Table 5.1**). Similarly, the low eta -square scores in **Table 4.11** could be due to the fact that only three different year levels were compared. A similar explanation can be given for the low eta - square scores in **Tables 4.14, 4.15** and **4.18**.

5.7 Chapter Summary

The discussion of the empirical results reported in **Chapter 4** have been presented in this chapter. An attempt has been made to account for the significant differences obtained among the variables which were investigated and to suggest explanations for the outcomes of the tested null hypotheses and the research questions. The discussion in **Chapter 6** will endeavour to relate these findings to those of previous investigations, and to draw conclusions and to make recommendations.

CHAPTER 6: SUMMARY, IMPLICATIONS, RECOMMENDATIONS AND CONCLUSIONS

6.1 Summary

The results of the present research study suggest that the **Science Laboratory Environment Inventory (SLEI)**, is suitable for use at a tertiary level in a South African bilingual context. Both the English and the Afrikaans versions of the **SLEI** have been found to be valid and reliable for use as instruments for assessing students' perceptions of their science laboratory classroom environments.

The results reported appear to corroborate previous research findings that there is a preferred classroom environment different from the actual perceived environment. Significant variables such as class membership, year level of study, type of science subject studied, and different lecturers were investigated and found to be associated with differences in laboratory learning environments. Non-significant variables were found to be gender of the student, and the home language.

Some of the findings show consistency with results of prior research studies. For example, the appreciable differences which occur between the actual and the preferred environments, the effect of class membership on perception, the effect of year level (or age), type of science subject and the particular lecturer are consistent with previous research.

Other findings raise possiblities for further research, as these show some degree of discrepancy with prior research findings obtained by Fraser and others. For example, the effect of home language and the gender of the students on laboratory environment perceptions are in this category.

6.2 Implications for the Instrument and its International Use

Since this research study is a preliminary study with the unrefined version of **SLEI**, the results can be viewed as part of the validation and refinement of the **SLEI** adapted to South African conditions at the tertiary level of education, especially the Afrikaans version.

The results of this investigation can also form part of the cross-national study with students from various countries commenced by Fraser, Giddings and McRobbie (1989; 90; 91; 92). However, further research with a more extensive and representative sample of South African college and university students has to be undertaken to replicate and to generalise the results and findings of this research.

6.3 Implications for the Local Colleges of Education and their Science Lecturers

It is hoped that the science lecturers of local colleges will attempt to improve the environments of science laboratories to harmonise the actual science laboratory classroom environment more closely with the preferred environment as perceived by students, because if the difference between these scores is low, then higher performance will result as shown by the "Person-Environment Fit Hypothesis" (Fraser and Rentoul 1980; Fraser and Fisher 1983).

The findings of the present study show that the Hewat students tended to perceive their science laboratory classroom environment positively in terms of a greater emphasis on Teacher Supportiveness, Student Cohesiveness and Material Environment, in both the actual and the preferred forms of SLEI. On the other hand, students tended to perceive their college science laboratory classroom environment less positive in terms of Involvement, Open-Endedness, Integration, Organization and Rule Clarity, in both the actual and the preferred forms of SLEI.

College lecturers are encouraged to improve their science laboratory environment so as to increase the degree of open-endedness, integration, organization and rule clarity, since these are characteristics of individualized classroom environments and of exemplary science teaching.

The very low mean scores on the actual version of the Open-Endedness scale indicate that closed-ended laboratory exercises dominate much of science education at Hewat College to the exclusion of, arguably, more desirable open-ended activities. This finding is consistent with the findings of Fraser, Giddings and McRobbie (1992) in their cross-national study with students from six different countries.

6.4 Implications for the Wider Context of South African Science Education

A wider implication for South African science education is that the laboratory classroom climate dimensions, as assessed by the **SLEI**, appear to be able to provide useful criteria in the evaluation of new and innovative approaches to laboratory teaching.

An example of innovation in South African science education was the introduction of the **Science Education Project (SEP)** in 1976 (MacDonald and Rogan 1988). It set out to help teachers to cope with the performance of practical work by pupils, and for teachers to move away from predominantly teacher-dominated lessons towards ones in which school pupils play a more active role, interacting with the materials, with their peers and with their teachers (MacDonald and Rogan 1988). Thus **SLEI** could be used in teacher training when teachers are using **SEP** kits in college laboratories, to measure perceived reactions to **SEP** materials.

6.5 Implications for the Wider Context of South African Education in General

According to MacDonald, Gilmour and Moodie (1985), many educational innovations rely on teacher education, either pre-service or in-service, for their successful implementation. They identify four roles for the teacher if the innovation and its demands are to be introduced successfully. These roles are the teacher as an employee, as a subject specialist, as a classroom director and as a professional.

