Science and Mathematics Education Centre

Associations Between Classroom Learning Environments, Teacher Interpersonal Behaviour and Student Outcomes in Secondary Mathematics Classrooms

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ABSTRACT

The classroom learning environment has increasingly been recognised as an important factor in education. However, over recent years the increasing research in this area has focussed on humanities or science classrooms. Virtually no investigations have been reported into the learning environment of the secondary mathematics classroom.

The study reported in this thesis focusses on the perceptions of 490 grade 9 mathematics students in 23 classrooms in 14 schools in Adelaide, South Australia. Students' perceptions of their mathematics learning environment were measured using a new classroom environment instrument which has been developed in both a Personal Form (which focusses on students' perceptions of their personal interaction with the learning environment) and a Class Form (which focusses on students' perceptions of the class's interactions with the learning environment).

This study confirmed the reliability and validity of both forms of the new instrument in its use with this sample of students, and examined the differences between the Personal and the Class Forms of the instrument. The sub-populations of male and female students were also profiled and differences between their perceptions of the classroom learning environment were examined. Differences between students' perceptions of their teacher's interpersonal behaviour in the classroom were also explored.

The study identified associations between students' perceptions of their mathematics classroom learning environment, their perceptions of their teacher's interpersonal behaviour, and student outcomes. The association between students' perceptions of their mathematics classroom environment and attitudinal outcomes was stronger than the association with cognitive outcomes.

Finally, the commonality and uniqueness of the two instruments measuring classroom learning environment and teacher's interpersonal behaviour in terms of predicting outcome variance were established, as were associations between the perceptions of students in these two areas.

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CHAPTER 1

INTRODUCTION

Background to the Study

Research into school effectiveness and into ways of improving students' learning and their attitudes towards their studies is not new. However, the ways in which the research is conducted, the emphases within it and the dimensions of school life which are investigated have changed continually as researchers build upon what is already known.

Although the study of classroom learning environments had its origins in the early 1970s, it is a relatively new area in the broader research of effective education. However, it is widely accepted that class/teacher effects play a significant part in students' learning (Fraser, 1994; Marzano, 1992; Rowe, Hill & Holmes-Smith, 1995). Marzano, for example, advocates five Dimensions of Learning in the classroom. The first of these is the establishment of an appropriate classroom learning environment which he considers essential in the effective classroom. His recognition of the importance of the classroom environment typifies the changes in emphasis in research towards classroom based educational factors.

Research in the 1980s showed that schools do make significant independent contributions (Corcoran & Wilson, 1989; Lezotte, 1989; Reynolds, 1987; Rutter et.al., 1979) in the variance in students' outcomes. However, recent research has shown that the between school differences are largely explained by between class/teacher differences.

For example, Australian research by Rowe, Hill & Holmes-Smith (1995) noted that between school differences explaining 12.6% of variance in students' mathematics achievement became only 4.1% once three level modelling was used and the class/teacher effects were considered. The class/teacher effects explained 35% of variance in students' mathematics achievement outcomes. This is comparable to research by Sheerens, Vermeulen & Pelgrum (1989) who re-analysed the IEA second mathematics study and showed similar results for Sweden, Finland and New Zealand. In each of these countries, once three level modelling was used, the percentage of variance explained by school effects reduced to zero, whilst the variance explained by class/teacher effects was 43%, 31% and 42% respectively. Reynolds and Packer (1992) concluded,

> On the causes of school effects, it seems that early beliefs that school influences were distinct from teacher or classroom influences were misplaced, since a large number of studies utilising multi-level modelling show that the great majority of variation between schools is in fact due to classroom variation and that the unique variance due to the level of the school, and not the classroom, shrinks to very small levels (p. 173).

Hill, Rowe and Holmes-Smith (1995) go a step further in their conclusion that, "This suggests that a given school is likely to be only as effective as the quality of the classroom teaching within that school" (p. 21). This conclusion is consistent with Australian research in the *Effective Schools Project* which reported that the quality of the teachers was the factor most frequently mentioned as contributing to school effectiveness (McGraw, Piper, Banks & Evans, 1992; Piper, 1993). Consequently, one of the important conclusions emerging in the study of school effectiveness is the importance of the class/teacher effects in students' learning.

Whilst research into school effectiveness has been a much publicised area of study over the past 30 years, the study of class/teacher effects, specifically through the study of classroom learning environments, has occurred but has received less prominence in mainstream educational studies. However, any practising teacher knows that classrooms usually

have a 'feel' about them. For example, as soon as a relief teacher walks through the door of someone else's classroom, he or she frequently senses whether the class will be cooperative and work oriented, or difficult and unfriendly. Students also perceive their classes in particular ways, perhaps as warm and accepting, or perhaps threatening. Each class seems to have its own character, or classroom environment, which is greater than the individuals within it.

Although studies in classroom learning environments have been conducted over the past 25 years (Fraser, 1994), it is only during the past few years that this area of research has significantly expanded. As part of the study of classroom environments, instruments have been developed for measuring students' perceptions of their environment. The recent broader acceptance of the importance of the classroom environment has seen the development of a number of new instruments, which will be reviewed in Chapter 2. However, these have been developed for specific purposes, such as for laboratories or computer classrooms, rather than for research in general classrooms. There is a need for the development and validation of a new instrument for general classroom use which reflects recent educational philosophy. Previous general instruments were designed for the classrooms of the 1970s and are now somewhat outdated. It is within this context of the expanding field of classroom environment research that the study which is the focus of this thesis is set. Part of the focus of this thesis is to validate a new instrument which has been developed for general classroom use.

Whilst there have been a number of studies which have investigated classroom environments in recent years, these have been centred primarily in science, physics and humanities classrooms. These studies have often sought to investigate associations between particular aspects of the classroom environment and students' outcomes, or have been used to monitor changes within classrooms as a result of the implementation of new programs. There has, however, been minimal investigation into classroom environments in secondary mathematics classes, either in Australia or overseas.

Rationale for the Study

This study focusses on the classroom environment of grade 9 mathematics classes in Adelaide, South Australia. Two primary instruments are used for the measuring of students' perceptions of their classroom environment. The first of these is a new instrument which has been developed for general classroom use. The *Classroom Environment Instrument* (CEI) uses some of the scales from previous instruments which have been shown to be associated with student outcomes and also reflects recent changes in educational philosophy. It has not previously been used in the form in which it is used in this study, although the use of a different version recently has been reported (Fraser, Fisher & McRobbie, 1996).

The second instrument to be used is the *Questionnaire on Teacher Interaction* (QTI) (Wubbels, Creton & Hooymayers, 1985). This instrument was developed in The Netherlands and focusses on students' perceptions of one specific aspect of the classroom environment, that of the teacher's interpersonal behaviour.

This study makes a number of significant contributions to the study of classroom environments. Firstly it validates a new instrument which can be used in the study of classroom environments by researchers or by classroom teachers. This is important because no instrument has been developed for this general purpose since the 1970s, and because, by its existence and reported use, it will encourage further research into classroom environments.

Secondly, this study is significant because it validates both a Personal form and a Class form of the new instrument. The use of Personal forms of instruments is in itself a new concept in the study of classroom environments. There are only two reported uses of Personal forms of instruments. However, only one of these describes the use of a Personal form of a general classroom instrument, and that was for the slightly

different version of the instrument used in this study (Fraser, Fisher & McRobbie, 1996). The other reported use was for a Personal form of an instrument developed specifically for science laboratories (Fraser, Giddings & McRobbie, 1993, 1995). Consequently, this study adds significantly to the knowledge of perceptions of the general classroom environment from a personal, as well as a class, perspective.

The third significant contribution made by this study is in its focus on secondary mathematics classrooms. There is an obvious deficiency in the literature on classroom environments when mathematics classrooms are considered. This study starts to redress that situation by examining the classroom environments of a large sample of mathematics classrooms. The instruments are used to profile students' perceptions of their mathematics classrooms, and also to profile the perceptions of the sub-populations of male and female students. The study also focusses on two sets of associations in the classrooms. The first is associations which exist between students' perceptions of their mathematics classroom environment, and their attitudinal and cognitive outcomes. The second is associations which exist between their perceptions of their mathematics teacher's interpersonal behaviour, and their attitudinal and cognitive outcomes. The study is also unique in that it uses a new instrument in this research in mathematics classrooms.

The fourth area of significance of this study is in the use of the QTI. The QTI has had limited use in Australia, having been used in only four published instances (Fisher, Fraser, Wubbels & Brekelmans, 1993; Fisher, Henderson & Fraser, 1995; Kent, Fisher & Fraser, 1995; Rickards, Fisher & Fraser, 1996), but has never been used here or overseas solely with a large sample of secondary mathematics students. Consequently, this study makes a unique contribution in its examination of the teacher-student interpersonal behaviour in Australian mathematics classes.

The final significant contribution made by this study is in the determining of associations between students' perceptions of their teacher's interpersonal behaviour and their perceptions of the classroom

environment. This is a unique contribution because previous research involving the QTI has not sought to link the findings to aspects of the classroom environment.

Research Questions

The research questions for this study encompass both the methodology of classroom environment research through the validation of a new instrument, and a specific focus on mathematics students, their classroom environments, and their attitudinal and cognitive outcomes.

There are six research questions.

1. Is the recently developed Classroom Environment Instrument (CEI) used in this study, in both its Personal and Class forms, a reliable and valid measure of students' perceptions of their classroom environment?

2. What differences exist between profiles of the mathematics classroom learning environment when measured by the Personal form of the CEI and when measured by the Class form of the CEI?

3. What differences exist between the perceptions of male and female sub-populations of mathematics students in their perceptions of their mathematics classroom environment and their mathematics teacher's interpersonal behaviour?

4. What associations exist between students' attitudinal and cognitive outcomes and their perceptions of their mathematics classroom environments and of their mathematics teacher's interpersonal behaviour?

5. What are the common and unique contributions made by the Questionnaire on Teacher Interaction (QTI) and the Personal and

Class forms of the Classroom Environment Instrument (CEI) in explaining variance in students' attitudinal and cognitive outcomes?

6. What associations exist between students' perceptions of their mathematics teacher's interpersonal behaviour and their perceptions of their mathematics classroom environment?

Overview of the Thesis

The objectives of this thesis have arisen out of a review of the literature on classroom environments. Chapter 2 reviews this literature and shows the development of classroom environment instruments since their first uses in the early 1970s. It reviews the development of more recent instruments, including the QTI, and shows the ways in which these instruments have been used in research. It concludes by reviewing the literature related specifically to the classroom environments of mathematics classes and notes that there have been very few studies in this area.

The third chapter outlines the methodology used in this study. It discusses the selection of the 23 grade 9 mathematics classes which constituted the sample for the research, along with the ways in which data were collected and analysed. Both qualitative and quantitative data were collected about the classroom environments. The ways in which students' attitudinal and cognitive outcomes were measured are also explained.

Chapters 4 and 5 relate primarily to the first three research questions of the study. Chapter 4 uses descriptive statistics to show that the new classroom environment instrument used in this study is reliable and valid. It also validates the QTI in its first use with a large sample of mathematics classes. Chapter 5 draws on the qualitative data as further support for the instrument's reliability. It also uses the findings to profile

the mathematics classes and to explore the differences between the profiles of the Personal and Class forms of the instrument. Because the use of Personal forms of environment instruments is particularly new, it also explores the profiles of sub-populations of the sample and the profiles of male and female students are presented and the differences between them discussed.

Chapter 6 addresses the remaining objectives and extends the findings of the previous two chapters. It firstly determines associations between students' perceptions of aspects of their mathematics classroom environment, and their attitudinal and cognitive outcomes. Secondly, it determines associations between students' perceptions of their mathematics teacher's interpersonal behaviour, and the students' attitudinal and cognitive outcomes. Chapter 6 also reports what is unique and what is common in the variance in students' outcomes as explained by the two instruments. Finally, it addresses associations between students' perceptions of their mathematics teacher's interpersonal behaviour and their perceptions of their mathematics classroom environment.

The final chapter, Chapter 7, draws together the strands of the study and summarises the findings for each of the research objectives and any implications which flow from them. It also notes the limitations of this study and makes recommendations for areas of further research.

CHAPTER 2

LITERATURE REVIEW

Overview

This chapter reviews the literature on the study of classroom learning environments and the effect of climate variance on student learning outcomes. Since the late 1960s many instruments have been developed for measuring the classroom environment and each instrument reflects a belief in specific determinants of the nature of the classroom learning environment through the choice of the dimensions which it measures.

This chapter considers five areas of importance in the literature on classroom learning environments.

1. The assessment of classroom learning environments.
   - Development of the CES and the LEI.
   - The development of other instruments.
2. Past research on classroom learning environments.
3. The assessment of teacher-student interpersonal relationships.
4. Past research on teacher-student interpersonal relationships.
5. Research linking the classroom learning environment and interpersonal teacher-student behaviour with mathematics related attitudinal and cognitive outcomes.

The Assessment of Classroom Learning Environments

The Development of the CES and the LEI

The current use of quantitative assessment measures of classroom learning environments dates from the late 1960s and early 1970s when trends in psychology studies coalesced with trends in observational studies in classrooms. Each of these two areas of research began to recognise the importance of social-psychological constructs formed by students within their classrooms environments.

For most of the middle part of this century, studies in psychology were dominated by behaviourism, with its emphasis on rewards and punishments. However, during the 1960s the recognition of cognitive maturation stages in children saw the rise of cognitive psychology. Cognitive psychologists viewed the teacher's role in the classroom as providing experiences which were relevant to each student's level of cognitive maturity. Students were seen as having a natural, internal, maturing cognition which needed the support of appropriate instruction or experiences to aid its development. Walberg (1976) termed the two teaching models associated with these two psychological perspectives the 'Behavioural Model' and the 'Structural Model'. However, by the late 1960s and early 1970s, psychology studies recognised that people perceive stimuli in different ways and that these perceptions mediate in the learning process. Walberg termed the teaching model which grew out of this psychological perspective the 'Perceptual Model'. He argued that,

> The perceptual model allows for behaviour and structural mechanisms but holds that the student's conscious perception of external and internal sfimuli and his choices are the proximate, mediating determinants of learning (Walberg, 1976 p. 142).

Consequently, psychology studies arrived at a point where behaviour was seen to be influenced by the individual's perceptions of stimuli rather than merely the stimuli themselves or the individual's stage of cognitive development.

Bloom (1964) considered these external stimuli, or the conditions and forces which impact on an individual, to be the environment of the individual. These stimuli, according to Bloom, surround an individual and are not only intellectual in nature, but may also be physical or social. He proposed that, "Such a view of the environment reduces it for analytical purposes to those aspects of the environment which are related to a particular characteristic or set of characteristics" (Bloom 1964, p. 187) which impact on individuals. For Bloom, analysing the environment meant analysing a set or sets of characteristics which form part of the environment, i.e. the conditions, forces or stimuli which make up the environment.

In Moos' (Moos, 1974; Trickett & Moos, 1973) examination of a variety of environments he characterised three sets of variables in the environment which consistently seemed important. The first of these was the Relationship characteristics. Variables here address the nature of the relationships between people in the environment. The variables in the second set of characteristics were those which focus on personal goal orientation and personal growth. These he termed Personal Development characteristics. The final set of characteristics was the System Maintenance and Change characteristics. Variables in this set of characteristics centre around innovation, a clear understanding of rules governing behaviour and appropriate response to change. These three sets of characteristics have been considered important by subsequent researchers who have continued to try and represent each of the sets of characteristics as they have designed instruments for measuring the classroom environment. (This will be illustrated later in Table 2.2).

Walberg (1976, 1981, 1982) also recognised the importance of the environment as he built on the Lewelian formula (Lewin, 1936) that behaviour is a function of personal and environmental characteristics; i.e. $B = f(P,E)$. More specifically, Walberg proposed that learning was a function of seven variables. These were the person's age, ability and motivation, the quality and quantity of instruction, and the social-

psychological environments of the class and the home. He also later included the peer environment and exposure to the media.

Consequently, by the 1970s, psychology studies in classrooms had moved beyond the Behavioural Model and the Structural Model to recognise the impact which students' perceptions of the environment had on their learning. This was supported, also in the '70s, by changes in the ways in which researchers investigated what happens in classrooms.

Prior to this time, two methodologies dominated the study of classrooms and teaching; systematic observation of classrooms, and naturalistic, ethnographic research. Examples of the former include Flanders' Interaction Analysis System (Amidon & Hough, 1967) and the Observation Schedule and Record (OScAR) (Medley & Mitzel, 1958). Haertel and Walberg (1988) noted a trend within this methodology from highly objective, low inference observations, often of predefined categories of teacher behaviour, to more open, high inference observations which sought to interpret the behaviour. This approach conceptualised the teacher as the determinant of the classroom environment. A second common approach to classroom research was the naturalistic, ethnographic research which often involved a case study approach and was very descriptive in nature. This approach conceptualised the teacher as a major determinant of the classroom environment but also recognised the importance of teacher-student interaction and sought to report on, and interpret, the teacher's behaviour in the classroom.

The environmental forces which impact on individuals can be described in two ways; either by individuals within the environment or by observers outside the environment. Murray (1938) discussed these two ways of describing the environment and defined them by using the concept of alpha and beta press. The alpha press is the concept of an outside observer describing the environment whilst the beta press is the perceptions of those within the environment, "the subject's own

interpretation of the phenomena that is perceived" (p. 122). In the classroom, the beta press is the student's views of the conditions, forces or external stimuli as the student perceives them acting on him or herself. Changes in methodologies for studying classrooms and teaching paralleled the conceptual changes in psychology studies and by the late 1960s researchers and educationalists were beginning to recognise the importance of the environment as a mediating force in learning and to recognise the importance of Murray's beta press. Consequently, classroom research methodologies moved on from systematic observation and ethnographic research.