Effective science and technical education are of crucial importance for developing countries. The study of science has posed distinct problems for educators in developing countries and elsewhere, for they have not yet agreed on how to teach it or how to develop curriculum materials (MacDonald, Gilmour and Moodie 1985). South Africa is in more than one way still a developing country. According to Cumming (1990), that although a large portion of the national budget is devoted to education in some of these developing countries, the planning, management and administrative structures are weak, and a large proportion of the teachers are professionally weak.

According to Layman (1983) (in MacDonald, Gilmour and Moodie 1985), any approach usually assumes that the teacher's basic knowledge of the subject is sound. But this assumption is not always valid in developing countries like South Africa, and may not be true in certain developed countries.

In South Africa, where education is mostly still segregated along racial lines, except for some of the recently integrated private schools and Model C schools, this is particularly so.

It must be pointed out, however, that these recently integrated private schools and Model C schools are still out of reach of the most neglected sections of the South African population, namely the disadvantaged people, and many black teachers remain underqualified for the work they are expected to do.

Thus, it is the writer's viewpoint that before any large scale improvements in classroom environments can be initiated in South African education in general, imbalances existing within the education system must be addressed and redressed. The major innovation for South African education seems to point in the direction of a single education system for all, irrespective of colour, race, creed, class, gender or religion.

6.6 Recommendations

The writer recommends that teachers and lecturers could begin to use classroom environment instruments like **SLEI**, together with all the other measures that they use in formative evaluations, to improve the effectiveness of their teaching strategies.

For example, it is also recommended that some laboratory activities emphasize an open-ended, divergent, individualized approach to experimentation. It is quite common to hear students say that laboratories are boring and that they sometimes go through the motions of experimentation without stimulation and often without any clear purpose (Giddings and Fraser 1989; McRobbie, Giddings and Fraser 1991). Lecturers and teachers should plan to improve laboratory teaching techniques so that the great expense of maintaining and staffing laboratories is more defensible (Hofstein and Lunetta 1982). Hodson (1988) describes open-ended laboratory work as "the very pinnacle of science education" (in Fraser, Giddings and McRobbie 1992). However, more often than not, laboratory activities are closed-ended and involve students in investigations for which they already know the correct answer (Fraser, Giddings and McRobbie 1992).

To overcome this problem, it is further recommended that lecturers and teachers should:

* provide more hands-on activities;
* provide more student-relevant topics that encourage student involvement;
* use more co-operative learning activities to promote student-to-student interaction;
* focus on positive and supportive communication with every student;
* provide an organized classroom setting;
* diversify their teaching strategies (Myers III and Fouts 1992); and

* then use **SLEI** to evaluate whether all this renewed effort does in fact produce the desired outcomes in improved laboratory environment.

6.7 Conclusion

As a result of this research study, further research and practical applications involving the psychosocial environment of science laboratory classrooms can be stimulated and facilitated.

The **SLEI** has considerable potential usefulness for teachers and lecturers to monitor their own science laboratory classroom environments. Features that are likely to attract teachers and lecturers to make use of **SLEI** are its economy in terms of testing and scoring time, its specific relevance to science laboratory classes, and its proven reliability now with samples from seven different countries.

6.8 Possible Future Research Directions

According to Fraser (1981a) teachers should act in the role of researchers in their own classrooms, as well as in the role of instructors.

Possible future research directions using the **SLEI** include measuring and evaluating the effectiveness of innovations in science laboratory teaching, examining whether the nature of the laboratory environment influences student achievement and satisfaction, and whether students' preferences differ from the teachers' and lecturers' perceptions (McRobbie, Giddings and Fraser 1991), to guide systematic attempts to improve the laboratory learning environments (Fraser, Giddings and McRobbie 1992).

The evolution of a Personal Form of the **SLEI** opens up the possibility of conducting meaningful and sensitive investigations into the sub-environments existing within a class for different groups of students, as well as constructing meaningful case studies of individual students (Fraser, Giddings and McRobbie 1992).

The Personal Form of **SLEI** can be used in case studies involving students who are neutral towards dissections, abortions, pollution, evolution, vegetarianism, and euthanasia in contrast to those who are strongly opposed for religious and cultural reasons.

It is also arguably desirable to break away from the tradition to separate the fields of classroom and school environment and to combine these two within the same research study (Fraser, Giddings and McRobbie 1992).

Another attractive future research direction is to use **SLEI** in a cross-cultural study in the wider South African context, for example actual and preferred cultural responses of Zulus-, Xhosa-, Sotho-, and Afrikaans-speaking pupils and students to lightning experiments with a van der Graaf generator, to circumcision and AIDS in the reproductive topics; and Hindus to carnivores, herbivores and omnivores, and locust eating in the nutritional topics of the biology syllabi.