Moos and Walberg, quite independently, pioneered a third approach to the study of classroom environment, that of using the perceptions of students and teachers within the environments. This was conceptually new for two reasons. Firstly, underpinning this new approach was a new conceptualisation of the classroom environment. This approach

> conceptualised (the) environment as a dynamic social system which includes not only teacher behaviour and teacher student interaction but student-student interaction as well. The relevance of student-student interaction is suggested by the increasing importance of peer associations in adolescence. Thus the focus of conceptual work is somewhat different to prior work (Trickett & Moos, 1973 p. 94).

The work of both Moos and Walberg was also unique because it used the concept of Murray's (1938) beta press and involved the subjective perceptions of teachers and students within the classroom environment rather than the perceptions of external, objective researchers.

It was to the identification and measurement of classroom environment characteristics that Moos and Walberg independently focussed their research in the late 1960s. Both researchers identified similar measurable characteristics, or dimensions, of the classroom environment. From Moos' previous work in psychiatric hospitals (Moos & Houts, 1968) and correctional institutions (Moos, 1968), he ultimately developed and refined what has become known as the *Classroom Environment Scale*

(CES), (Moos & Trickett, 1974; Trickett & Moos, 1973). At the same time Walberg developed the *Learning Environment Inventory* (LEI), (Anderson & Walberg, 1968; Fraser, Anderson & Walberg, 1982; Walberg, 1968) as part of evaluating the Harvard Project Physics. These two instruments remain in use and have been the basis for the development of many similar instruments.

In his initial development of the CES (Trickett & Moos, 1973), Moos delineated 13 conceptual dimensions of the classroom environment for measurement. This delineation was achieved through examining the relevant literature on classroom environments, through structured interviews with both teachers and students about what they considered to be the most important aspects of the classroom environment, and through classroom observation.

242 items of varying abstractions were then chosen as indicators on 13 scales. Classroom trials were conducted in which students marked the items as either True of False depending on whether or not they perceived that the item represented the classroom environment correctly. Each of the items was then scored to yield a quantifiable assessment of the 13 scales, thus giving a profile of the classroom environment.

Following a series of trials in which items were tested for internal reliability and discriminant validity, a final form of the instrument was produced which contained 9 scales, each represented by 10 items. Table 2.1 shows these 9 scales, their relationship to Moos' three sets of environmental characteristics, and a sample item for each scale.

The LEI, as already mentioned, reflects a similar conceptualisation of the classroom environment to that of the CES.

> Classroom social climate or learning environment...includes the profile of class group properties that are measurable and presumably have significance for research on classes as social groups. These properties include interpersonal relationships among pupils, relationships between pupils and their teacher, relationships between

pupils and both the subject studied and the method of learning, and, finally, pupils' perceptions of structural characteristics of the class. (Fraser, Anderson and Walberg, 1982, p. 2).

The final version of the LEI contained 15 dimensions, (which measured the four properties quoted above), each represented by 7 items to which students and teachers respond by using a 4 point Likert type scale with response categories of 'Strongly Disagree, Disagree, Agree, Strongly Agree'. As with the CES the item responses are scored to give a profile, by 15 scales, of the classroom environment. This instrument also underwent trials and statistical analysis to ensure reliability and discriminant validity. These descriptive statistical details are reported extensively in Fraser, Anderson and Walberg (1982).

Table 2.1

The Classroom Environment Scale (CES) and Sample Items

Dimension	Moos' classification	Sample item
Involvement	Relationship dimension	Students daydream a lot in this class.
Affiliation	"	Students in this class get to know each other really well.
Teacher support	"	The teacher takes a personal interest in students.
Task orientation	Personal development dimension	Almost all class time is spent on the lesson for the day.
Competition	"	Students don't feel pressured to compete here.
Order & Organisation	System maintenance & change dimension	This is a well organised class.
Rule clarity	"	There is a clear set of rules for students to follow.
Teacher control	"	The teacher is not very strict.
Innovation	"	New ideas are always being tried out here.

The independent contributions of Moos and Walberg in the development

of the CES and the LEI respectively have pioneered much of the subsequent quantitative research into classroom learning environments. There are a number of advantages, listed below, which have been identified in this quantitative approach. They centre in the main around economy of time and resources, and a greater degree of predictability of student outcomes.

* Systematic observations are often prohibitively expensive in time and personal resources whereas a pen and paper instrument offers greater economy.
* Classroom observation generally yielded 'low inference' variables with regard to student learning.
* The people best able to address the classroom environment were considered to be the participants within the classroom, i.e. the students and the teachers.

(Fraser, Anderson & Walberg, 1982)

* Students' observations are based on a longer time period of observation than those of an outside observer.
* Perceptions of the whole class are gathered rather than only one or two observers.
* Students' perceptions are considered to be determinants of their classroom behaviour. Therefore, even if students' perceptions are not accurate they still explain students' behaviour.
* Perceptual measures have been shown to account for considerably more variance in student learning outcomes than directly observed variables. (Fraser, 1994)

The conceptualisation of the classroom environment as being a determinant of student behaviour was based on

> the underlying assumption...that environments exercise meaningful, coercive power over their members, - like psychological experiments, they have certain 'demand characteristics' which influence the participants in those environments. (Trickett & Moos, 1974, p. 1)

Once instruments such as the CES and the LEI were developed to measure classroom environments it was logical to address the question of whether or not Trickett & Moos' assumption was true. If the assumption was true, it was believed that there would be a relation between particular types of classroom environments and particular types of student behaviour or learning outcomes because of the 'coercive power' of the environment.

The corollary to the above assumption is that "our basic research task is to understand how much alterable (environmental) variables can be altered and their consequent effects on students, teachers and learning" (Bloom, 1980, p. 16). For example, Trickett and Moos (1974) hypothesised that some aspects of the classroom environment would correlate with a greater degree of 'satisfaction' amongst students. Consequently, in a study of a normative sample of 315 classrooms, the dependent variable of 'satisfaction' was used in analysis (a second dependent variable of 'mood' was also used) and the dimensions of the CES became the independent variables.

From their research Trickett & Moos concluded that student satisfaction with the class and with the teacher is more evident in classes with strong student-teacher relationships, high student involvement, innovative teaching efforts and high clarity of rules governing classroom behaviour. The first three of these four dimensions are from Moos' relationships characteristics and support the researchers' original hypothesis that classrooms which emphasise interpersonal relationships would be perceived as more satisfying by students.

On the other hand, the study also found that the 'amount of material learned' was related positively to the dimensions of rule clarity and competition. From this observation the authors contended,

> The data from the present study suggests that one would attempt to create a somewhat different classroom environment if student's perceptions of 'amount of material learned' was seen as a primary goal than if 'satisfaction with the teacher' was seen as primary.
> (Trickett & Moos, 1974, p. 10)

For example, if increased perception of the 'amount of material learned' is the primary goal then this is more likely to occur in classrooms with clear rules governing behaviour, and a degree of competition between students. On the other hand, if student's perceptions of 'satisfaction with the teacher' are primary then this is more likely to occur in classrooms where interpersonal relationships and rule clarity are emphasised.

Trickett and Moos also commented that, "One might hypothesise that as a classroom moves towards an environment stressing the learning of material, one might sacrifice some of the interpersonal satisfaction gained through supportive student-student relationships" (Trickett & Moos, 1974, p. 10). It would be interesting to assess the changing interpersonal relationships between the students and the teacher in such a classroom using the Questionnaire of Teacher Interaction (Wubbels & Levy, 1991) which will be discussed later.

This example of research linking aspects of the classroom learning environment to student satisfaction is illustrative of the many research studies which have sought to investigate relations between the classroom environment and particular outcomes, and to use this data to try and change the environment to increase the likelihood of desired outcomes.

Development of Other Instruments for Measuring the Classroom Environment

It is interesting to note that Trickett and Moos, upon detailing the development of the CES, boldly commented, "Thus, the purpose of creating a measure of the perceived environment of the high school classroom which clearly differentiates the environments of different classrooms was achieved" (Trickett & Moos, 1973, p. 97). The sense of finality in their comments belies the continual evolution of such instruments to profile a variety of classrooms.

Following the development of the CES and the LEI there have been many other instruments developed and some of these are briefly reviewed below in the chronological order of their development. They share a common conceptualisation of the classroom environment as a dynamic social system but each focusses on aspects of the environment which are perceived by the developers to be important to the purpose of the instruments.

Each of these instruments has been trialled extensively, statistically analysed and refined so that researchers can be confident of the reliability and discriminant validity of the measures. This aspect of the development of each instrument is not reviewed here but is extensively covered in the references given for each of the instruments.

Individualised Classroom Environment Questionnaire (ICEQ)
The ICEQ (Fraser, 1990; Rentoul & Fraser, 1979) is used to assess the extent to which a classroom environment is characterised by the perception that the curriculum is individualised for students. Consequently, it includes dimensions of 'Personalisation', 'Participation', 'Independence', 'Investigation' and 'Differentiation' which are considered to be important variables in an individualised curriculum.

My Class Inventory (MCI)
This instrument is a simplified version of the LEI and is intended for use in primary classrooms. Consequently, it is shorter than the LEI, the language is simpler and the items only require Yes/No responses (Fisher & Fraser, 1981; Fraser, Anderson & Walberg, 1982; Fraser & O'Brien, 1995).

College and University Classroom Environment Inventory (CUCEI)
Like the MCI this inventory was developed for a particular age cohort of students. It has been developed specifically to investigate the learning environment of university and college classes of up to 30 tertiary students (Fraser & Treagust, 1986; Fraser, Treagust & Dennis, 1986). It contains

dimensions adapted from previous instruments, including the ICEQ which reflects the greater degree of individualised work expected in tertiary classrooms. It is not intended for laboratory work.

Science Laboratory Environment Inventory (SLEI)
Laboratory settings are different from classroom settings and teachers expect different relationships between students who are usually engaged in tasks which differ from those in regular classrooms. The SLEI (Fraser, Giddings & McRobbie, 1995; Fraser, McRobbie & Giddings, 1993; Wong & Fraser, 1994) was developed to allow investigation of this unique environment. It includes dimensions such as 'Open Endedness' which reflects a commonly stated aim of laboratory work.

Constructivist Learning Environment Survey (CLES)
This instrument (Taylor, Dawson & Fraser, 1995; Taylor & Fraser, 1991; Taylor, Fraser & White, 1994) reflects the epistemological changes inherent in constructivist methodology and was developed to allow teachers and researchers to examine classrooms from a constructivist referent perspective. This is clearly seen in dimensions such as 'Critical Voice' and 'Mathematical Uncertainty'.

Geography Classroom Environment Inventory (GCEI)
Although this instrument has the subject of geography in its title, the subject area is not the focus for which it was designed (Teh & Fraser, 1993, 1995). Its focus was the investigative use of computer assisted learning in a geography classroom in Singapore. It also focusses on gender equity. Consequently, these concerns are reflected in its four dimensions of 'Gender Equity', 'Investigation', 'Innovation' and 'Resource Adequacy'.

Computer Classroom Environment Inventory (CCEI)
Modern technology has brought about many changes in the classroom, both in terms of resources and teaching methodologies. The CCEI (Maor & Fraser, 1993, 1996) investigates the computer classroom environment and focusses specifically on the perceptions of inquiry and investigation.

Table 2.2
Scales of Classroom Environment Instruments
(LEI, CES, MCI, CUCEI, SLEI, CLES, GCEI, CCEI)

Instrument	Level	Items /Scale	Moos' Classification		
			Relationship Dimension	Personal Dimension	System Maintenance & Change dimension
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal Direction Disorganisation Democracy
Classroom Environment Scale (CES)	Secondary	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order/Organisation Rule Clarity Teacher Control Innovation
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalisation Participation	Independence Investigation	Differentiation
My Class Inventory (MCI)	Elementary	6-9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
College & University Classroom Environment Inventory (CUCEI)	Higher Education	7	Personalisation Involvement Cohesiveness Satisfaction	Task Orientation	Innovation Individualisation
Science Laboratory Environment Inventory (SLEI)	Upper Secondary	7	Cohesiveness	Open-endedness Integration	Rule Clarity Material Environment
Constructivist Learning Environment Survey (CLES)	Secondary	6	Critical Voice	Mathematical Uncertainty Negotiation Personal Relevance	Shared Control
Geography Classroom Environment Inventory (GCIE)	Secondary	4	Gender Equity	Investigation Resource Adequacy	Innovation
Computer Classroom Environment Inventory (CCEI)	Secondary	5	Satisfaction	Investigation Open Endedness	Material Environment Organisation

(Adapted from Fraser, 1994)

Consequently, it has used some dimensions such as 'Open Endedness' and 'Investigation' which were developed for previous instruments but are also applicable here.

Modifications of these instruments are constantly being made, not only in Australia, but in many other countries, to produce other versions of these instruments to meet particular needs.

Table 2.2 shows the instruments reviewed here, the level of student for which they are intended and relates the scales to Moos' three environment dimensions outlined earlier. When viewing the instruments in chronological order it is easy to see the major changes in educational philosophy and practice evident in the scales which have been chosen for the instrument. For example, transmission epistemology is less evident in recent instruments which include 'Investigation', 'Innovation' and 'Open Endedness'. 'Gender Equity' would probably not have been considered an important issue in the late 1960s, nor 'Individualisation', 'Personalisation' or 'Differentiation'. Computers were also not an issue in classroom methodology. However, the dimensions of 'Resource Adequacy' (GCEI) and 'Material Environment' (CCEI) have obvious connections with the early 'Material Environment' dimension of the LEI.

Although these instruments span over 25 years and each focusses on different aspects of classroom environments, they share in common a number of underlying assumptions identified by Fraser (1992). They assume the following.

1. Educational environments are a determinant of learning.
2. Social-psychological theory is the foundation for studies of educational environments.
3. Internal and external factors (e.g. students, physical objects, curricula, teachers, administrators, parents) influence the educational environment.

4. The rating of abstract criteria (e.g. satisfaction, friction, cliquishness, democracy) by participants within educational environments portrays an accurate description of that environment.
5. Cause and effect parameters operate within educational environments.
6. The participant's views of the educational environment is of greater value than is the observer's view.

(p. 2-3)

These assumptions are evident in the CES and the LEI, and also in the range of more specific instruments which have been subsequently developed.

This section of the chapter has been concerned with reviewing these instruments. Only the original two instruments, the CES and the LEI which were developed over 25 years ago, were designed for use in general classrooms. Each of the instruments developed since then has been developed for very specific classrooms (e.g. the SLEI) or for very specific educational focusses (e.g. the CCEI). The next section of this chapter focusses on the ways in which some of the instruments have been used in past research.

Past Research on Classroom Learning Environments

Past research has tended to focus on three main functions in measurement of the classroom leaning environment (Haertel and Walberg, 1988)

* The profiling of classroom learning environments.
* The use of classroom environment scales as measures of program outcomes. Fraser (1986, 1994) describes this use as studies using classroom 'Environment Perceptions as Criterion Variables'.
* The use of classroom environment scales as independent

variables in the study of various student outcomes. Fraser (1986, 1994) terms this usage 'Associations between Student Outcomes and Classroom Environment'.

These three functions are reviewed separately.

Past Research Profiling Classroom Learning Environments

When students are asked to complete a classroom environment instrument, they usually indicate the extent of their agreement with items which make up the scales of the instrument. For example, the CES, as previously mentioned, consists of 9 scales, each with 10 items. Following the completion of such instruments by a class of students, class mean scores can be calculated for each of the scales. These mean scale scores will vary from class to class. The pattern of mean scale scores of a particular class constitutes the profile of that classroom learning environment. These profiles can be a useful way of monitoring the classroom environment. Three common ways in which class environment profiles have been used in research are detailed below.

The first involved the development and the use of Actual and Preferred forms of the instruments. Whilst these two forms are almost identical in wording, the Actual form asks for students' perceptions of the actual classroom environment as they perceive it, whilst the Preferred form asks for their perceptions of their ideal or preferred classroom environment. For example, on the SLEI Actual form the first item is, "I get on well with students in this laboratory class". Students are asked to indicate whether this is the case 'Almost Never', 'Seldom', 'Sometimes', 'Often' or 'Very Often'. In the Preferred form of the SLEI the item asks the extent to which, in the student's preferred classroom, "I would get on well with students in this laboratory class". The same five response categories are used. Apart from this difference in perspective between Actual and Preferred classroom environments, the items remain the same on each form.

Profiles of classrooms using these two forms consistently show higher ratings for the preferred environment (Fraser, 1986; Moos & Trickett, 1987). The discrepancy between the two sets of results can, of course, be the basis of intervention treatment by the teacher (Fisher, 1992; Fraser, 1981; Fraser & Fisher, 1986; Fraser, Malone & Neale, 1989).

An example of a study using Preferred and Actual versions of classroom environment instruments is that by Hattie, Byrne & Fraser (1987). This study focussed on the perceptions of 1675 students in grade 7, 9 and 11 in 18 schools in NSW and concluded that there is a preferred secondary school environment which seems to change in focus as students mature. They reported that Grade 7 students "prefer structure and cohesiveness, whereas grade 9 students were more disposed to friction and competitiveness. The older grade 11 students preferred more self initiated activities, but they also wished to be involved in a cohesive network" (Hattie, Byrne & Fraser, 1987 p. 87). The study also found that male students preferred more competitiveness than did female students.

The same study also concluded that the CES, the MCI and the ICEQ each contributed something unique in profiling the preferred classroom learning environment but areas of overlap also existed. The researchers concluded that three factors emerged as significant when the instruments were used together to assess the preferred environments of students. These were the preferred levels of Peer Conflict, Individualisation and Teacher Management Structure. The preferred level of Peer Conflict was best measured using the Competitiveness and Friction scales from the MCI. The preferred level of Individualisation was best measured using the Independence, Participation and Investigation scales from the ICEQ, whilst the preferred Teacher Management Structure was best measured using the Order and Organisation, Teacher Support, and Involvement scales from the CES. None of the instruments assessed the preferred classroom learning environment completely by themselves. Each instrument made a unique contribution.

A second way of profiling the classroom environment is to include the teacher's perspective (Haladyna & Shaughnessy, 1984; Maor & Fraser, 1994; Moos and Trickett, 1974; Wong & Fraser, 1994). However, as mentioned earlier, a discrepancy often occurs when teachers and students profile the same classroom environments. Early in their research Moos and Trickett (1974) noted that teachers consistently see their classes in a more favourable light than do their students. Research by Haladyna & Shaughnessy (1984) into the way in which teachers view their classroom environment led them to a more extreme conclusion. They commented, "Therefore we can conclude with some assurance that there is substantially no relationship between teacher's and student's judgements of their learning environments ... teacher judgements of the learning environments are questionable" (p. 13). Profiling student and teacher perspectives of the classroom environments together can be a useful way for teachers to understand and improve their classroom interactions.

A third and more recent way of profiling classrooms is through the use of Personal and Class forms of classroom environment instruments. These two forms of the instrument are identical except for the focus of each statement. The Class form focusses on a student's perception of the environment as it seems to affect the class, whereas the Personal form focusses on a student's perceptions of his or her own interaction with the learning environment. For example, an item in the Class form might be, "Students are able to depend on each other for help during laboratory classes", or "Our laboratory class has clear rules to guide student activities". In the Personal form the item would read, "I am able to depend on other students for help during laboratory classes", or "My laboratory class has clear rules to guide me".

The need for a Personal form of classroom environment instrument was first identified by Fraser and Tobin (1991) who suggested that it would be useful as a measure of students' perceptions of their specific interaction with the classroom learning environment.

They also suggested that it would be more useful than the Class form for exploring sub-populations amongst students. For example, the Personal form was anticipated to be more useful in determining the views of sub-populations such as those of male and female students because it measured students' perceptions of their specific, and individual, interaction with the learning environment rather than students' perceptions of the class's interactions.

There have been two published accounts of the use of Personal forms of classroom environment measures. The first reported use was in a study by Fraser, Giddings & McRobbie (1994, 1995) in which a Personal form of the Science Laboratory Environment Inventory was validated. The Personal form items quoted above are, in fact, taken from this instrument. This study also used Actual and Preferred forms of the instrument.

Where students' perceptions as measured on the Personal form and the Class form were significantly different, students perceived a more positive environment on the Class form. The researchers speculated that this could be because students saw the class in a more detached way than they saw their own involvement, and hence saw it more positively.

The research also confirmed previous research (Giddings & Fraser, 1990; Lawrenz, 1987) that female students view the classroom environment more positively than do male students. Differences between the perceptions of male and female students were more pronounced when the Personal form was used, which the researchers believed "supported the general premise (on which the decision to develop a Personal form was initially based) that the Personal form of classroom environment scales are more sensitive than the Class form for detecting differences in the perceptions of with-in class groups." (Fraser, Giddings & McRobbie, 1995, p. 411).

The study also addressed the issue of student outcomes but found that the two forms were not significantly different in their associations with the

outcomes. However, they did find that each form contributed uniquely, as well as having some overlap, in the contribution to the variance in outcomes. They saw this, also, as a vindication of the development of the Personal form to complement the Class form.

The second reported use of a Personal form of a classroom environment instrument was a recent report by Fraser, Fisher & McRobbie (1996). The instrument about which the report is based is a 54 item version of the same general classroom instrument which is being validated in this thesis. Consequently, reference is made to it in later chapters.

The Fraser, Fisher & McRobbie study found significant differences between the Personal form and the Class form existed on six of the seven scales. On the Personal form students perceived significantly higher levels of Student Cohesion, Task Orientation and Equity, and significantly lower levels of Teacher Support, Involvement and Investigation. There was no significant difference on the Cooperation scale. These findings did not replicate the differences found using Personal and Class forms of the SLEI which showed significantly differing perceptions were all higher on the Class form.

Fraser, Fisher and McRobbie (1996) concluded,

> The findings reported in this paper provide convincing evidence that many respondents have differing perceptions of the learning environment in classrooms from the perception of the whole class relative to their perceptions of their personal role in that class. However, the research on the characteristics and associations of Personal Forms of learning environment instruments is still in its infancy and much further research will be required before the implications associated with Personal Forms are understood fully.
>
> (p. 16)

Consequently, classroom environment instruments have been used to profile classrooms, and sub-populations within classrooms. They have been used to compare Actual and Preferred environments, and to

compare the views of teachers and students. More recently, a Personal form of the SLEI has been developed and used in conjunction with the Class form. However, the use of the Personal form is still in its infancy. It has only been used in science classes as the SLEI, and Personal forms of other instruments have yet to be developed and their use reported. The reporting of research using a Personal form of a new classroom instrument in this thesis is therefore all the more significant.

Past Research Using Classroom Environment Scales as Measures of Program Outcomes

Often programs have specific outcomes which can be measured using classroom environment measures (Burden & Fraser, 1992; Fraser, 1980; Maor & Fraser, 1994; Teh & Fraser, 1994; Waxman & Duschl, 1987). For example, researchers examining the program referred to earlier in Singapore, which sought to increase students' investigative skills using computer assisted learning, were able to measure the effect of this program on the classroom environment (Teh & Fraser, 1994).

Similarly the ICEQ was used in a study (Fraser, 1980) to evaluate the outcomes of a program in Sydney designed to individualise the curriculum. In both of these studies control classes were used so that comparisons could be made between the classroom environments of each class in order to draw conclusions about the impact of the programs. Fraser (1994) contains a table detailing studies of this form.

A prospective use could be to monitor the introduction of the national profiles and statements in mathematics in Australia to investigate their outcomes on the classroom environment.

Past Research Using Classroom Environment Scales as Independent Variables

This has been an enduring function of classroom environment research. Many researchers have sought to establish relations between dependent variables such as attitudes towards a subject (Fraser & Butts, 1982; Hofstein et. al., 1979; Lawrenz, 1976; Power & Tisher, 1975, 1979; Wiestra, 1984; Wiestra et. al., 1987) and the independent variables of the classroom environment.

The example of Trickett and Moos' (1973) research into student perceptions of 'Satisfaction' has already been detailed. Other examples include studies which have as their dependent variable 'Absenteeism' (Moos, 1978), 'Gender' (Lawrenz, 1987), 'Psychological Outcomes' (Galluzi, Kirby & Zucker, 1980) or 'Academic Achievement' (Fisher & Fraser, 1983). In each of these studies, relationships were sought between the dependent variable and the scales of the classroom environment instrument which was used.

Haertel, Walberg and Haertel (1981) conducted a meta-analysis of 12 previous studies and drew a number of important conclusions from the research about relations between the environment and particular outcomes. For example, they report that learning gains are positively associated with student perceptions of Cohesiveness, Satisfaction, Task Difficulty, Formality, Goal Direction, Democracy and the Material Environment. Conversely learning gains are negatively associated with Friction, Cliqueness, Apathy and Disorganisation.

From examining many studies into relations between the classroom environment and student outcomes, Walberg (1985) concluded,

> Student perceptions of the social environment of learning accounted for a median of 30% (range = 13% - 46%; all significant) of the variance in cognitive, affective and behavioural postcourse measures

> beyond that accounted for by parallel precourse measures. Efforts at generalising these results suggest consistency across different school subjects and different languages and cultures.
>
> (p. 754)

Fraser (1994) details 40 research studies and their samples in which various dependent variables were investigated. It is notable that only one of these studies, (Haladyna, Olsen & Shaughnessy, 1982; Haladyna, Shaughnessy & Redsun, 1982a, 1982b; Haladyna, Shaughnessy & Shaughnessy, 1983) specifies mathematics classes in the sample. The study investigated student attitudes towards mathematics.

Conclusion

There have been a range of instruments developed for measuring aspects of the classroom learning environment. These instruments have been developed in different forms, the most recent being the Personal form, which complements existing Class forms. It is timely for a review and consolidation of these. Part of the study in this thesis is to validate a new instrument for general use in secondary classrooms, both in Personal and Class forms, whose dimensions have been chosen to reflect current knowledge and concerns about classroom learning environments.

In spite of the fact that in most countries mathematics is a compulsory subject, at least until senior grades, little research into the nature of the mathematics classroom environment is evident. Science classrooms and laboratories, along with general humanities subjects are well represented. Many other studies include a range of subjects in their sample of classes, but without differentiating between them. However, little use has been made of what is known of classroom environments to enhance understanding of the secondary mathematics classroom.

The Assessment of Teacher-Student Interpersonal Relationships

The literature reviewed so far has discussed the classroom learning environment and ways which have been developed to measure it. Underpinning this has been the conceptualisation of the environment "as a dynamic social system" (Trickett & Moos, 1973 p. 94). Moos (1974) identified three consistently important characteristics of social environments. These were 'Relationship' characteristics, 'Personal Development' characteristics, and 'System Maintenance and Change' characteristics. Instruments were reviewed which measure the classroom learning environment, reflecting these characteristics in varying ways. The literature has also reflected a belief that Murray's (1938) beta press concept is important and that the environment can usefully be described by those within it. The literature to be reviewed in this section focusses specifically on one variable within Moos' Relationship characteristics, that of interpersonal relationships between students and teachers.

Studies in The Netherlands over the past decade (Brekelmans, 1989; Creton & Wubbels, 1984; Wubbels, Creton & Hooymayers, 1985) have recognised the importance of teacher-student interpersonal relationships in the classroom. Brekelmans, Wubbels & Creton (1990) used the term 'interactional teacher behaviour' and defined this as "behaviours that concern the relationship between the teacher and the students and that are expressed in the interaction between the persons communicating in the classroom" (Brekelmans, Wubbels & Creton, 1990, p. 336). Wubbels and his colleagues went on to conceptualise, and ultimately develop an instrument for measuring, the teacher-student interpersonal relationships in the classroom.

The conceptualisation of the interpersonal relationships within the classroom drew on the systems theory of communication (Watzlawick, Beavin & Jackson, 1967). Communication in this theory is seen as circular, in that there is no beginning or end. It is unavoidable and it is ongoing, with communication both consisting of, and determining, behaviour.

Within the classroom the communication between teachers and students is found in the behaviour of teachers and students, as well as determining the behaviour of teachers and students. Communication is also seen as consisting of two aspects; report and command. The report aspect of communication is 'what' is said whilst the command aspect is the 'way or manner' in which it is said. Students perceive both what the teacher says and the way in which he or she says it. In effective communication there will be a congruence between these two perceptions. Creton, Wubbels & Hooymayers (1993) note the following with regard to the command aspect of the teacher's communication.

> The way it is received actually depends upon the history of the relationship, or the accumulation of all teacher and student molecular behaviours. This can include things which are below the surface, such as the choice of text books or the development of tests. When the curriculum is not presented clearly or instructional activities are difficult, students may begin to think they lack ability. In this way the command aspect also provides information about how communicators see themselves and each other.
>
> (p. 6)

The importance ascribed in the systems theory of communication to the command aspect of communication and the ways in which it is interpreted underscore the use of students' perceptions as the means of gathering data in classrooms.

On occasions, there will be differences between the perceptions of teachers and their students in their communication. The systems approach recognises that communication is ongoing and does not seek to find the beginning of these differences. Rather it recognises that teachers and students have perhaps interpreted different punctuation points in their conversations which have leád to different interpretations. However, it does note that it is common to 'blame the other person' for any misunderstanding. It is from this systems perspective of communication that Wubbels and his colleagues conceptualised the teacher's interpersonal behaviour in the classroom.

In order to measure this behaviour, they used a framework based on Leary's (1957) model of interpersonal behaviour. In this model all interpersonal behaviour is conceptualised on two primary dimensions. One of these is called the Influence dimension and measures the dominance and submissiveness in the relationship. The other is the Proximity dimension which measures the degree of cooperative or oppositional behaviour.

Leary, and researchers who have followed this model (Hooymayers, Wubbels, Creton & Holvast, 1981; Wubbels, Creton, Levy & Hooymayers, 1993), argue that all interpersonal behaviour can be conceptualised into positions somewhere on these two dimensions. Furthermore they argue that these two dimensions are both necessary and sufficient to describe the interpersonal behaviour.

This conceptualisation of interpersonal behaviour has been expressed diagrammatically as shown in Figure 2.1.

> In this diagram the vertical axis represents the Influence dimension. A point at the top of the axis represents dominance in the interpersonal behaviour whilst the bottom of the axis indicates submission. Similarly in the horizontal axis, which represents the Proximity dimension, a point to the right indicates a high degree of cooperation whilst a point on the left indicates oppositional behaviour.
>
> (Hooymayers, Wubbels, Creton & Holvast, 1981).

In order to map a teacher's interpersonal behaviour onto this diagram an instrument now known as the Questionnaire on Teacher Interaction (QTI) was developed (Wubbels, Creton & Hooymayers, 1985; Wubbels & Levy, 1993) which asks students to indicate their perceptions of their teacher's interpersonal behaviour using a 5 point Likert type scale. The QTI focusses on eight dimensions. These are the dimensions evident as the eight sectors in Figure 2.2.

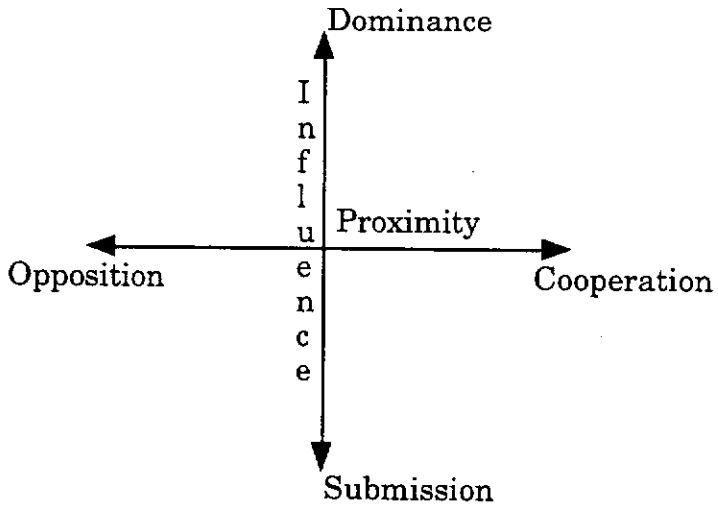


Figure 2.1 Leary model of interpersonal behaviour.
(Hooymayers, Wubbels, Creton & Holvast, 1981)

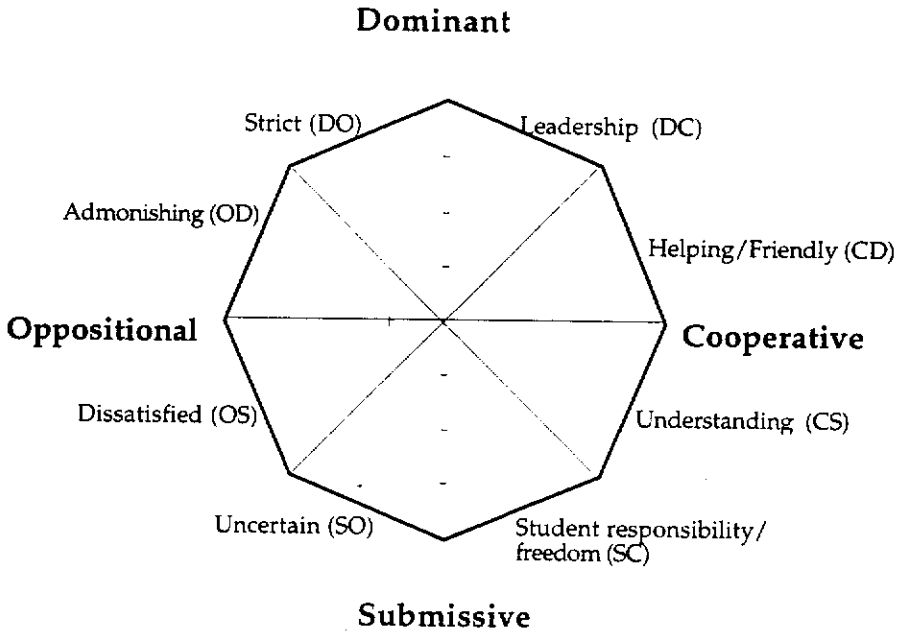


Figure 2.2 The eight dimensions of interpersonal behaviour.

The first of these is labelled DC. This is because it is the Dominant-Cooperative sector but with the teacher being perceived by students to be more dominant than cooperative. Strong leadership characterises interpersonal behaviour in this sector. The second sector is labelled CD because the cooperative aspect is perceived as more pronounced than the dominant aspect. This sector is characterised by helping and friendly behaviour by the teacher. The eight sectors shown in Figure 2.2, are further amplified in Table 2.3. The table shows the dimension labels which characterise the interpersonal behaviour in each sector, along with sample items for each dimension. Adjacent sectors in this model reflect interpersonal behaviours which are similar, whereas opposite sectors reflect opposite behaviours. Consequently, it is called a circumplex model.