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APPENDICES

curtin
University of Technology
Perth Western Australia

GPO Box U 1987
Perth 6001
Western Australia
Fax (09) 458 4661
Telex AA92983

Telephone
(09) 350 7700

April 21, 1989

Mr W E Adams
"Wil-joro" No. 6
Coby Close
Grassy Park
Cape Town
SOUTH AFRICA 7945

Dear Mr Adams

Thank you for your interest in my classroom environment instrument for higher education and the information about your interesting study.

Information is enclosed about (1) the STEI, which is now called the College and University Classroom Environment Inventory (CUCEI) and (2) a new instrument called the Science Laboratory Environment Inventory (SLEI). As your own study is in science, I thought that the SLEI might interest you.

Thank you for offering to share your results with me. I will be interested to see them. There might even be an opportunity to write a joint paper.

Please could you do me a favour to join our AERA Special Interest Group, which is described in the orange advertisement attached.

Yours sincerely

BJ Fraser

Barry J Fraser
Professor
School of Curriculum Studies
Faculty of Education

Encl.

WAIT
Curtin University
of Technology
formerly
Western Australian
Institute of Technology

SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)

ACTUAL FORM

DIRECTIONS

This questionnaire contains statements about practices which could take place in this laboratory class. You will be asked <u>how often</u> each practice <u>actually takes place</u>.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

Please do not write on this questionnaire. All answers should be given on the separate Answer Sheet.

Think about how well each statement describes what your laboratory class is actually like. Draw a circle around

1	if the practice actually takes place	ALMOST NEVER
2	if the practice actually takes place	SELDOM
3	if the practice actually takes place	SOMETIMES
4	if the practice actually takes place	OFTEN
5	if the practice actually takes place	VERY OFTEN

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

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

<u>Practice Example</u>. Suppose that you were given the statement: "Students choose their partners for laboratory experiments." You would need to decide whether you thought that students <u>actually</u> choose their partners 'Almost Never', Seldom', 'Sometimes', 'Often' or 'Very Often'. For example, if you selected 'Very Often', you would circle the number 5 on your Answer Sheet.

Remember that you are being asked how often (Almost Never, Seldom, Sometimes, Often, Very Often) that each of the following practices actually takes place in this laboratory class.

1. The teacher/instructor is concerned about students' safety during laboratory work.
2. The teacher/instructor dominates class discussions during laboratory sessions.
3. Students in this laboratory class get along well as a group.
4. There is opportunity for students to pursue their own science interests in this laboratory class.
5. We use the laboratory to investigate problems that come up in our regular science class.
6. This laboratory class is well organized.
7. Our laboratory class has clear rules to guide student activities.
8. The laboratory is crowded when we are doing experiments.
9. Certain students are allowed to monopolize the teacher's/instructor's time.
10. Students put effort into what they do in laboratory sessions.
11. Students have little chance to get to know each other in this laboratory class.
12. In this laboratory class, we are required to design our own experiments to solve a given problem.
13. The laboratory work is unrelated to the topics that we are studying in our science class.
14. Many students are confused about what to do during laboratory sessions.
15. This laboratory class is rather informal and few rules are imposed.
16. The equipment and materials that students need for laboratory activities are readily available.
17. The teacher/instructor goes out of his/her way to help students.
18. In laboratory group work, students leave it to their partners to do all the work.
19. Members of this laboratory class help one another.
20. The teacher/instructor tells us the exact procedures to use in our practical work.
21. We talk about the results of laboratory sessions in regular science class time.
22. At the beginning of laboratory sessions, we begin work without delay.
23. Students are required to follow certain rules in the laboratory.
24. Students are ashamed of the appearance of this laboratory.

Remember that you are being asked how often (Almost Never, Seldom, Sometimes, Often, Very Often) that each of the following practices actually takes place in this laboratory class.

25. Certain students are favoured by the teacher/instructor.
26. Students in this laboratory class listen to other students' ideas.
27. This laboratory class is made up of individuals who don't know each other very well.
28. We know the results that we are supposed to get before we commence a laboratory activity.
29. What we do in our regular science class is unrelated to our laboratory work.
30. There is confusion during laboratory sessions.
31. There is a recognized way of doing things safely in this laboratory.
32. The laboratory is an attractive place in which to work.
33. The teacher/instructor is friendly towards students.
34. Students present their laboratory results to the whole laboratory class.
35. Students in this laboratory class are unfriendly towards each other outside the laboratory.
36. In our laboratory sessions, different students may collect different data for the same problem.
37. Our regular science class work is integrated with laboratory activities.
38. In our laboratory class, it takes a long time to gather equipment and/or clean up.
39. Students are unpenalised for breaking laboratory rules.
40. Safety equipment (e.g. fire extinguisher) is readily available in this laboratory.
41. The teacher/instructor is busy with grading/marking or other work while we are working in the laboratory.
42. The teacher/instructor is unwilling to listen to students during laboratory sessions.
43. Students in this laboratory class get to know each other well.
44. Students are allowed to go beyond the regular laboratory exercise and do some experimenting of their own.
45. We use the theory from our regular science class sessions during laboratory activities.
46. We spend the right amount of time before laboratory sessions in discussing what we will be doing during the session.
47. Students are uncertain about the safety rules that they should follow during laboratory sessions.
48. Laboratory equipment is in poor working order.