Table 2.3

QTI Dimensions and Sample Items

Sector	Dimension	Sample Items
DC (Dominance-Cooperative)	Leadership	This teacher explains things clearly.
CD (Cooperative-Dominance)	Helping /Friendly	This teacher helps us with our work.
CS (Cooperative-Submissive)	Understanding	This teacher trusts us.
SC (Submissive-Cooperative)	Student Responsibility & Freedom	We can influence this teacher.
SO (Submissive-Oppositional)	Uncertain	This teacher is hesitant.
OS (Oppositional-Submissive)	Dissatisfied	This teacher thinks that we cheat.
OD (Oppositional-Dominance)	Admonishing	This teacher gets angry quickly.
DO (Dominance-Oppositional)	Strict	This teacher is strict.

The QTI was first developed in The Netherlands (Wubbels, Creton & Hooymayers, 1985) but has since been translated into English and used both in the USA (Wubbels & Levy, 1989) and in Australia (Fisher, Fraser, Wubbels & Brekelmans, 1993). It has been developed in both a 64 item version and a shorter 48 item version. The instrument's reliability and validity has been established and is reported elsewhere for Dutch (Brekelmans, Wubbels & Creton, 1990), American (Wubbels & Levy, 1991) and Australian (Fisher, Fraser, Wubbels & Brekelmans, 1993) research.

Underlying the QTI is the systems approach to communication which contends that teachers communicate constantly in the classroom in both report and relationship form (Creton,Wubbels & Hooymayers, 1993; Van Tartwijk, Fisher, Fraser & Wubbels, 1994). Once a class and teacher have been together long enough, usually about 2 months, a stable pattern emerges, and the relationship aspect of their interpersonal behaviour becomes predictable.

As with the CES and the LEI discussed earlier, the QTI is based on the belief that student perceptions are a more appropriate way of describing this behavioural pattern than using the perceptions of outside observors. Advantages of using student perceptions have already been discussed. However, Wubbels & Levy (1991) note additional reasons which seem particularly relevant when addressing teacher interpersonal behaviour in the classroom. Firstly, teacher behaviour may be specifically functional in acting as a cue for particular students. As such it may be unnoticed or misinterpreted by an observer. Secondly, students provide insights into the normal interactive behaviour over a longer period of time. As soon as an observer is present in the classroom the teacher student interactive behaviour has a new dimension. Thirdly, idiosyncratic behaviour may be missed by an observer but, however, its impact and message would not have gone unnoticed by students.

Student perception scores are averaged in the QTI to give a class mean score in each of the dimensions. Studies (Brekelmans, 1989; Wubbels & Levy, 1993) have shown that student perceptions of their teacher's

interpersonal behaviour do not vary significantly once the predictable pattern of behaviour has become stable, usually after two months. They also show that 10 students in a class is a sufficient number to yield reliable data at the class level.

Past Research into Classroom Learning Environments Using the QTI

Research involving other learning environment instruments has already been discussed. The QTI has been used in similar ways and for similar purposes. However, although the QTI has been used in The Netherlands since the early 1980s, an English version was not developed for use in English speaking countries until earlier this decade. Since then its use in these countries has been limited. Consequently, most published research originates from The Netherlands. Research uses of the QTI have been to

1. Profile interpersonal behaviour in classroom learning environments.
2. Use QTI data as measures of program outcomes.
3. Use QTI scores as independent variables in addressing associations with student outcomes.

Past Research Profiling Interpersonal Behaviour in the Classroom Learning Environment

The QTI dimensions can be used to profile students' perceptions of their teacher's interpersonal behaviour in the classroom by determining the mean scores for each scale. Although this profile is, in itself, illustrative of the way in which students perceive their teacher's interpersonal behaviour, it is frequently used more effectively in a comparative sense, similar to the uses made of the more general classroom environment instruments to which earlier reference has been made. For example, students' profiles and the teacher's profile of the teacher's interpersonal behaviour can be compared. These two viewpoints can then be the basis

for reflection and subsequent action. Research which has profiled interpersonal behaviour in this way frequently shows that, on average, teachers view their relationship with students more positively than do their students (Wubbels & Levy, 1993) and see themselves as more dominant and more cooperative. For example, a study by Brekelmans & Wubbels (1991) showed that,

> in 71% of the teacher-class combinations the difference between perceptions of teachers and their students of the dominant behaviour of the teachers, was larger than the measurement error, in 76% of the teacher-class combinations the difference between perceptions of students and their teachers of the cooperative behaviour was larger than the measurement error. It turned out that in 92% of the teacher-class combinations there was a difference larger than the measurement error on either one or both of the interpersonal dimension scores. (p. 9)

The report also noted that teachers and students tended to disagree more in their perceptions of the teacher's interpersonal behaviour in classes with lower student outcomes. Wubbels & Levy (1993), however, note that student perceptions correlate more with observed data than do the teacher perceptions. Research also suggests;

> It appears that the more that the teacher and his or her students disagree in their perceptions of teacher behaviour, the more that students think that the teacher is uncertain (SO), dissatisfied (OS) and admonishing (OD). These are three types of behaviour which have been shown to be counter productive with respect to the promotion of cognitive and affective student outcomes (Wubbels, Brekelmans & Hooymayers, 1991, p. 57).

The QTI has also been developed in an Actual and an Ideal form. The actual form measures students' perceptions of the actual teacher-student interpersonal behaviour whereas the Ideal version asks students what that relationship would be in their ideal classroom. These two forms have been used to profile both students' perceptions and their teacher's perceptions of the actual classroom interpersonal behaviour, along with the teacher's perceptions of the ideal interpersonal behaviour (Wubbels, Brekelmans & Hooymayers, 1991, 1993). This usually results in data which

places the teacher's ideal interpersonal behaviour as the most dominant and cooperative behaviour, followed by the teacher's perceptions of the actual behaviour, followed by the students' perceptions of the actual behaviour. The same researchers suggest that the teacher's perceptions of his or her ideal interpersonal behaviour may influence his or her perceptions of the actual situation and consequently explain, at least in part, the teacher's inflated view of the actual interpersonal behaviour in the classroom (Festinger, 1957).

In a cross cultural study Wubbel & Levy (1991) compared students' perceptions of the interpersonal behaviour of American and Dutch teachers using the QTI. Differences between the two groups of teachers emerged both at the level of students' perceptions of their teacher's interpersonal behaviour and the students' perceptions of their ideal teacher. For example, American teachers were perceived to place a greater emphasis on strictness than the Dutch. The converse was true for the student freedom and responsibility dimension.

There has been no cross cultural study completed to date which specifically compares Australian data with American or Dutch data. However, the recent study by Rickards, Fisher & Fraser (1996) provides a large data base of nearly 4000 students from which comparisons will be able to be made.

Past Research Using QTI Data as Measures of Program Outcomes

This has been a popular use of the QTI and data gathered has been used to investigate a number of areas. For example, it has been used to investigate changes in teacher communication styles during the teaching career (Brekelmans & Creton, 1993; Brekelmans, Holvast & Van Tartwijk, 1990). This research noted the increase in dominant behaviour exhibited by teachers during their first few years as they develop a wider repertoire of management skills. This increase occurs until about the tenth year of

teaching after which time it tends to stabilise. The research also noted that the Proximity dimension did not show a similar increase and suggested that beginning teachers have quite often developed their cooperative skills but are still developing their management skills. However, the research also mapped a decline in tolerance in teachers with more than twenty years experience.

Two rating scales in Influence and Proximity dimensions underlie the model used in research to examine teacher nonverbal behaviour in the classroom (Van Tartwijk, Brekelmans, Creton & Wubbels, 1992; Van Tartwijk, Fisher, Fraser & Wubbels, 1994). This research shows a positive correlation between perceived Dominance in the classroom and nonverbal behaviour such as standing in front of the whole class, looking at the class, being in a position for the class to see the teacher's face clearly, speaking audibly at performance level, having an upright head position and not being too close to an individual student. The link between the nonverbal behaviour and the Proximity dimension was much weaker.

In the first reported Australian research using the QTI, Fisher, Fraser, Wubbels & Brekelmans (1993) investigated links between the school learning environment and teacher's interpersonal behaviour in the classroom. However, these links were shown to be weak and the authors noted, "A teacher's behaviour in class could have little to do with his/her perceptions of the school environment" (p. 40), suggesting that factors other than the school environment have a more determining impact on how teachers behave in their classrooms.

Levy, Wubbels, Brekelmans & Morganfield (1994) conducted research in America to examine the way in which cultural and language factors influenced students' perceptions of their teacher's interpersonal behaviour. They showed that students from different cultural backgrounds such as Hispanic or Asian cultures brought cultural understandings into the classroom which influenced their perceptions of their teacher's behaviour. They noted that "cultural membership was a significant variable ... in the students' QTI perceptions of their teacher's

communication styles in this study". (p. 26). The research also showed that teachers were often unaware of this cultural influence and the fact that these students often perceive the teacher's actions differently from that of other students.

A recent study in Australia (Rickards, Fisher & Fraser, 1996) showed similar results. The study addressed the perceptions of students in different cultural groups in Australian schools and showed that there were significant differences between the perceptions of students in these groups. The authors reported that, "Students from an Asian background perceive their teachers more positively than those from the other cultural groups used in the analysis" (p. 11). This was the case both when the student's cultural group was defined by the father's birthplace and when it was defined by the language spoken in the home.

Adaptations of the QTI have also been used extensively in investigating teaching and teacher training programs. For example, the instrument was adapted to become the *Questionnaire on Supervisor Interaction* (QSI) (Kremer-Hayon & Wubbels, 1992, 1993a) for the purpose of examining the relationships between student teachers and their supervisors. It was also adapted to the *Questionnaire on Principal Interaction* (QPI) (Kremer-Hayon & Wubbels, 1993b) to help teachers and principals describe the interpersonal behaviour of the principal.

A recent Australian adaption of the QTI and the QPI is the *Principal Interaction Questionnaire* (PIQ) (Cresswell & Fisher, 1996). This questionnaire was developed to measure teachers' perceptions of their principal's interpersonal behaviour and was used in a study involving 50 Australian principals and 850 teachers. Associations were shown to exist between teachers' perceptions of their principal's interpersonal behaviour, and teachers' perceptions of their school level environment.

It can be seen then that the QTI has been an important springboard for the development of other instruments. It provides data about the nature of

the teacher's interpersonal behaviour in the classroom. As such it has been used in a variety of investigations, particularly in The Netherlands, but more recently in other countries such as America and Australia.

Past Research Using QTI Scores as Independent Variables

Research in this area has sought to identify whether or not relationships exist between types of teacher interpersonal behaviour in the classroom and particular student outcomes, both in the cognitive and affective domains.

Studies (Brekelmans, 1989; Brekelmans, Levy & Rodriguez, 1993; Wubbels, Brekelmans & Hooymayers, 1991) have identified a typology of eight teacher behaviour styles according to student perceptions of teacher interpersonal behaviour. This typology is taken from a Dutch sample and cross cultural studies have yet to verify the typology for other cultures. Figure 2.3 shows the typology with the percentage of teachers found to belong to each type.

Associations have been found to exist between student outcomes and the behaviour represented in the sectors of these typologies. However, the associations are different for attitudinal and cognitive outcomes. Where teachers are perceived to exhibit strong behaviour in the dimensions labelled Strict, Leadership, Helping/Friendly and Understanding, a positive relationship has been found to exist with stronger academic performance. Conversely where teachers are perceived to be Admonishing, Dissatisfied, Uncertain or give Student Responsibility and Freedom, there is a negative relationship with academic performance.

With regard to positive attitudinal outcomes, where teachers are perceived as having strengths on the right of the vertical axis (Leadership, Helping/Friendly, Understanding, Student Responsibility and Freedom) a positive relationship was found to exist. Conversely where students

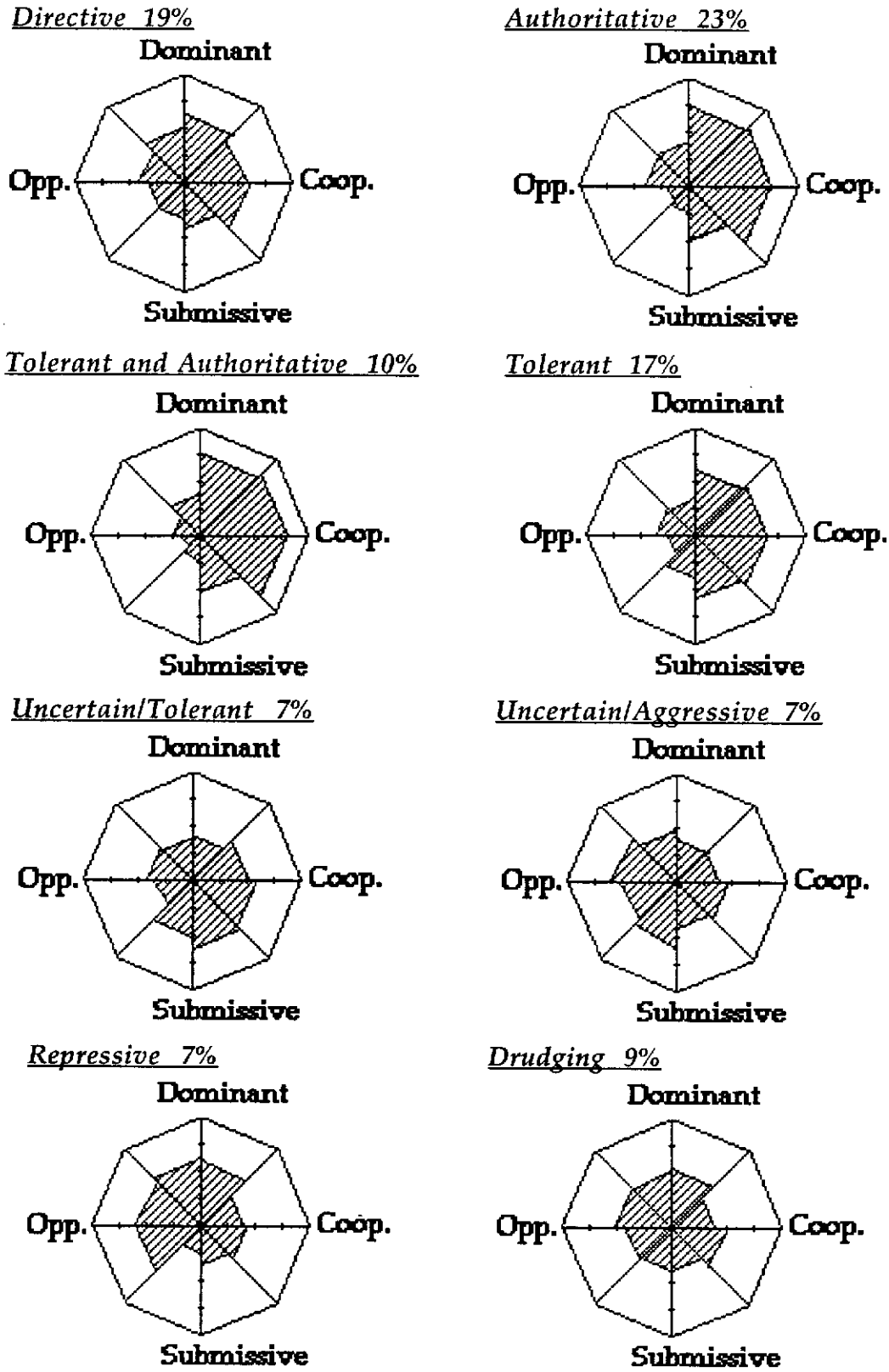


Figure 2.3 Typology of teacher interpersonal behaviour (Wubbels, Brekelmans & Hooymayers, 1991, p. 147)

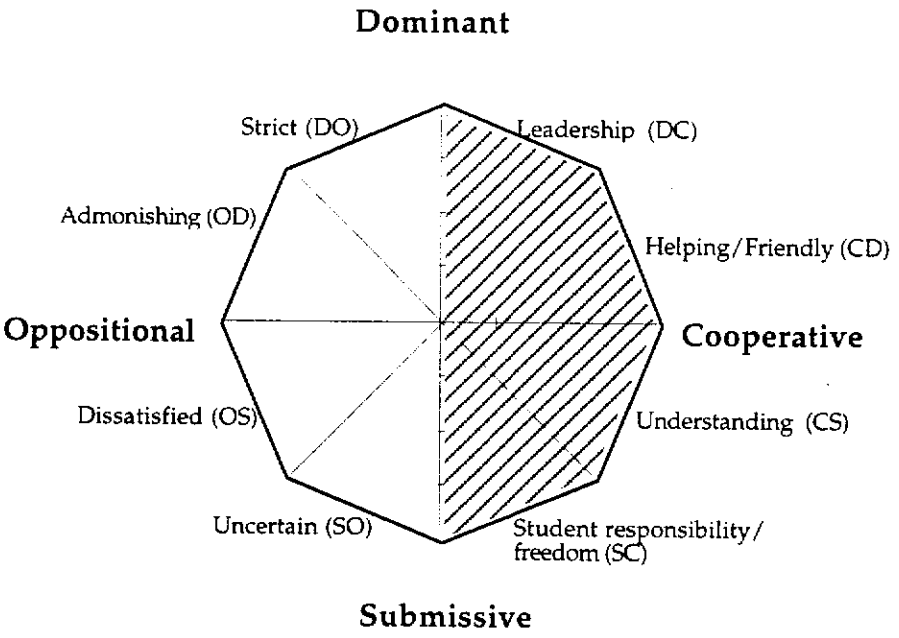
perceived their teacher typically exhibits behaviour on the left of the vertical axis (Uncertain, Dissatisfied, Admonishing, Strict), a negative relationship exists with attitudes and affective outcomes (Brekelmans, Levy & Rodriguez, 1993; Wubbels, Brekelmans & Hooymayers, 1991). These relationships are shown in Figure 2.4.