Remember that you are being asked how often (Almost Never, Seldom, Sometimes, Often, Very Often) that each of the following practices actually takes place in this laboratory class.

49. Every member of this laboratory class has the same rights.
50. Students express their opinions during laboratory classes.
51. Students are able to depend on each other for help during laboratory classes.
52. In our laboratory sessions, different students do different experiments.
53. The topics covered in regular science class work are quite different from topics dealt with in laboratory sessions.
54. The work of this laboratory class is interrupted by students who have nothing to do.
55. There are few fixed rules for students to follow in laboratory sessions.
56. The laboratory is hot and stuffy.
57. The teacher/instructor answers clever students' questions more sympathetically than those of other students.
58. Students share ideas and information during laboratory activities.
59. It takes a long time to get to know everybody by his/her first name in this laboratory class.
60. We know the answer to a laboratory problem that we are investigating before we start the experiment.
61. What we do in laboratory sessions helps us to understand the theory covered in regular science classes.
62. Laboratory activities are carefully planned.
63. The teacher/instructor outlines safety precautions before laboratory sessions commence.
64. Appropriate books and other resources are available in the laboratory for student use.
65. The teacher/instructor helps students who are having trouble during laboratory activities.
66. Students have spare time during laboratory sessions.
67. Students work cooperatively in laboratory sessions.
68. Students decide the best way to proceed during laboratory experiments.
69. Laboratory work and regular science class work are unrelated.
70. There are long periods during laboratory work when we achieve nothing useful.
71. This laboratory class is run under clearer rules than other classes.
72. The laboratory has enough room for individual or group work.

WETENSKAPLABORATORIUM-OMGEWINGSINVENTARIS (WLOI)

VOORKEURINGSVORM

INSTRUKSIES

Hierdie vraelys bevat stellings aangaande praktyke wat mag in hierdie laboratoriumklas plaasvind. U word gevra hoe gereeld u sou verkies dat elke praktyk plaas moes vind.

Daar is geen `korrekte' of `verkeerde' antwoorde. U mening word gevra.

Moenie op hierdie vraelys skryf nie, asseblief. Alle antwoorde moet aangegee word op die aparte Antwoordblad.

Dink hoe presies elke stelling beskryf dit wat u sou verkies moet in u laboratoriumklas plaasvind. Trek 'n sirkel om

1	indien u sou verkies dat die praktyk plaasvind	BYNA NOOIT
2	indien u sou verkies dat die praktyk plaasvind	SELDE
3	indien u sou verkies dat die praktyk plaasvind	SOMS
4	indien u sou verkies dat die praktyk plaasvind	DIKWELS
5	indien u sou verkies dat die praktyk plaasvind	MEER DIKWELS

Maak seker dat u al die vrae beantwoord. Indien u 'n antwoord verander, moet u dit deurhaal en 'n ander omsirkel.

Sommige stellings in hierdie vraelys is heelwat soortgelyk aan ander stellings. Moenie u daaroor bekommer nie. Verskaf slegs u mening omtrent al die stellings.

Praktiese Voorbeeld:

Gestel u word die volgende stelling gegee: "Studente sou hul maats wou kies vir laboratoriumeksperimente." Dan sal u moet besluit of u sou verkies dat studente hul maats `Byna Nooit', `Selde', `Soms', `Dikwels' of `Meer Dikwels' moet kies. Byvoorbeeld, indien u `Meer Dikwels' sou kies, moet u nommer 5 omsirkel op die Antwoordblad.

Onthou dat u gevra word hoe gereeld (Byna Nooit, Selde, Soms, Dikwels, Meer Dikwels) u sou verkies dat elk van die volgende praktyke in hierdie laboratoriumklas plaasvind.

1. Die onderwyser/instrukteur sou besorgd wees oor die studente se veiligheid gedurende laboratoriumwerk.
2. Die onderwyser/instrukteur sou die klasbesprekings gedurende laboratoriumsessies domineer.
3. Studente in hierdie laboratoriumklas sou as 'n groep goed oor die weg kom.
4. Die laboratoriumklas sou vir elke student die geleentheid bied om sy/haar eie wetenskapbelangstelling na te streef.
5. Ons sou die laboratorium gebruik om probleme wat in ons gereelde wetenskapklas opduik te ondersoek.
6. Hierdie laboratoriumklas sou goedgeorganiseer wees.
7. Ons laboratoriumklas sou duidelike reëls hê wat studente-aktiwiteite rig.
8. Die laboratorium sou oorvol wees wanneer ons eksperimente uitvoer.

9. Sekere studente sou die onderwyser/instrukteur se tyd monopoliseer.
10. Studente sou moeite doen met laboratoriumaktiwiteite gedurende laboratoriumsessies.
11. Studente sou nie veel geleentheid hê om mekaar in hierdie laboratoriumklas te leer ken nie.
12. In hierdie laboratoriumklas sou dit van ons verwag word om ons eie eksperimente te ontwerp om 'n gegewe probleem op te los.
13. Die laboratoriumwerk sou nie verband hou met die onderwerpe wat ons in ons wetenskapklas bestudeer nie.
14. By baie studente sou daar verwarring bestaan omtrent aktiwiteite gedurende laboratoriumsessies.
15. Laboratoriumklasse sou eerder informeel wees en min reëls sou toegepas word.
16. Die apparaat en materiaal wat studente nodig het vir laboratoriumaktiwiteite sou geredelik beskikbaar wees.

17. Die onderwyser/instrukteur sou baie moeite doen om die studente te help.
18. By laboratoriumgroepwerk sou studente dit oorlaat aan hul groeplede om al die werk te doen.
19. Lede van hierdie laboratoriumklas sou mekaar help.
20. Die onderwyser/instrukteur sou vir ons sê presies watter prosedure ons moet gebruik in ons praktiese werk.
21. Ons sou die resultate van die laboratoriumsessies in ons greelde wetenskapperiode bespreek.
22. Aan die begin van laboratoriumsessies sou ons dadelik begin werk.
23. Daar sou van die studente verwag word om sekere reëls in die laboratorium na te kom.
24. Die voorkoms van hierdie laboratorium sou 'n verleentheid wees vir die studente.

Onthou dat u gevra word hoe gereeld (Byna Nooit, Selde, Soms, Dikwels, Meer Dikwels) u sou verkies dat elk van die volgende praktyke in hierdie laboratoriumklas plaasvind.

25. Sekere studente sou deur die onderwyser/instrukteur
-- begunstig word.
26. Studente in hierdie laboratoriumklas sou ag slaan op die idees van ander studente.
27. Hierdie laboratoriumklas sou bestaan uit indiwidue wat
-- mekaar nie baie goed ken nie.
28. Ons sou weet watter resultate ons veronderstel is om te
-- bereik voordat ons met 'n laboratoriumaktiwiteit begin.
29. Die werk wat ons in ons gereelde wetenskapklas doen, sou
-- nie verband hou met ons laboratoriumwerk nie.
30. Daar sou verwarring wees gedurende laboratoriumklasse.
--
31. Daar sou 'n aanvaarbare praktyk wees om in hierdie laboratorium binne sekere veiligheidsgrense te bly.
32. Die laboratorium sou 'n aangename plek wees om in te werk.

33. Die onderwyser/instrukteur sou vriendelik teenoor die studente wees.
34. Studente sou hul laboratoriumresultate aan die hele laboratoriumklas bekend maak.
35. Studente in hierdie laboratoriumklas sou onvriendelik
-- teenoor mekaar wees buite die laboratorium.
36. In ons laboratoriumsessies sou verskillende studente verskillende gegewens vir dieselfde probleem mag insamel.
37. Ons gereelde wetenskapklaswerk sou geïntegreer word met die laboratoriumaktiwiteite.
38. In ons laboratoriumklas sou dit 'n lang tyd neem om
-- apparaat te versamel en/of skoon te maak.
39. Studente sou nie gestraf word vir die verbreking van
-- laboratoriumreëls nie.
40. Veiligheidstoerusting (bv brandblusser) sou geredelik beskikbaar wees in hierdie laboratorium.

41. Die onderwyser/instrukteur sou besig wees met gradering/
-- nasien of enige ander werk terwyl ons in die laboratorium werk.
42. Die onderwyser/instrukteur sou nie luister na die studente
-- gedurende laboratoriumsessies nie.
43. Studente in hierdie laboratoriumklas sou mekaar goed leer ken.
44. Studente sou nie beperk word tot die normale laboratorium-oefening nie, en sou toegelaat word om op hul eie so 'n bietjie te eksperimenteer.
45. Ons sou die teorie van ons gereelde wetenskapklas-sessies gebruik gedurende laboratoriumaktiwiteite.
46. Ons sou die aangewese hoeveelheid tyd voor elke laboratoriumsessie gebruik vir bespreking van beoogde aktiwiteite gedurende die sessie.
47. Studente sou onseker wees omtrent die veiligheidsreëls wat
-- gedurende laboratoriumsessies gevolg moet word.
48. Laboratoriumtoerusting sou in 'n swak werkende toestand
-- wees.