Attempts have been made to quantify the effect of teacher interpersonal behaviour on student cognitive and affective outcomes. One study (Brekelmans, Wubbels & Creton, 1990; Wubbels, Brekelmans & Hermans, 1987) indicated that interpersonal behaviour had a much greater effect on student outcomes than did the introduction of a new physics curriculum.

Another study (Brekelmans, Wubbels & Levy, 1993) quantified this further by concluding that teacher communication style accounted for over two thirds of the variance in outcomes in both the cognitive and affective areas open to teacher influence. In the cognitive area, 20% of variance in outcomes was made up from class membership. 15% out of this 20% was accounted for by the student's ability, leaving 5% open to teacher influence. With affective outcomes, 13% of variance was found to be accounted for by class membership and was open to teacher influence. In both instances over two thirds of the variance in areas where teachers can make a difference were accounted for by the students' perceptions of the teacher's interpersonal behaviour. In terms of cognitive outcomes this could account for variance of a full assessment grade.

This has obvious implications for teachers wishing to maximise their students' cognitive and affective growth. However, researchers caution about assuming causality. While they imply that in their opinion it is likely that teacher behaviour leads to certain student behaviour it may in fact be the other way around with student behaviour impacting on the way in which teachers behave.

Teacher interpersonal behaviour associated with positive attitudes.



Teacher interpersonal behaviour associated with positive cognitive outcomes.

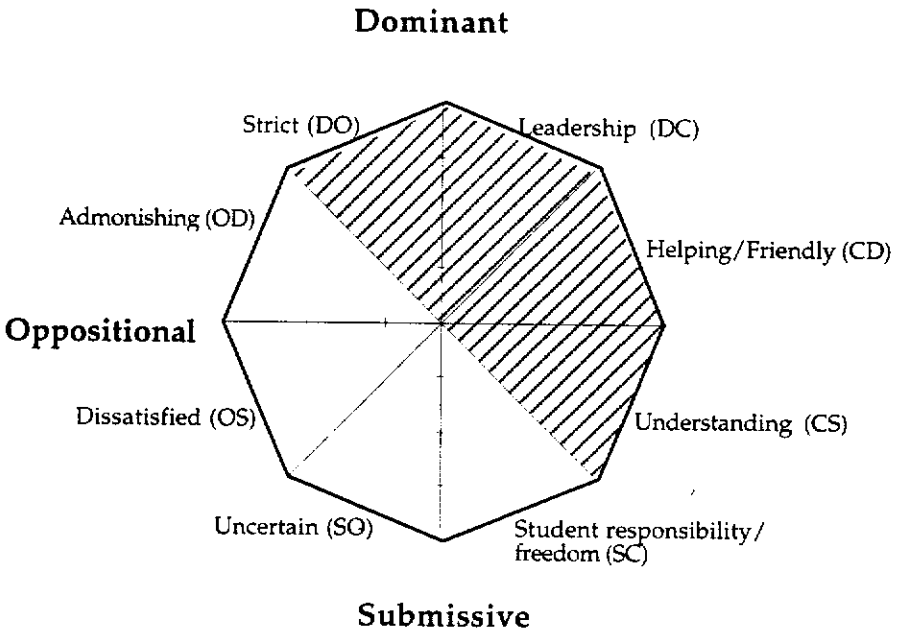


Figure 2.4 Associations between QTI scales, and attitudinal and cognitive outcomes

If causation from teacher to student is assumed, three interpersonal behavioural dimensions overlap in relation to both higher student cognitive and affective outcomes; i.e. Leadership, Helping/friendly and Understanding behaviours. However, Strict behaviour (for cognitive growth) and Student Responsibility and Freedom (for affective growth) involve opposite teacher behaviours. Therefore,

> If teachers aim to achieve both higher cognitive and affective outcomes, they are pulled in opposite directions by the conflicting demands of the sectors DO and SC. In order to achieve higher cognitive outcomes, teachers have to be strict but, to achieve higher affective outcomes, they have to be less strict. The other six sectors of the model do not present conflicting demands (Wubbels, Brekelmans & Hermans, 1987, p. 20).

Consequently, the QTI scales have frequently been used in research as independent variables when researching student outcomes. Significant positive associations have been shown to exist between attitudinal outcomes and the scales of Leadership, Helping/Friendly, Understanding and Student Responsibility and Freedom, and between student cognitive outcomes and the scales of Strict, Leadership, Helping/friendly and Understanding. In each case the outcome is negatively associated with the remaining scales.

Conclusion

The QTI is an internationally recognised and effective instrument for mapping the interpersonal behaviour of teachers in the classroom. It sits comfortably within Moos' Relationship dimension (Moos, 1974) of the classroom learning environment. Associations have been shown to exist between student perceptions of particular types of teacher interpersonal behaviour, and cognitive and affective outcomes. The QTI has been used for a variety of purposes, particularly in The Netherlands, but increasingly in other countries such as the USA and Australia. However, to date there is limited published data available on its use in Australia. There is a need

to build a bank of data to enable a more accurate profile of Australian teachers and classrooms. No reported research, using the QTI, has been carried out in a large sample of secondary mathematics classrooms, either overseas or in Australia. The literature is deficient on this topic showing a need for further research in this area.

Research Linking the Classroom Learning Environment and Interpersonal Teacher-Student Behaviour with Mathematics-Related Attitudinal and Cognitive Outcomes

The review of literature above has included discussion of studies where the measures of the classroom learning environment and the teacher-student interpersonal behaviour have been used as independent variables to find associations with student's affective and cognitive outcomes. This has been illustrative of the variety of classroom environment measuring instruments which have been used to gather data and also of the uses to which these instruments have been put. However, the focus of this study is specifically the classroom learning environment in the secondary mathematics classroom.

The literature seems to be inconclusive on the extent to which aspects of mathematics classroom environments are similar to, or different from, classrooms in other subject areas. Grouws (1980) cited research by Evertson, Anderson and Brophy (1978) to show that "behaviours highly correlated with teacher effectiveness in mathematics did not correlate with teacher effectiveness in English" (Grouws, 1980 p. 202). This is supported by Hill, Rowe & Holmes-Smith (1995) whose Australian research suggested that, "Different sets of variables may be significant in explaining student progress in english as opposed to mathematics. This is in line with evidence cited by Reynolds et. al. (1994) against the proposition of 'across the board' effectiveness" (p. 20). On the other hand Costello's research linked the classroom environments of mathematics and english classes together in his study of ability groupings where he

noted "that students in the higher ability tracks of mathematics and english view the classroom environment significantly more favourably than students in middle and lower ability tracks" (Costello, 1987 p. 64).

Grouws (1980) cited research by Cooney (1980) to suggest that affective variables and cognitive variables may play different roles in classroom environments. For example, Cooney suggested that affective variables such as warmth and enthusiasm may be more generalisable across subject boundaries, whereas the cognitive variables of clarity and variability may be more subject specific and with particular relevance to mathematics.

Grouws (1980) concluded that, "There is a significant need for such general variables to be operationally defined in a mathematics setting and then examined in an experimental framework to determine if there is a causal relationship between the variables and mathematics learning gains" (p. 202). It is not the purpose of this study to compare the classroom environments of mathematics and other classrooms. However, data from this study will add to the general knowledge about mathematics classrooms and the affective and cognitive outcomes of students.

A search of the literature has shown that little research has been undertaken in this specific area. For example, as mentioned earlier, Fraser (1994) collated lists of studies which have used classroom environment measures as either independent or dependent variables. Of the 40 studies listed, only one study specifically distinguished secondary mathematics classes in the sample. Aspects of this study were reported by Haladyna, Olsen & Shaughnessy (1982), Haladyna, Shaughnessy & Redsun (1982a, 1982b) and Haladyna, Shaughnessy & Shaughnessy (1983).

A search of the 79 research articles published by the Special Interest Group on the Study of Learning Environments of the American Education Research Association (AERA) in the eight volumes of its journal to date shows that only seven articles used measures of classroom environments in secondary mathematics classrooms. Five of these studies treated the

measures of the mathematics classroom environment as a dependent variable and the remaining two used the measures as an independent variable. However, not all of these studies used the measures described in this chapter for measuring the classroom environment and only one of these studies was carried out in Australia.

There are no Australian studies, and very few other studies which parallel this study and use measures of student perceptions of their mathematics classroom environment to examine associations with student affective and cognitive outcomes. Some of the more related but general studies are reviewed below.

Reyes (1980) outlined 4 factors which she believed shape a student's attitude towards mathematics. These are;

-the student's confidence in mathematics
-the level of the student's anxiety associated with the study of mathematics
-the student's attribution theory for success or failure
-the perceived usefulness of mathematics to the student.

This conceptualisation is supported by Shaughnessy, Haladyna & Shaughnessy (1983) whose research suggested that while achievement in mathematics was a determining factor in a student's attitudes, it was not large enough to preclude other important factors. However, 'achievement' is an umbrella term and they argue that underlying student variables in a student's attitude towards mathematics are;

-the student's sense of fatalism
-the student's self confidence
-the student's perceived importance of mathematics.

(Shaughnessy, Haladyna & Shaughnessy, 1983)

These variables are similar to those proposed by Reyes. Reyes' identification of the student's attribution theory parallels that of the student's sense of fatalism. Reyes' levels of confidence and anxiety parallel

the confidence mentioned above, and similarly the identification of the student's perceptions of the importance of mathematics is singled out by both researchers.

A number of studies have addressed the issue of confidence in mathematics (Dowling, 1978; Fennema & Sherman, 1977, 1978; Reyes, 1980) and have shown that there is a high correlation between confidence and achievement. Additionally, Fennema & Sherman showed in their studies that boys were generally more confident than girls. This was echoed in Reyes' findings in regard to attribution theory where she reports that boys generally held higher estimates of their own performance in mathematics than did girls. Reyes also showed that girls were often more anxious than boys.

A study by Reyes and Fennema (1980) showed that teachers tend to take more initiative in interacting with students who show greater confidence in their mathematical abilities and that this interaction is often at a higher cognitive level. The reverse was also true that students with a higher level of self confidence in mathematics tended to approach the teacher more often. In terms of the classroom environment, one would expect that these students would perceive their teachers as more involved and with a higher level of task orientation.

Research into attitudes and cognitive outcomes in mathematics classes has not had a specific focus on the effects of the classroom learning environment. However, aspects of the environment are frequently acknowledged, although often indirectly. For example, Reyes commented that the perceived usefulness of mathematics "is probably the easiest attitude for teachers to change" (Reyes, 1980 p. 176). Similarly, the central role of the teacher is recognised in the comments made earlier about the interactions between teachers and students who have higher confidence levels in mathematics.

One study which did focus on the association between student outcomes

and the learning environment variables is that by O'Reilly (1975). O'Reilly used the LEI, amongst other instruments, to examine classroom environment variables in 48 mathematics classes in eastern Ontario. Ten LEI scales were found to correlate with student achievement. Those with positive correlations were Cohesion, Environment, Satisfaction, Difficulty and Democracy. The variables with negative correlations were Friction, Favouritism, Cliqueness, Disorganisation and Apathy. O'Reilly was impressed by the importance of these associations to the extent that he concluded his paper by arguing that,

> Educators could begin to systematically monitor classroom climate and attempt to influence its nature... A supervisory program could be designed which would call for early monitoring of classroom climates, and if the situation warrants it, expert assistance, perhaps in the form of a school guidance teacher or an organisational development professional, would assist in a program of climate change (O'Reilly, 1975, p. 247).

However, in spite of O'Reilly's plea for the systematic examination of environmental variables, Haladyna, Shaughnessy & Shaughnessy noted eight years later in 1983 that many studies still tended to focus on individual student factors in their search for correlations with attitudes towards mathematics. They did conclude, however, that attitudes are formed within the context of a classroom learning environment and that aspects of this environment have a shaping effect greater than the sum of the individuals who are affected. For example, they commented that, "Changes in instruction probably have a more pervasive effect on a class of students than they do on the individuals who compose the class" (Haladyna, Shaughnessy & Shaughnessy, 1983 p. 19). They also advocated that it was time to recognise the importance of the whole class effect in shaping student outcomes by also examining class variables such as teacher quality and the learning environment.

Shaughnessy, Haladyna & Shaughnessy (1983) found that, in the middle school grades, the classroom environment variables of Enjoyment of Mathematics, Class Satisfaction, Disorganisation, Classroom

Environment, Materials Usage and Attentiveness each had a substantial correlation with positive attitudes towards the subject. Many of these findings probably come as no surprise to the astute practitioner.

Less obvious perhaps are some of the findings of studies which have carried a gender focus in the mathematics classroom. For example, a study of 23 mathematics classes of 14 year old students in The Netherlands concluded that, "Boys perceive their learning environment as more reality centred and more task oriented than do girls" (Terwel, Brekelmans, Wubbels & Eden, 1994, p. 47).

Perhaps this has links with the more general work of Reyes, quoted earlier, who noted that boys are frequently less anxious, more confident and hold higher estimates of their own ability in mathematics than girls. Terwel et. al. also offered the suggestion that girls may be looking for a higher standard than boys and that this may be part of the explanation of their different perceptions.

They also reported that the mean student perception of cooperation in a mathematics class decreased as the number of girls in the class increased or, as the authors expressed it, "the more boys in a class, the more cooperation between students" (p. 47).

This is partly at odds with an American study (Huang & Waxman, 1994) of 2400 students of a similar age to those in The Netherlands study where it was reported that statistically significant differences existed in the way boys and girls perceived their mathematics classroom environments. Girls reported significantly more Involvement, Affiliation and Satisfaction in their classes than did boys. They also reported a significantly higher level of Achievement Motivation which was defined as, "the extent to which students feel the intrinsic desire to succeed and earn 'good' grades in mathematics" (Huang & Waxman, 1994 p. 98). Correlations were not reported in either study to determine associations between student's perceptions of their learning environment and their attitudes or

achievement.

The Huang & Waxman (1994) study also addressed the issue of ethnicity and found that a significant difference existed between the perceptions of Asian-Americans and Anglo-Americans of their mathematics learning environments. The study recognised from the outset that Asian-Americans typically and consistently outscored Anglo-Americans on tests of mathematical ability. The study found that Asian-Americans had higher perceptions of Involvement and Satisfaction in their classes. They also recorded higher Academic Self Concept and Achievement Motivation scores. Interestingly their perceived levels of Affiliation were lower. The authors suggest that this may have been because these students spent more time on their homework, and therefore less time socialising, or it may have been because of parental limitations on their social life.

Whilst research into attitudes towards mathematics has been conducted from a range of viewpoints, there is minimal research which links secondary students' perceptions of their classroom environment with their attitudes towards mathematics. Consequently, the investigation of this link is one of the focusses of this study.

Conclusions

The study of classroom learning environments began in earnest in the 1970s with the independent development of the CES and the LEI. Since then many instruments have been developed for the study of specific aspects of the classroom environment or for specific age groups. Amongst these has been the QTI which has focussed specifically on the teacher's interpersonal behaviour in the classroom.

Many of these instruments have also been developed in Preferred and Actual forms, in Teacher and Student forms, and, more recently, in Personal and Class forms. The use of different forms has enabled classes to

be profiled from more than one perspective so that intervention strategies can be implemented to improve the learning environment.

The instruments have been used as outcome measures of new programs or of changes implemented in the classroom. The instruments have also been used as independent variables to address associations between the classroom environment and dependent variables such as students' attitudinal or cognitive outcomes.

In spite of the development of these instruments over the past 25 years, three issues remain of concern. Firstly, although new specific instruments have been developed since the CES and the LEI, most of which are reviewed in this chapter, no new instruments have been developed for the purpose of general classroom use. Some of the scales on the early instruments have been shown over time to be better predictors of student outcomes than others. It is also the case that the nature of teaching has changed since the 1970s, as has teacher-student relationships. Consequently, there is a need to develop an instrument which can be used in general classrooms and which takes into account the previous development of instruments, as well as the changed nature of teaching.

The second area which has not been investigated in reported research is that of associations between students' perceptions of their teacher's interpersonal behaviour and their perceptions of the classroom environment. Is specific teacher interpersonal behaviour associated with specific aspects of the classroom learning environment?

The third area of concern is that despite the compulsory nature of mathematics in most countries, and its fundamental importance in society, little research has been carried out in the mathematics classroom to address the nature of the classroom environment or its associations with student outcomes.

An important and related issue to the development of classroom learning

environment instruments is the noticeable absence of supportive qualitative data in studies reported in the literature. Recent research (Fraser & Tobin, 1991) highlights the importance of including qualitative data to complement, explain and amplify information gained through the use of quantitative methods. However, such studies are conspicuous by their absence.

Each of these issues is addressed in this thesis which validates a new instrument in 23 grade 9 mathematics classes. It also validates the QTI, for the first time, in the context of a sample of Australian mathematics classes and compares the results of the use of this instrument with the perceptions indicated on the new general classroom environment instrument. The next chapter describes the methodology used in this study, including the development of a new classroom environment instrument.

CHAPTER 3

METHODOLOGY

Overview

Only a small amount of general research has been carried out into secondary students' perceptions of their mathematics classroom environments. In this regard, this study is significant because it addresses these perceptions and also validates instruments which can be used easily by mathematics teachers in the context of Australian secondary schools. This study is the first to examine secondary mathematics classes in Australian schools in this way.

There are six objectives of this research.