Onthou dat u gevra word hoe gereeld (Byna Nooit. Selde, Soms, Dikwels, Meer Dikwels) u sou verkies dat elk van die volgende praktyke in hierdie laboratoriumklas plaasvind.

49. Elke lid van hierdie laboratoriumklas sou gelyke regte geniet.
50. Studente sou hul menings lug gedurende laboratoriumklasse.
51. Studente sou kan op mekaar staat maak vir hulp gedurende laboratoriumklasse.
52. In ons laboratoriumsessies sou verskillende studente verskillende eksperimente doen.
53. Die onderwerpe wat in die gereelde wetenskapklaswerk gedek
-- word, sou heeltemal verskil van die onderwerpe wat in die laboratoriumsessies gedek word.
54. Werk van hierdie laboratoriumklas sou onderbreek word deur
-- studente wat ledig is.
55. Daar sou min vaste reëls vir alle studente wees om te volg
-- gedurende laboratoriumsessies.
56. Die laboratorium sou warm en bedompig wees.
--

57. Die onderwyser/instrukteur sou meer simpatiek wees in sy
-- beantwoording van die slim studente se vrae.
58. Studente sou idees en inligting gedurende laboratorium= aktiwiteite uitruil.
59. Dit sou lank neem om elkeen in hierdie laboratoriumklas op
-- sy/haar voornaam te leer ken.
60. Ons sou die antwoord van 'n laboratoriumprobleem wat ons
-- ondersoek, ken voordat ons met die eksperiment begin.
61. Ons laboratoriumsessies sou ons help om die teorie wat in die gereelde wetenskapklasse behandel word, te verstaan.
62. Laboratoriumaktiwiteite sou sorgvuldig beplan word.
63. Die onderwyser/instrukteur sou die veiligheidsmaatreëls skets voordat laboratoriumsessies 'n aanvang neem.
64. Toepaslike boeke en ander naslaanwerke sou in die laboratorium beskikbaar wees vir gebruik deur studente.

65. Die onderwyser/instrukteur sou hulp verleen aan die studente wat probleme ondervind gedurende laboratorium= aktiwiteite.
66. Studente sou vry tyd hê gedurende laboratoriumsessies.
--
67. Daar sou 'n goeie samewerking tussen studente tydens laboratoriumsessies bestaan.
68. Studente sou besluit op die beste manier om te werke te gaan gedurende laboratoriumeksperimente.
69. Laboratoriumwerk sou nie verband hou met ons gereelde
-- wetenskapklaswerk nie.
70. Daar sou lang periodes gedurende laboratoriumwerk wees
-- waartydens ons niks konstruktiefs doen nie.
71. Vir hierdie laboratoriumklas sou duideliker reëls geld as vir ander klasse.
72. Die laboratorium sou genoegsame ruimte vir individuele of groepwerk hê.

SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)
WETENSKAPLABORATORIUM-OMGEWINGSINVENTARIS (WLOI)

NAME _____

SCIENCE GROUP (e.g. 3A) _____ ACTUAL FORM/WERKLIKSHEIDSVORM

COLLEGE _____

ANSWER SHEET / ANTWOORDBLAD

COURSE (e.g. D.E. II SP) _____

Remember you are rating your actual laboratory/Onthou u beoordeel die laboratorium soos dit werklik is

ALMOST NEVER
SELDOM
SOMETIMES
OFTEN
VERY OFTEN

1.	1 2 3 4 5	17.	1 2 3 4 5	33.	1 2 3 4 5	49.	1 2 3 4 5	65.	1 2 3 4 5			
2.	1 2 3 4 5	18.	1 2 3 4 5	34	1 2 3 4 5	50.	1 2 3 4 5	66.	1 2 3 4 5			
3.	1 2 3 4 5	19.	1 2 3 4 5	35.	1 2 3 4 5	51.	1 2 3 4 5	67.	1 2 3 4 5			
4.	1 2 3 4 5	20.	1 2 3 4 5	36.	1 2 3 4 5	52.	1 2 3 4 5	68.	1 2 3 4 5			
5.	1 2 3 4 5	21.	1 2 3 4 5	37.	1 2 3 4 5	53.	1 2 3 4 5	69.	1 2 3 4 5			
6.	1 2 3 4 5	22.	1 2 3 4 5	38.	1 2 3 4 5	54.	1 2 3 4 5	70.	1 2 3 4 5			
7.	1 2 3 4 5	23.	1 2 3 4 5	39.	1 2 3 4 5	55.	1 2 3 4 5	71.	1 2 3 4 5			
8.	1 2 3 4 5	24.	1 2 3 4 5	40.	1 2 3 4 5	56.	1 2 3 4 5	72.	1 2 3 4 5			
9.	1 2 3 4 5	25.	1 2 3 4 5	41.	1 2 3 4 5	57.	1 2 3 4 5					
10.	1 2 3 4 5	26.	1 2 3 4 5	42.	1 2 3 4 5	58.	1 2 3 4 5					
11.	1 2 3 4 5	27.	1 2 3 4 5	43.	1 2 3 4 5	59.	1 2 3 4 5					
12.	1 2 3 4 5	28.	1 2 3 4 5	44.	1 2 3 4 5	60.	1 2 3 4 5					
13.	1 2 3 4 5	29.	1 2 3 4 5	45.	1 2 3 4 5	61.	1 2 3 4 5					
14.	1 2 3 4 5	30.	1 2 3 4 5	46.	1 2 3 4 5	62.	1 2 3 4 5					
15.	1 2 3 4 5	31.	1 2 3 4 5	47.	1 2 3 4 5	63.	1 2 3 4 5					
16.	1 2 3 4 5	32.	1 2 3 4 5	48.	1 2 3 4 5	64.	1 2 3 4 5					