* To validate a new instrument, the CEI, which has been developed for the purpose of measuring the classroom learning environment;
* To determine any differences between data gathered through the Personal and Class forms of the CEI;
* To determine the perceptions of the sub-populations of male and female students of their mathematics classroom environment and their mathematics teacher's interpersonal behaviour;
* To investigate associations between the mathematics classroom learning environment, teacher-student interpersonal behaviour in the mathematics classroom and student outcomes;
* To determine what is common and what is unique in the variance in students' outcomes explained through the use of the

CEI, in each of its forms, and the QTI; and

* To investigate associations between the Classroom Environment Instrument and the Questionnaire on Teacher Interaction.

It is not possible for the researcher to control all the variables in this research. Neither classroom learning environments nor teacher-student interpersonal behaviour can be held constant, controlled or manipulated in the scientific sense for the duration of the research. These variables exist and, it is hypothesised, link with the attitudes which students form in mathematics and with students' understanding of their mathematics. Consequently, this research is ex post facto. Kerlinger (1970) defines such research as, "systematic, empirical enquiry in which the scientist does not have direct control of independent variables because the manifestations have already occurred or because they are inherently not manipulable" (p. 379).

Cohen & Manion (1989) delineate two types of ex post facto research; co-relational study (or causal research) and criterion group study (or causal comparative research). The research of this study is co-relational study and seeks to determine associations between classroom variables as perceived by students, and students' attitudes towards, and their understanding of, mathematics.

The methodology outlined in this chapter involves identification of the population and the sample, description of the data gathering instruments and procedures, and an outline of the methods to be used for the description, analysis and interpretation of the results.

The Research Population and Sample

The population chosen for this research was grade 9 mathematics students in Adelaide, South Australia. In South Australia, grade 9 is the second grade of the secondary school which currently runs from grade 8 to grade 12. It has been the researcher's experience that students in grade 8

are often motivated by the novelty and enthusiasm found in their first year of the secondary environment. Similarly grades 11 and 12 provide a focus beyond school for many students, and students can often be motivated and learn in spite of the teacher because of the external goals. A focus of this study is the role of the teacher in the classroom learning environment. Grades 8, 11 and 12 seem to be less dependent upon the teacher to establish the learning environment for the reasons given. Although grade 10 students would have been a suitable population, in some schools students at this grade level are able to choose between pure, applied and business mathematics. Rather than introduce these variables into the study it was considered desirable to settle on grade 9 students.

It was also felt that grade 9 provided the grade level where the teacher has the largest impact. It is a grade level well known for student relationship difficulties; with peers, with parents, and with teachers. This was confirmed in studies into peer relationships in Adelaide schools in the Improving Peer Relations in Secondary Schools conference (Rawnsley, 1995; Rigby, 1995). Rigby reported that along with grade 8, grade 9 students exhibit more bullying and peer conflict than in other senior grades.

It is also a grade level where mathematics becomes more abstract and is conceptually difficult for some students. However, the less academic students who would be likely to choose applied or business mathematics in grade 10 are still part of the mainstream classes. Consequently, the role of the teacher in the classroom is perhaps more central to the establishment of the classroom learning environment than in other grade levels.

In choosing the sample, three factors were felt to be important. Firstly, there are three school systems in South Australia; the State Education Department system, the Catholic Education system and the Independent School system. The Catholic and Independent systems purport to encourage a different ethos from state schools and so it was felt that they should be represented in the sample. Secondly, gender was also deemed

important and so the sample was chosen to represent single sex girls classes and single sex boys classes as well as coeducational classes. The third factor was to ensure a range of ability groups, ranging from mixed ability to a variety of streamed classes.

Using the stratified sampling method, a sample of schools was approached in order to give a broad cross section of classes which met these criteria. Each school was asked to allow the survey to be carried out in two of its grade 9 mathematics classes. However, pragmatics influenced the outcome of the sampling procedure and the independent sector was proportionally over represented in the final sample of 18 schools and 34 classes. This sector responded more positively to participating in the survey.

When each participating school was asked to allow the research to be conducted in two of its grade 9 classes, they were also asked to try to provide two classes which were not merely their best two classes. It was emphasised to Principals and Mathematics Coordinators that a range of teaching styles and competencies was sought, along with a range of student mathematical abilities. A number of Mathematics Coordinators indicated that this request was observed in suggesting teachers and classes for participation.

The intention behind this request was to minimise the dangers of using solely a volunteer group of teachers because this would diminish the extent to which the sample could be considered representative of other grade 9 teachers. This is a problem which Levy, Creton & Wubbels (1993) observed in their surveys and noted that research based solely on volunteer teachers "may provide an overly-positive view of teachers in general" (p. 31).

However, during the year, unexpected disruptions such as teacher long service leave, changes of staff, or regrouping of students in classes meant that the final sample was a little smaller and consisted of 490 students in 23 classes in 14 schools.

Table 3.1 shows the final distribution of classes from which the data were gathered.

Table 3.1
Distribution of Classes in the Research Sample.

School Type			Gender of the Class			Setting & Ability Level			
Govt.	Ind.	Cath.	Coed.	Girls	Boys	Mixed	High	Middle	Low
10	9	4	14	3	6	10	5	7	1

This sample represented about 3.5% of grade 9 students in metropolitan Adelaide.

Letters were sent to parents of all students whose classes were to participate in the survey (Appendix A). These letters explained the study, gave assurances of confidentiality, and allowed parents to 'opt out' if they did not want their son or daughter to participate. To the researcher's knowledge, no students opted out of the study.

Data collection

Data were collected on four occasions during the year. A test for cognitive outcomes was administered during the second half of first term and again in mid fourth term. During week 4 of the third term students completed instruments which assessed their attitudes towards mathematics, and gathered data about their perceptions of the classroom learning environment and their teacher's interpersonal behaviour. Qualitative data was collected via interviews with students early in term 4. This time scheme is represented in Table 3.2.

The instruments were administered by the classroom teachers, following instructions from the researcher. Because of the more sensitive nature of the questionnaires used in term 3, students were asked to put their

completed questionnaire into an envelope on the teacher's desk without handing it to the teacher. This was to reduce bias due to student anxiety about the teacher reading his or her answers.

Table 3.2
Data Gathering Time Line

Term 1	Pretest for cognitive outcomes
Term 3	Test for affective outcomes
	Administration of the Classroom Environment Instrument (CEI)
	Administration of the Questionnaire on Teacher Interaction (QTI)
Term 4	Postest for cognitive outcomes
	Interviews for qualitative data

All questionnaires were named so that the instruments used over the year could be collated at the individual level. Schools and students were assured that the collation of individual's responses over the year was the only way in which the names would be used. Some students used fictitious names over the three questionnaires. Over the course of the year the results from a few students from each class were discarded due to absences on the survey date or transfers in or out of the class.

Test for Cognitive Outcomes

Given the wide variety of assessment procedures and the lack of a common exam across schools it seemed inappropriate to consider grades applied to students' work by the schools. It was also felt that any test needed to contain work specific to the grade 9 course. This meant that the final test in term 4 was testing grade 9 work which all students had covered. Confirmation was sought on this point from each teacher. Therefore a short test was prepared containing 17 mathematics items typical of those studied at grade 9 level. These items reflected the range of material covered during the grade 9 course and included number theory, algebra, geometry and problem solving .

This test was trialled in first term in both a grade 9 class and a grade 10 class to gauge the reactions of students new to the grade 9 course and those who had just completed it. Following analysis of the results, and discussions with students and mathematics teachers with experience in a variety of schools, the test was reduced to a 12 item test (Appendix B).

This final version of the test was administered in first term, and again at the end of the school year. On the second occasion the test was of the same form but the questions were slightly altered. The average score for these two tests was used as the measure of each student's understanding of grade 9 mathematics. Where students did not have two named tests available to determine an average, no cognitive score was entered. These cognitive tests were the only longitudinal aspect of this research.

The test was given twice during the year to incorporate a measure of the increase in understanding. The increase alone was not used as the cognitive measure because the nature of the test did not allow for weak students and able students to increase to the same extent. For example, students who had a high level of understanding of the grade 9 work early in the year gained a similar score later in the year. Consequently the average of the two tests was used because this differentiated between students who had a sound understanding of their mathematics and those with a lesser understanding, as well as differentiating between similar students who made different gains in understanding during the year.

Unfortunately, this longitudinal nature of the study caused some problems and the sample size for the test of cognitive outcomes was considerably reduced. Five classes changed teacher after the initial test was given in first term. Three classes refused to conduct the test in the final term. In each of these three cases the teacher, or her senior, considered the classes too unruly or the tests too threatening for the teacher. One teacher commented to the researcher, "No I'm not going to (conduct the test). The kids are out of control. There's no way I'd even try to get them to sit still and do it. They wouldn't take it seriously anyway." A second teacher shared similar comments whilst in the third class the

research was terminated by the mathematics coordinator because she believed that the teacher could not control the class. Four classes failed to use names on one or other of the two tests for cognitive outcomes, (as did a few students in each of the other classes). Consequently, the sample size was reduced to 207 students in 12 classes for the measurement of students' cognitive outcomes.

Test for Affective Outcomes

To determine the attitudes of students towards mathematics, eight items were included as a scale at the end of the classroom environment instrument (See items 65-72 in Appendices C & D). Students were asked to rate their agreement with such items as, 'Maths lessons are fun' and 'I find it interesting to hear about new mathematical ideas'.

These items were adapted from the *Test Of Science Related Attitudes* (Fraser, 1981b). This 70 item test of science related attitudes has been used extensively and has proven reliability. Eight items were chosen from this test and adapted to read 'mathematics' instead of 'science'. Three of these items were reversed to minimise the risk of students' response set bias.

Collectively, these items gave each student a score for a positive attitude towards mathematics. From these data, class means were generated.

Classroom Learning Environment Data

Both quantitative and qualitative data were collected. Classroom research has moved through eras of systematic observation (Medley & Mitzel, 1958; Amidon & Hough, 1967) and ethnographic and case study research (Merriam, 1988). Whilst discussions in the past have focussed on the merits of each of quantitative and qualitative data, researchers now frequently recognise the important contribution made by each method of research and advocate the use of both types of data in order to provide

complementary perspectives on the research problem. This has been mentioned in the previous chapter and is discussed extensively elsewhere (Burns, 1990; Cohen & Manion 1989; Fraser & Fisher, 1994; Fraser & Tobin, 1991).

Cohen & Manion (1989) commented that,

> We, for our part, will attempt to present the two perspectives in complementary light and will try to lessen the tension which is sometimes generated between them. Merton and Kendall express the same sentiment when they say, 'Social scientists have come to abandon the spurious choice between qualitative and quantitative data: they are concerned rather with that combination of both which makes use of the most valuable features of each.' (p. 42)

Consistent with this methodology, both qualitative and quantitative data were collected. The quantitative data were gathered using two classroom environment measures, the Classroom Environment Instrument (CEI) and the Questionnaire on Teacher Interaction (QTI), and the qualitative data were gathered from interviews with students.

The gathering of both forms of data proved beneficial, as is outlined later.

The Development of the Classroom Environment Instrument (CEI)

The use of quantitative data gathering methods in researching school classroom learning environments has been covered, and shown to be well accepted, in the literature review. It was also shown that the two primary instruments used for such research were the Classroom Environment Scale (CES) (Moos & Trickett, 1974; Trickett & Moos, 1973) and the Learning Environment Inventory (LEI) (Anderson & Walberg, 1968; Fraser, Anderson & Walberg, 1982). Other instruments have since been developed for more specific purposes.

However, as general classroom tools, the CES and the LEI are dated and do not reflect changes in education since their inception in the early

1970s. This study has as one of its objectives the validation of a new general instrument, the Classroom Environment Instrument (CEI), which is designed for use in secondary classrooms. This instrument was developed by Fraser, Fisher & McRobbie (1996) in a form similar to previous instruments and consists of 9 scales, each with 10 items. Students were asked to respond to each item by indicating if the statement in the item represented a situation which 'Almost Never Happens', 'Seldom Happens', 'Sometimes Happens', 'Often Happens' or 'Almost Always Happens'. The instrument was also developed in both a Class form and a Personal form. This initial instrument was independently trialled by the researcher, refined and used in the gathering of data for this thesis. Concurrently with the researcher's trials, the initial instrument was also trialled and refined by its authors, who have recently published a report on their first use of a modified 54 item version of the instrument (Fraser, Fisher & McRobbie, 1996).

Table 3.3 shows the nine scales of the initial version of the instrument, with a sample item from each scale. For illustrative purposes, the first five sample items are taken from the Class form and the remaining sample items are from the Personal form.

Table 3.3

Scales and Sample Items of the Classroom Environment Instrument (CEI)

Scales	Items
Student Cohesion	Members of this class are friends
Teacher Support	The teacher goes out of his or her way to help students
Involvement/Negotiation	Students discuss ideas in class
Autonomy	Students have a say in how class time is used
Investigation	Students draw conclusions from information
Cooperation	I cooperate well with other class members
Task Orientation	I am ready to start this class on time
Equity	I am treated the same as other students in this class
Emphasis on Understanding	I must understand the work to get good marks on class tests

The CEI is representative of Moos' three characteristics. As outlined in Chapter 2, developers of classroom environment instruments for general classroom use have sought to assess aspects of each of these three variables. The first three scales, Student Cohesion, Teacher Support and Involvement/Negotiation, measure Moos' Relationship Dimension. The second three scales, Autonomy, Investigation and Cooperation, measure the Personal Development Dimension whilst the final three scales, Task Orientation, Equity and Emphasis on Understanding measure the System Maintenance and Change Dimension.

The Class form of the CEI was trialled prior to its use in the actual research project. (At that stage the Personal form had not been developed.) The trial was to determine face validity of the items, to ascertain reliability figures for the scales and to find out how long it would take for students to complete the instrument. Initially, it was used in two grade 9 mathematics classes, and this was followed by discussions with students about their understanding of the items. Items on the Autonomy scale appeared to cause some concern. This seemed to be because of the nature of mathematics classes. Work is more sequential than in many other subjects and generally students are not as autonomous in their learning. Further discussion showed that students found a greater teacher dependency in mathematics and some of the Autonomy items did not seem relevant to them, and therefore they found them difficult to answer. Also, students indicated that they did not understand some of the Autonomy scale items clearly. A few concerns were also expressed by a lesser number of students about the relevance of the Investigation scale. A few students commented that mathematics is frequently text oriented, and investigative behaviour was not emphasised very often.

The data from the trial also were analysed statistically to determine reliability. The Cronbach alpha reliability scores for each scale are shown in Table 3.4. The scales with the least reliability were the Autonomy and the Cooperation scales.

Table 3.4

Cronbach Alpha Reliability for the Trial Version of the CEI

Scales	Alpha reliability
Student Cohesiveness	0.63
Teacher Support	0.82
Involvement/Negotiation	0.73
Autonomy	0.59
Investigation	0.65
Task Orientation	0.78
Cooperation	0.56
Equity	0.79
Understanding	0.67

Part of the trial was also to determine how long the instrument would take to complete. The final questionnaire to be sent to schools needed to be completed in a single module lesson, (about 30 minutes of actual class time), so as to cause minimum disruption to participating schools. However, the trial showed that the instrument needed to be shortened.

On the basis of the discussions with students, consideration of the reliability figures and the need to shorten the instrument, the Autonomy scale was deleted from the final form. Also the two items in each scale which had the lowest correlation with other items in the same scale were deleted. These deletions were to improve the overall internal consistency and reliability of the instrument as well as to meet the practical requirements of shortening the length.

The CEI was developed for use in general classrooms and was not mathematics classroom specific. Within the context of grade 9 mathematics classes the Autonomy scale was deemed to be less important than other scales. Mathematics is sequential in nature, frequently more so than other subjects. It "has developed into an extensive hierarchy or network of concepts, each more abstract than, and dependent upon, those feeding into it" (Barnard, 1996, p. 7). Given this

hierarchical nature of mathematics, classes are frequently more teacher directed, and students less autonomous, than in other subjects. Consequently, and particularly given students concerns about the difficulties of this scale, the autonomy scale was not used in this survey of mathematics classes.

On the other hand, the Cooperation scale, which also had a low Alpha Reliability score, was considered to be an important aspect of the mathematics classroom environment and needed to be included. It was anticipated that with the deletion of the two least consistent items, the internal consistency of the Cooperation scale would improve to an acceptable level. Consequently, the scale was included. The Investigation scale had also been queried by a few students. However, it was not removed because it was also considered by the researcher to be an important part of mathematics. The student queries had related to the relevance of the scale rather than difficulties with individual items.

With regard to the remaining six scales, it was expected that each scale would prove to be even more acceptable with the deletion of the two least internally consistent items. This would also make the instrument a more desirable length in order for students to complete it in a single module of class time. Table 3.5 shows the scales in the CEI, scale descriptors, and a sample item from each scale for both the Personal form and the Class form.

The final instrument consisted of eight scales, each with eight items. Appendices C and D show the Personal form and the Class form of the CEI respectively. In the final survey the CEI was presented to half of each class in the Class form and half of each class in the Personal form. This was to enable the gathering of student perceptions about how the class perceived the classroom learning environment and also about how each student perceived it as it impacted directly on him or her as an individual.

The use of Personal and Class forms of the CEI enabled a comparison of

class profiles to be made and significant differences between the two forms to be addressed. It also enabled sub-populations of students to be explored and profiles of classrooms, by gender of the student, are also presented as part of the discussion.

Table 3.5
The CEI Scales and Sample Items From the Personal and Class Forms

CEI Scale	Scale Descriptor	Personal Form Sample Item	Class Form Sample Item
Student Cohesion	Students show friendship and help each other with their work.	I do favours for members of this class.	Members of this class do favours for one another.
Teacher Support	The teacher is friendly, helpful, supportive and interested in his/her students.	The teacher takes a personal interest in me.	The teacher takes a personal interest in students.
Involvement/ Negotiation	Students are involved in questioning, answering and discussing their work.	My ideas and suggestions are used during class discussions.	Students' ideas and suggestions are used during class discussions.
Investigation	Students investigate mathematical problems in a variety of ways to find solutions.	I carry out investigations to test my ideas.	Students carry out investigations to test their ideas.
Cooperation	Students work cooperatively rather than competitively.	I cooperate well with other class members.	Students cooperate well with other class members.
Task Orientation	Students are focussed on their mathematics work in class.	I am ready to start this class on time.	Students are ready to start this class on time.
Equity	All students are treated equally in their work and their class contributions	The teacher is as friendly to me as to other students.	The teacher is equally friendly to all students.
Emphasis on Understanding	The teacher questions, explains, and emphasises student understanding of the work.	The teacher's questions help me to understand.	The teacher's questions help students to understand.

Teacher-Student Interpersonal Behaviour (QTI)

The instrument used for the collection of data for this section of the study was the Questionnaire on Teacher Interaction (QTI) (Wubbels, Creton & Hooymayers, 1985). (Appendix E).

This instrument has been reviewed in the previous chapter and its reliability has been well established, both for the 64 item form and the shorter 48 item form. The 48 item form was chosen because of time constraints in host schools and because its reliability has been well established both oversees and in Australian schools. For example, Fisher, Henderson & Fraser's recent study (1995) in Tasmania yielded alpha reliability coefficients for the eight QTI scales ranging from 0.63 to 0.83 with the student as the unit of analysis, and from 0.74 to 0.95 with the class as the unit of analysis. This showed the instrument to have acceptable levels of internal consistency. However, neither the 64 item form nor the 48 item form have been validated previously with a large sample of mathematics classes. The validation of the 48 item versions with a sample of mathematics classes is one of the unique aspects of this study.

Qualitative Data

Qualitative data are different in nature to quantitative data. It allows students to explore ideas, to interpret, to debate and to amplify ideas about, in this study, their classroom environment and mathematics. It enables the researcher to see new insights in the quantitative data and reinforces, or falsifies, the data (Popper, 1963).

Six students were chosen from each of 5 participating classes for interviews. Students were chosen on the basis of their responses to the instruments in term 3. They were not always the typical respondents and included some students who responded in atypical fashion. The students from each school were interviewed in a group situation.

Similarly, classes from which the students were interviewed were chosen in order to represent the range of classroom environments represented in the data from the term 3 instruments. One class was chosen from each end of the spectrum of classroom environments as identified by students' responses in the collection of the quantitative data. One class was chosen because it appeared to be a class where students perceived the teacher (who will be called John) to be uncertain, admonishing and to offer less teacher support than most other classes. Similarly a contrasting class was chosen because students perceived their teacher (who will be called Peter) to offer support, to be helpful and understanding, and to have an emphasis on learning. Three other classes were chosen because they reflected positions at varying points between these two extremes.

Interview questions were not scripted although they followed the same pattern for each interview session. General questions were asked about student's enjoyment of mathematics and their mathematics classes. This was then narrowed to address their perceptions of their classroom learning environment, followed by further narrowing to the scales and their class's mean scores on the instruments. Finally, individual responses by the interviewees to some of the items were discussed.

This allowed discussion to occur; in fact lively debate at times. It also allowed the probing for further information, for individual's views to be expressed, as well as contrary and group views. Interviews were taped, with each student's and teacher's permission, for later analysis. All interviews were transcribed in full and examined according to the scales in the CEI and the QTI. Comments made by students in relation to the concept measured in each scale were noted and compared across classes. Similarly the transcrips were examined for comments relating to gender differences and differences resulting from personal and class perspectives on issues. As a follow up to each interview the researcher also kept a journal outlining what had happened in each interview and his impressions of the teacher, the class and the interview.

Data Analysis

The data analysis focusses on the objectives of the study. The first objective was to validate both the Personal and Class forms of the instrument used for the collection of quantitative data about student perceptions of their classroom learning environment. Also the QTI was analysed to show its reliability and validity in its use with a large sample of Australian mathematics students. Having validated the two forms of the instruments, a second area of analysis was to identify significant differences between the Personal and Class forms of the CEI. Included in this analysis is the profiles of the sub-populations of male and female students using each form of the CEI, and also the QTI. The third area of analysis was to identify associations between the perceptions expressed using the CEI and the QTI, with students' attitudinal and cognitive scores. The final area of analysis was to determine the unique and common contributions made by each of the instruments through a commonality analysis and to address associations between the perceptions shown on the two instruments.

Validation of the Classroom Environment Instrument (CEI)

Four areas of statistical validation were employed. These were the establishment of the instrument's reliability, discriminant validity in the scales, factor analysis, and the ability of the instrument to discriminate between classes.

The reliability, or internal consistency, of the instrument was established using the Cronbach alpha coefficient (Cronbach, 1951) and the discriminant validity was established by calculating the mean correlation of each scale with the other scales. The units of analysis for these tests were the individual student and the class mean.

An analysis of variance (ANOVA) determined the ability of the instrument to distinguish between classes. In theory each class should

have its own environment and the instrument should be sensitive enough to detect differences between classes. Within class perceptions should be similar but sufficiently different from those of students in other classes. The ANOVA was performed on each scale of the instrument to show the proportion of variance of each of the scales which could be explained through class membership.

Finally each of the items was subjected to a principle components factor analysis with varimax rotation to determine the extent to which they contributed to their substantive scale, and to any other scales.

The validation of the instruments was also supported with the qualitative data collected during the interviews. These data were used to help explain the quantitative data, particularly in the class profiles.

Validation of the Questionnaire on Teacher Interaction (QTI)

The QTI was analysed in a similar manner to the CEI as described above. Alpha Reliability scores were used to determine the internal consistency and an analysis of variance (ANOVA) was used to show the ability of the instrument to discriminate between classes. However, interscale correlations were used to show the circumplex nature of the model, rather than the use of mean correlation scores to show the discriminant validity of the scales. Adjacent scales in the model should correlate highly whereas opposite scales should show strong negative correlations. Each of these analyses were undertaken with both the individual and the class mean as the unit of analysis.

Analysis of Differences Between the Personal Form and the Class Form of the CEI

It was the contention of Fraser and Tobin (1991) that Personal forms of classroom environment measures would profile classroom environments in a slightly different way to Class forms because they

measure different student perceptions. The Personal form focusses on students' personal interactions with the classroom environment, rather than perceptions of the class's interactions.

The significance of the differences was determined with a multivariate analysis of variance (MANOVA). One way analysis of variance (ANOVA) was then used to determine the level of significance of the differences for each scale. Qualitative data gathered from student interviews were also analysed in order to support or counter the quantitative data, and to explain, where appropriate, the differences between the Personal and Class forms.

It was also the contention of Fraser and Tobin (1991) that Personal forms would be more useful than Class forms in profiling sub groups of the population. Differences between the perceptions of male and female students are analysed using a MANOVA, followed by ANOVA's, as described above, for students from coeducational classes for both the Personal form and the Class form of the CEI. Once again qualitative data were used, where appropriate, for comparison with the quantitative data.

Investigations of Associations Between Student Perceptions using the CEI and the QTI, and their Attitudinal and Cognitive Outcomes

Having established the validity of the CEI, the fourth objective of this study was to ascertain if associations existed between the way students perceived their classroom learning environments, including their teacher's interpersonal behaviour, and their attitudes towards mathematics and their understanding of mathematics.

An 'attitude score' was calculated for each student based on the student's responses to the attitude scale. Similarly a 'cognitive score' was determined by administering a short mathematics test at the beginning and at the end of the school year. The average of these two scores was used as each student's cognitive score.

Simple correlations (r), standard regression coefficients (β) and multiple correlation scores (*R*) were calculated for the scales on the CEI with the attitude and cognitive scores. These correlations were determined separately for the Personal form and the Class form.

The simple correlations were to determine the correlations between each scale, and the attitude and cognitive scores. The standard regression coefficient showed the relative weighting of each of the scales in the overall correlation whilst holding the effect of other scales constant. The multiple correlation was to determine the overall correlation of the scales when taken together. The same procedures were also carried out for the scales on the QTI.

Associations Between the Classroom Environment Instrument (CEI) and the Questionnaire on Teacher Interaction (QTI)

This study sought to further explore the CEI and the QTI by determining the extent to which each contributed uniquely to the variance in students' outcomes. A commonality analysis was used to show the amount of overlap, and the amount of unique contribution, measured by the QTI and each of the Personal and Class forms of the CEI.

Associations between students' perceptions of their teacher's interpersonal behaviour as measured by the QTI, and their perceptions of their mathematics classroom environment as measured by the two forms of the CEI also were examined. Simple correlations (r), standardised regression coefficients (β) and multiple regressions (*R*) were determined using the scales of the QTI as independent variables and the scales of each form of the CEI as the dependent variables. This analysis draws out associations between the two instruments as well as highlighting any differences between the Personal and Class forms in their association with the QTI. These correlations add to the understanding of the instruments and ways in which they can be used.

Summary

The review of the literature in Chapter 2 identified the need for a new general classroom environment instrument. This chapter describes the development and recent trialling of such an instrument, the CEI, and the methodology by which it is validated. It also identifies the sample of grade 9 mathematics classes used in this research, and the methodology for the quantitative and qualitative data collection and analysis. Because this study validates a new instrument which can be used in general classrooms, it makes a unique contribution to classroom environment research. It also validates the QTI in a new context; that of a large sample of mathematics classrooms.

Chapter 2 also identified a lack of research in mathematics classrooms addressing associations between the mathematics classroom environment and student outcomes. Chapter 3 outlines the procedures to be used in this study to determine the associations with students' understanding of their mathematics and their attitudes towards their mathematics classes.

The methodology described in this chapter for the validation of the instruments and the identification of associations with student outcomes is consistent with previous research which has validated other more specific classroom environment instruments (Henderson, 1996; Fraser, 1986; Fraser, Fisher & McRobbie, 1996; Teh & Fraser, 1993; Wong & Fraser, 1994).

This chapter also describes how associations between students' perceptions of their teacher's interpersonal behaviour and their mathematics classroom environment are addressed, along with identification of the unique and common contributions made by each of the two classroom environment instruments in their explaining of the variance in student outcomes.

Chapter 4 addresses the first objective of the study and reports the descriptive statistics which validate the Personal and Class forms of the CEI. It also reports the validating statistics for the QTI and the Attitude scale which was developed for this study.

CHAPTER 4

VALIDATION OF THE INSTRUMENTS

Overview

An important purpose of this study has been to validate the Personal and Class forms of the CEI for measuring classroom learning environments. The recent development of this instrument was outlined in the previous chapter. The CEI was developed because the CES and the LEI were considered to be somewhat dated in their conceptualisations of classroom environments, both having been developed in the early 70s.

Mention has already been made of the paucity of research in mathematics classrooms. The research which is the focus of this study is unique because it is validating a new instrument, the CEI, in general mathematics classrooms. This is the first study to do so apart from the recent presentation of a slightly different, 54 item, version of the instrument by its developers (Fraser, Fisher & McRobbie, 1996). The CEI, as used in this study, includes a scale measuring student perceptions of the Emphasis on Understanding in the classroom which was not included in the other instrument. This chapter uses the data gathered in the 23 grade 9 mathematics classrooms to determine the reliability and validity of the instrument.

The study is also significant because it has involved the use of two forms of the CEI; the Personal form and the Class form. Student responses on these two forms are compared and analysed, so that the reliability and validity of each form is determined.

This chapter also addresses the validity and reliability of the QTI. However, this instrument is not new and its credentials have been well established over time, and have been discussed in Chapter 2. Nevertheless, this study is the first to use the QTI with a large sample of mathematics classes. Previous studies, as outlined in Chapter 2, have primarily involved physics, chemistry or biology classes. The descriptive statistics in this chapter make a new contribution to the validation of the QTI and add to the data already gained elsewhere.

The validity and reliability of the attitude test developed for this research is also addressed in this chapter.

Reliability and Validity of the Classroom Environment Instrument (CEI)

The administration of the CEI involved a sample of 490 grade 9 students in 23 mathematics classes, described in the previous chapter.

The instrument consists of 64 items which, in blocks of 8 items, form each scale. The internal consistency of the scales, i.e. the degree to which the 8 items in each scale are internally consistent, was measured using the Cronbach alpha coefficient (Cronbach, 1951). The results of this analysis are shown in Table 4.1

This measure showed that there was an acceptable level of reliability, alpha > 0.60, both when either the individual student or the class mean are used as the units of analysis. The alpha coefficients with the individual student as the unit of analysis ranged from 0.60 to 0.85 with the Personal form of the instrument and 0.63 to 0.84 with the Class form. When the class means were used as the unit of analysis the alpha coefficients were slightly higher with scores from 0.66 to 0.93 with the Personal form and 0.73 to 0.90 with the Class form. These results are similar to those reported by Fraser, Fisher and McRobbie (1996), who

reported a range from 0.77 to 0.89 with the Personal form and from 0.67 to 0.88 with the Class form on their 54 item version of the instrument, using the individual as the unit of analysis. The alpha coefficients for both forms of the instrument are shown in Table 4.1. These are within acceptable limits and attest to the internal consistency and reliability of the CEI.

Table 4.1
Internal Consistency (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with Other Scales) and the Ability to Differentiate Between Classrooms for Personal and Class Forms of the CEI

Scale	Unit of Analysis	Alpha Reliability		Mean Correlation with Other Scales		ANOVA Results (eta^2)	
		Personal form	Class form	Personal form	Class form	Personal form	Class form
Student Cohesion	Individual	0.60	0.63	0.19	0.30	0.19**	0.22**
	Class mean	0.66	0.73	0.32	0.21		
Teacher Support	Individual	0.85	0.83	0.37	0.48	0.22**	0.23**
	Class mean	0.93	0.90	0.46	0.54		
Involvement/ Negotiation	Individual	0.77	0.71	0.35	0.48	0.21**	0.24**
	Class mean	0.88	0.78	0.49	0.58		
Investigation	Individual	0.67	0.70	0.22	0.29	0.13	0.29**
	Class mean	0.67	0.85	0.35	0.43		
Task Orientation	Individual	0.83	0.77	0.34	0.41	0.21**	0.25**
	Class mean	0.90	0.89	0.41	0.47		
Cooperation	Individual	0.63	0.68	0.24	0.34	0.21**	0.32**
	Class mean	0.75	0.89	0.42	0.49		
Equity	Individual	0.82	0.84	0.33	0.38	0.30**	0.25**
	Class mean	0.93	0.90	0.45	0.52		
Emphasis on Understanding	Individual	0.62	0.70	0.39	0.43	0.17*	0.19**
	Class mean	0.67	0.77	0.50	0.55		

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

Personal Form N = 246 students in 23 classes
Class Form N = 244 students in 23 classes

The discriminant validity of the instrument was measured using each scale's mean correlation with the other scales. Table 4.1 shows that these scores range from 0.19 to 0.39 with the Personal form and 0.29 to 0.48 with the Class form using the individual as the unit of analysis. When the class means are used as the unit of analysis, the scores range from 0.32 to 0.50 with the Personal form and 0.21 to 0.58 with the Class form. This indicates that the items used in the instrument correlate far more with items in the same scale than with items in other scales. Consequently, the instrument has satisfactory discriminant validity and each scale measures distinct as well as somewhat overlapping components of the classroom environment. These results replicate those found by Fraser, Fisher and McRobbie (1996, p. 10) who reported scores ranging from 0.09 to 0.48 with the Personal form and 0.06 to 0.45 with the Class form.

The ability of a classroom environment instrument to differentiate between classes is important. Students within a class usually view the classroom learning environment similarly, but differently from students in other classes. The instrument's ability to differentiate in this way was measured using one-way analysis of variance (ANOVA) with results on all scales being significant to at least the 0.01 level, except the Investigation scale on the Personal form which did not differentiate significantly between classes. The amount of variance explained by class membership is reflected in the eta^2 scores which ranged from 0.13 to 0.30 using the Personal form and 0.19 to 0.32 using the Class form. These results also were very similar to those reported by Fraser, Fisher and McRobbie (1996, p. 10). The eta^2 scores in their study ranged from 0.07 to 0.35 for the Personal form and 0.18 to 0.35 for the Class form.

Consequently, the instrument used in this research to measure student perceptions of the classroom learning environment is reliable, having satisfactory levels of internal consistency. The scales discriminate between different, but somewhat overlapping, aspects of the environment, and also differentiate between classes.

A further analysis of the instrument involved a principal components

factor analysis with varimax rotation. The results of this factor analysis are shown in Table 4.2. The 64 items were analysed to determine the commonality of factors measured. The 8 factors are listed across the top of the table with the items and scales on the side. It can be seen that there is a reasonable degree of similarity between the factors measured by the two forms of the questionnaire. The Personal form and the Class form have similar factor loadings to each other. They are clearly not identical, and could more accurately be described as having similar, or considerably overlapping, factors which they measure. Each form of the instrument has a number of outlying clusters of items which stand apart from the main factor loading of the scale. For example, the Personal form has an outlying cluster of items in the Student Cohesiveness scale (factor 8) and the Equity scale (factors 5 and 7), whilst the Class form has a cluster of outlying items in Teacher Support (factor 3). Nevertheless there is substantial agreement between the two forms and the factors which they measure. Similar results were reported by Fisher, Fraser and McRobbie (1996) who carried out a factor analysis on their 54 item version of the classroom instrument. They observed outlying clusters on the scales of Student Cohesiveness, Teacher Support and Cooperation for the Personal form, and Teacher Support and Involvement for the Class form.