Teacher Use Only

TS _____
Inv _____
SC _____
OE _____
Int _____
OR _____
RC _____
ME _____

TS _____
Inv _____
SC _____
OE _____
Int _____
OR _____
RC _____
ME _____

Remember you are rating your actual laboratory/Onthou u beoordeel die laboratorium soos dit werklik is

TS _____ Inv _____ SC _____ OE _____ Int _____ OR _____ RC _____ ME _____

SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)
WETENSKAPLABORATORIUM-OMGEWINGSINVENTARIS (WLOI)

NAME _____

PREFERRED FORM/VOORKEURINGSVORM

SCIENCE GROUP (e.g. 3A) _____

COLLEGE _____

ANSWER SHEET / ANTWOORDBLAD

COURSE (e.g. D.E. II SP) _____

Remember you are rating your preferred laboratory/ Onthou u beoordeel die laboratorium soos u dit sou verkies

ALMOST NEVER
SELDOM
SOMETIMES
OFTEN
VERY OFTEN

															Teacher Use On
1.	1 2 3 4 5	17.	1 2 3 4 5	33.	1 2 3 4 5	49.	1 2 3 4 5	65.	1 2 3 4 5	TS _____
2.	1 2 3 4 5	18.	1 2 3 4 5	34	1 2 3 4 5	50.	1 2 3 4 5	66.	1 2 3 4 5	Inv _____
3.	1 2 3 4 5	19.	1 2 3 4 5	35.	1 2 3 4 5	51.	1 2 3 4 5	67.	1 2 3 4 5	SC _____
4.	1 2 3 4 5	20.	1 2 3 4 5	36.	1 2 3 4 5	52.	1 2 3 4 5	68.	1 2 3 4 5	OE _____
5.	1 2 3 4 5	21.	1 2 3 4 5	37.	1 2 3 4 5	53.	1 2 3 4 5	69.	1 2 3 4 5	Int _____
6.	1 2 3 4 5	22.	1 2 3 4 5	38.	1 2 3 4 5	54.	1 2 3 4 5	70.	1 2 3 4 5	OR _____
7.	1 2 3 4 5	23.	1 2 3 4 5	39.	1 2 3 4 5	55.	1 2 3 4 5	71.	1 2 3 4 5	RC _____
8.	1 2 3 4 5	24.	1 2 3 4 5	40.	1 2 3 4 5	56.	1 2 3 4 5	72.	1 2 3 4 5	ME _____
9.	1 2 3 4 5	25.	1 2 3 4 5	41.	1 2 3 4 5	57.	1 2 3 4 5			TS _____
10.	1 2 3 4 5	26.	1 2 3 4 5	42.	1 2 3 4 5	58.	1 2 3 4 5			Inv _____
11.	1 2 3 4 5	27.	1 2 3 4 5	43.	1 2 3 4 5	59.	1 2 3 4 5			SC _____
12.	1 2 3 4 5	28.	1 2 3 4 5	44.	1 2 3 4 5	60.	1 2 3 4 5			OE _____
13.	1 2 3 4 5	29.	1 2 3 4 5	45.	1 2 3 4 5	61.	1 2 3 4 5			Int _____
14.	1 2 3 4 5	30.	1 2 3 4 5	46.	1 2 3 4 5	62.	1 2 3 4 5			OR _____
15.	1 2 3 4 5	31.	1 2 3 4 5	47.	1 2 3 4 5	63.	1 2 3 4 5			RC _____
16.	1 2 3 4 5	32.	1 2 3 4 5	48.	1 2 3 4 5	64.	1 2 3 4 5			ME _____

Remember you are rating your preferred laboratory/ Onthou u beoordeel die laboratorium soos u dit sou verkies

TS _____ Inv _____ SC _____ OE _____ Int _____ OR _____ RC _____ ME _____

Science and Mathematics Education Centre (SMEC)
Director: Professor Barry J Fraser

curt
University of Techr
Perth Western Au

GPO Box U 1987
Perth 6001
Western Australia
Fax (09) 351 2503

Telephone
(09) 351 7896

BJF.rw

21 August 1992

Mr W E Adams
PO Box 31192
Grassy Park
Republic of South Africa 7888

Dear Mr Adams

I was pleased to receive your letter of 7 August and to see the large amount of progress which you have made on your MEd research.

A lot has happened at this end since last we were in contact. Enclosed is a 1992 conference paper which summarises the state of play at the moment. You will note that we have further refined the SLEI so that it now has only five scales with seven items in each (ie. a total of 35 items altogether). However the important point to note is that the final 35-item version only has one new item that it not present in the long version which you have been using.

Yes I am still keen to write an article with you. However, it would make sense for us to report, not your old version, but the new version consisting of a subset of 34 of the items in your version. This means that we would need to do some more analyses. Are you able to perform the analyses at your end with ease? Or would you prefer to send me your data on disk so that I can ask my research assistant to do the required analyses? Please let me know your preferences. (Enclosed is a page which shows how the item numbers on your version of the questionnaire may be equated to the item numbers on the new version.)

With respect to a publication outlet, I would be relying on you to select an appropriate educational journal within South Africa. Probably we could go for one of the most prestigious journals in existence in South Africa provided that it does publish the sort of empirical research that we would want to report. I am assuming that we would draw heavily on my conference paper enclosed, but that we would want to report your data from South Africa along with the data for the large cross-national sample. Please would you suggest one or two journals and send me a photocopy of a typical article from these journals?

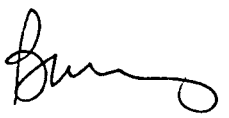
Do you have any further data on any variables that are not already covered in the tables which you have sent me already?

Again, congratulations on approaching the end of your Masters thesis. I will be looking forward to hearing from you about how we will now move forward to coauthor a journal article.

International
Fax +619 351 2503, Tel +619 351 7
Email: NTANNERTD@cc.curtin.edu.a

At your request, I am enclosing a copy of the latest version of SIG brochure. I am delighted that you are planning to renew your membership.

Best wishes



BARRY J FRASER
Professor
Director
Science and Mathematics Education Centre

Addendum to Table 4.8

* The mean scores of the sixteen classes for all the scales, actual and preferred of **SLEI** appear in **Table 5.1.**

* For the **Teacher Supportiveness** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between **Classes 9** and **16** at the 0.05 level.

* For the **Organization** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between **Classes 5** and **12** at the 0.05 level.

* For the **Rule Clarity** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between **Classes 12** and **15** at the 0.05 level.

* For the **Student Cohesiveness** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between **Classes 4** and **6** at the 0.05 level.

Addendum to Table 4.10

* The mean scores for all the scales, actual and preferred of **SLEI** for the Three Year Levels appear in **Table 5.2**

* For the **Teacher Supportiveness** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between **Year Levels** 2 and 3; and 1 and 3 at the 0.05 level.

* For the **Organization** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between **Year Levels** 2 and 3; and 1 and 3 at the 0.05 level.

* For the **Rule Clarity** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between **Year Levels** 2 and 3; and 1 and 3 at the 0.05 level.

* For the **Teacher Supportiveness** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between **Year Levels** 1 and 2 at the 0.05 level.

* For the **Open-Endedness** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between **Year Levels** 1 and 3; and 2 and 3 at the 0.05 level.

* For the **Integration** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between **Year Levels** 2 and 3 at the 0.05 level.

* For the **Rule Clarity** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between **Year Levels** 1 and 2; and 2 and 3 at the 0.05 level.

Addendum to Table 4.16

* The mean scores for all the scales, actual and preferred of **SLEI**, for the Learning Environments of the Three Lecturers appear in **Table 5.3**.

* For the **Teacher Supportiveness** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 1, 2** and **3** at the 0.05 level.

* For the **Organization** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 1** and **2**; and **2** and **3** at the 0.05 level.

* For the **Rule Clarity** scale in the actual version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 1** and **2**; and **2** and **3** at the 0.05 level.

* For the **Teacher Supportiveness** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 2** and **3** at the 0.05 level.

* For the **Open-Endedness** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 2** and **3**; and **1** and **3** at the 0.05 level.

* For the **Integration** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 1** and **2** at the 0.5 level.

* For the **Organization** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 1** and **2**; and **2** and **3** at the 0.05 level.

* For the **Rule Clarity** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 1** and **3**; and **1** and **2** at the 0.05 level.

* For the **Material Environment** scale in the preferred version of **SLEI**, the post hoc test shows that there is a significant difference between the learning environments of **Lecturers 1** and **2** at the 0.05 level.