According to the factor analysis, there are two scales (Teacher Support and Equity) which substantially measure factor one and there are two scales (Student Cohesiveness and Cooperation) which substantially measure factor two. This appears to be the case for both forms of the instrument. This closeness of the scales is also reflected in the scale correlations. The Teacher Support and Equity scales correlate significantly ($p < 0.001$) at 0.57 (Personal form) and 0.62 (Class form) and the Student Cohesiveness and Cooperation scales likewise ($p < 0.001$) at 0.50 (both forms).

It may be that when students consider the amount and nature of the support which they receive from their teacher, that the equal treatment

Table 4.2
Factor Analysis of the Personal and Class Forms of the CEI Scales

Scale	Item No.	Factor 1 P	Factor 1 C	Factor 2 P	Factor 2 C	Factor 3 P	Factor 3 C	Factor 4 P	Factor 4 C	Factor 5 P	Factor 5 C	Factor 6 P	Factor 6 C	Factor 7 P	Factor 7 C	Factor 8 P	Factor 8 C
Student Cohesiveness	1			*0.34*	0.47											*0.49*	
	2				0.35		0.40									*0.66*	
	3			*0.65*	0.48												
	4			*0.73*													
	5			*0.27*												*0.34*	0.69
	6			*0.18*	0.30											*0.32*	
	7		0.33	*0.56*	0.31										0.34		
	8			*0.44*	0.22										0.32		
Teacher Support	9	*0.70*					0.52										
	10	*0.77*	0.35				0.56										
	11	*0.77*	0.42				0.55										
	12	*0.62*	0.52				0.51										
	13	*0.68*	0.31				0.55										
	14	*0.19*	0.48				0.25			*0.33*							
	15	*0.71*	0.35				0.44										
	16	*0.45*	0.54				0.27			*0.49*							
Involvement/ Negotiation	17					*0.73*	0.44										
	18					*0.74*	0.64										
	19					*0.62*	0.45										
	20					*0.74*	0.39										
	21					*0.27*	0.46										
	22		0.32							*0.46*		*0.32*					
	23				0.64	*0.41*		*0.34*									
	24				0.74	*0.32*		*0.46*									
Investigation	25											*0.81*	0.55				
	26											*0.83*	0.72				
	27								0.36			*0.66*	0.35				
	28											*0.77*	0.63				
	29											*0.64*	0.64				
	30											*0.43*	0.30			*0.40*	0.64
	31														0.62		
	32														0.61		
Task Orientation	33									*0.70*	0.58						
	34									*0.69*	0.58						
	35									*0.60*	0.45						
	36									*0.70*	0.44						
	37									*0.62*	0.62						
	38									*0.59*	0.40						
	39								0.30	*0.29*							
	40									*0.70*	0.62						
Cooperation	41			*0.63*	0.64						0.30						
	42			*0.18*	0.22									*0.62*			
	43			*0.68*	0.58												
	44				0.17									*0.64*			
	45													*0.59*	0.45		
	46		0.46	*0.49*	0.48												
	47			*0.44*	0.49												
	48			*0.17*	0.67			*0.50*									
Equity	49	*0.51*	0.80											*0.54*			
	50	*0.47*	0.74											*0.53*			
	51		0.45											*0.58*	0.32		
	52	*0.39*	0.72							*0.45*				*0.33*			
	53	*0.44*	0.68											*0.50*			
	54									*0.31*	0.38						
	55	*0.55*	0.71							*0.42*							
	56	*0.33*	0.60							*0.47*							
Emphasis on Understanding	57	*0.56*	0.62						0.24								
	58	*0.46*	0.48					*0.36*	0.41								
	59							*0.40*	0.36								
	60					*0.41*		*0.35*	0.44								
	61							*0.47*	0.71								
	62					*0.45*		*0.47*	0.69								
	63	*0.34*															
	64	*0.41*	0.35					*0.42*	0.49	*0.41*							

of students is a part of their consideration. Similarly, the concept of Student Cohesiveness is not far enough removed from student Cooperation for students to differentiate. Perhaps these scales need some of the items to be either rewritten or amalgamated.

For the purposes of the analysis reported in Chapter 6, some of the items which the factor analysis indicated as correlating least with other items in the same factor were removed. The items removed were items 31, 32, 39, 45, 54 and 63.

However, in spite of the outlying clusters of items being depicted as measuring other factors, the reliability scores quoted earlier suggest good internal consistency among each set of 8 items.

Reliability and Validity of the QTI

The QTI, as already outlined in Chapter 2, has been extensively used in The Netherlands, and to a lesser extent in the USA, but only in a limited number of studies in Australia, for example, in biology and science classes (Fisher, Henderson & Fraser, 1995; Rickards, Fisher & Fraser, 1996). Establishing the reliability and validity of the QTI in Australian mathematics classes is therefore significant.

Table 4.3 shows the descriptive statistics from the use of the QTI in this study. The internal consistency shown by the 6 items in each of the 8 scales (alpha coefficient) ranges from 0.64 to 0.87 when the individual is used as the unit of analysis and 0.73 to 0.94 using the class mean as the unit of analysis.

This is similar to other reported Australian results in biology (Fisher, Henderson & Fraser, 1995), which indicated alpha coefficients ranging from 0.63 to 0.83 with the student as the unit of analysis, and from 0.74 to 0.95 using the class mean, and shows the reliability of the instrument to be well within acceptable limits. As with the biology data, it is the scales

Table 4.3
Internal Consistency (Cronbach Alpha Coefficient) and the Ability to Discriminate Between Classrooms for the QTI

Scale	Unit of Analysis	Alpha Reliability	ANOVA (eta^2)
Leadership (DC)	Individual	0.83	0.22*
	Class mean	0.92	
Helping/ Friendly (CD)	Individual	0.87	0.23*
	Class mean	0.90	
Understanding (CS)	Individual	0.87	0.25*
	Class mean	0.94	
Student Responsibility /Freedom (SC)	Individual	0.64	0.28*
	Class mean	0.81	
Uncertain (SO)	Individual	0.77	0.15*
	Class mean	0.84	
Dissatisfied (OS)	Individual	0.84	0.22*
	Class mean	0.92	
Admonishing (OD)	Individual	0.81	0.29*
	Class mean	0.88	
Strict (DO)	Individual	0.67	0.17*
	Class mean	0.73	

*$p < 0.001$ N = 490 Grade 9 Mathematics students in 23 classes

of Strict, and Student Responsibility and Freedom, which show the lowest, although still acceptable, alpha scores.

The eta^2 results shown in Table 4.3 indicate that the QTI significantly differentiated between classrooms ($p < 0.001$). Items on each scale were answered similarly by students in the same classes but significantly differently from students in other classes. The eta^2 statistic shows that the amount of variance explained by class membership ranges from 0.15 to 0.29. This is the fourth Australian sample for which these statistics have been reported. Fisher, Henderson & Fraser (1995) reported eta^2 statistics

ranging from 0.07 to 0.35. Kent, Fisher & Fraser's eta^2 statistics ranged from 0.26 to 0.37 and Rickards, Fisher and Fraser (1996) reported eta^2 statistics ranging from 0.22 to 0.35. Thus acceptable levels of reliability, and the ability to differentiate between classrooms, in the Australian context has been confirmed.

The QTI scales represent points along axes of Influence and Proximity, and, as discussed in Chapter 2, is described as a circumplex model. Consequently, it is not appropriate to expect low mean correlation scores between scales and to use these as a measure of discriminant validity. Rather there should be a high correlation between adjacent scales in the circumplex diagram, and a low correlation with scales which appear opposite each other on the graph. In this study, simple correlations between the scales for both the individual and the class mean as the unit of analysis are shown in Table 4.4 In each case the scales correlate highly with the one or two adjacent scales on either side but have strong negative correlations with scales which reflect opposite behaviour.

For example, the Dissatisfied scale should correlate highly with the adjacent scales of Admonishing (0.60) and Uncertain (0.59) but have a strong negative correlation with the opposite scale of Helping/Friendly behaviour (-0.61). This is because opposite scales reflect opposite interpersonal behaviour. (The figures quoted in this example are for the individual as the unit of analysis.)

Consequently, this study involving the administration of the QTI in grade 9 mathematics classes has shown similar reliability, and ability to differentiate between classes, to that of previous overseas research and in the other uses of the questionnaire in Australian schools which reported reliability and discriminant validity scores (Brekelmans, Wubbels & Creton, 1990; Fisher, Henderson & Fraser, 1995; Kent, Fisher & Fraser, 1995; Rickards, Fisher & Fraser, 1996; Wubbels and Levy, 1991).

Table 4.4
Correlations Between Scales of the QTI for Individual and Class Units of Analysis

Scale	Unit of Analysis	Lea.	H/Fr.	Und.	St.R/F.	Unc.	Dis.	Adm.	Strict
Leadership	Individual	1.00	0.71	0.78	0.08	-0.54	-0.51	-0.39	-0.17
	Class	1.00	0.68	0.72	-0.23	-0.73	-0.53	-0.52	0.02
Helping/ Friendly	Individual		1.00	0.81	0.34	-0.41	-0.61	-0.48	-0.41
	Class		1.00	0.91	0.37	-0.37	-0.67	-0.71	-0.47
Understanding	Individual			1.00	0.24	-0.47	-0.68	-0.51	-0.40
	Class			1.00	0.21	-0.51	-0.84	-0.85	-0.44
Student Resp./ Freedom	Individual				1.00	0.27	0.04	-0.07	-0.28
	Class				1.00	0.48	0.02	-0.18	-0.56
Uncertain	Individual					1.00	0.59	0.54	0.22
	Class					1.00	0.50	0.50	-0.08
Dissatisfied	Individual						1.00	0.60	0.51
	Class						1.00	0.81	0.48
Admonishing	Individual							1.00	0.43
	Class							1.00	0.52
Strict	Individual								1.00
	Class								1.00

N = 490

Reliability of the Attitude Questionnaire

The attitude questionnaire consisted of 8 items, which were amalgamated as a scale and included at the end of the classroom environment instrument. These items were taken from the Test of Science Related Attitudes (Fraser, 1981b) and adapted for mathematics classes as described in the Chapter 3.

The reliability of this scale is shown clearly in the alpha score of 0.86 when the individual was the unit of analysis and 0.92 when the class mean was the unit of analysis. This shows a high level of correlation

between the 8 items in the scale and therefore a high level of internal consistency.

Figure 4.1 shows a graph of the mean scores for each class, demonstrating the variability of attitude towards mathematics across classes.

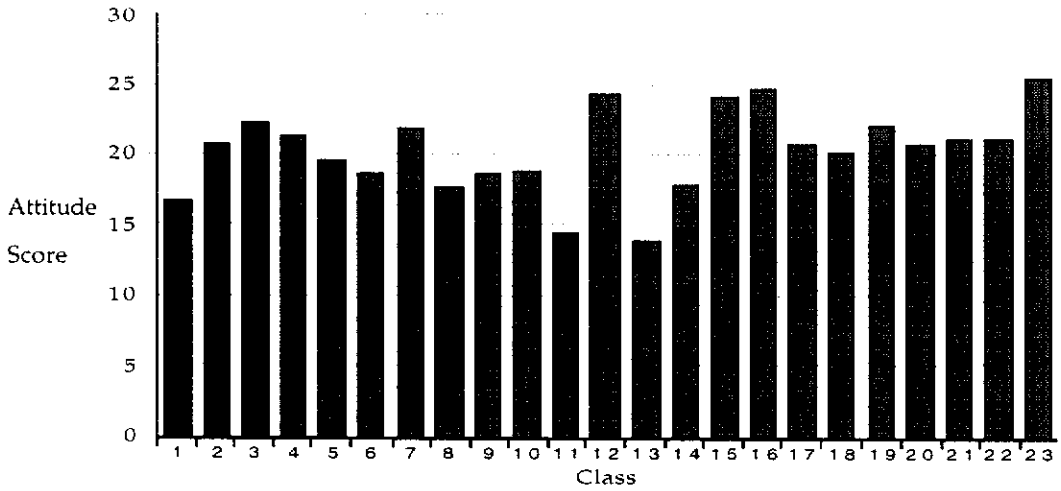


Figure 4.1 Mean attitude score for each class.

The Tests of Cognitive Ability

The two tests of cognitive ability were averaged to determine a cognitive score for each student. As explained in the previous chapter the sample for the measuring of cognitive outcomes was somewhat smaller than the sample for the remainder of the survey consisting of 207 students in 12 classes. Figure 4.2 shows the results of the tests of cognitive outcomes in the 12 classes and highlights the variation in test results across the classes.

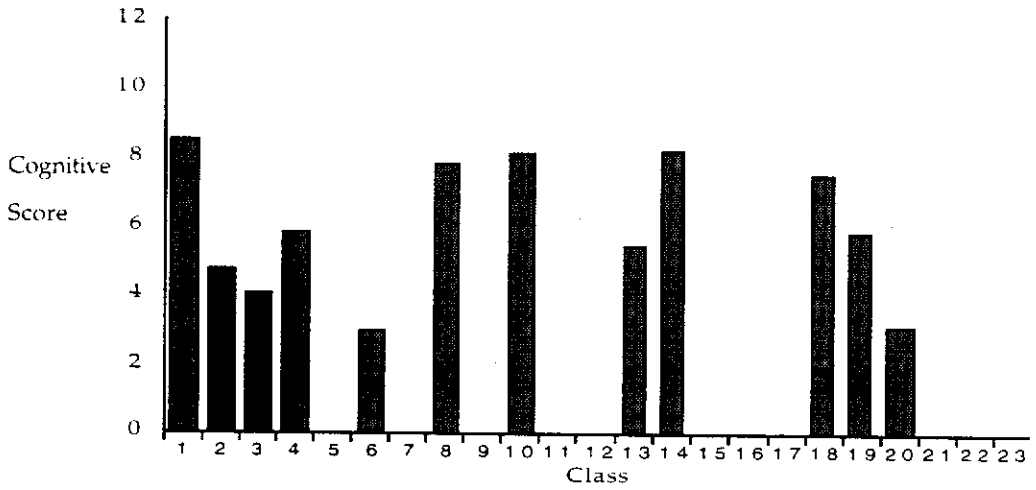


Figure 4.2 Mean cognitive score for each class.

Summary

This chapter has addressed the measuring of aspects of the mathematics classroom environment using a 64 item version of a newly developed classroom environment instrument (CEI), the measuring of teacher-student interpersonal relationships (QTI), and the measuring of student attitudes towards mathematics classes. In each case, the instruments have shown acceptable levels of internal consistency and the ability to differentiate between classes.

The CEI scales have each shown a low mean correlation with other scales and confirm that each scale measures different, although partially overlapping, aspects of the classroom learning environment. This has been the case for both the Personal form and the Class form of the instrument. In order to increase the reliability of the statistical analysis of the data which is described in the next chapter, six items which were identified through the factor analysis and the calculation of scale alpha reliability scores were deleted. Consequently, for the purpose of this analysis, the scales of Student Cohesiveness, Teacher Support, and Involvement/Negotiation each consisted of eight items, Investigation consisted of six, and the remaining scales of Task Orientation,

Cooperation, Equity, and Emphasis on Understanding each consisted of seven items, making 58 items in total.

The interscale correlations of the QTI confirmed the circumplex nature of the model with adjacent scales yielding strong positive correlations and opposite scales yielding strong negative correlations.

The findings for these two instruments supports previous findings, although these were not based on Australian samples of secondary mathematics students.

It has been one of the purposes of this study to validate the new classroom environment instrument (CEI). This chapter, through its descriptive statistics, has shown that the CEI is reliable and has acceptable discriminant ability for use in mathematics classes. Qualitative data are presented in the next chapter which further attest to the validity of these instruments. The profiles of the classes which the CEI describes and the usefulness of the CEI are also addressed, as are the profiles of classes drawn from students' responses to the QTI. The profiles of the sub-populations of the male and female students are also examined.

The use of Personal and Class forms of instruments is a relatively new concept in the measuring of classroom environments. Through examining the profiles of classes described by the CEI, the relationship between the Personal form and the Class form also is analysed in the next chapter.

CHAPTER 5

CLASSROOM PROFILES

Introduction

The previous chapter showed the reliability and validity of the two environment measures used in this research. This chapter explores the uses of these two instruments and describes the profiles of the classrooms in which these instruments are used.

It also considers the qualitative data collected in student interviews, alongside the profiles gained from the quantitative instruments. The qualitative data support the findings of the instruments, further validating them, and add explanations to the profiles.

The CEI and the QTI each profile classrooms distinctively. The QTI focusses on the teacher-student relationship within the classroom whilst the CEI profiles eight general dimensions of the classroom environment. The CEI was used in both the Personal form and the Class form. Each form profiles classrooms in very similar ways, but with some differences which are distinguished in this chapter. Because the use of Personal forms is new to the study of classroom environments, it is important to identify the differences between Personal form classroom profiles and those of Class forms. This will enable better recommendations to be made regarding their use in further research. It will also enable a better understanding of the classroom environment.

The first section of the chapter addresses the use of the CEI in each of its

forms whilst the second section focusses on the QTI. As part of addressing the profiles of classes as described by these two instruments, gender differences in perceptions of the classroom will also be addressed.

Class Profiles Using the Classroom Environment Instrument (CEI)

The CEI as used in the analysis in this study consists of 58 items which form 8 scales. Through the calculation of class mean scores for each scale, it is possible to profile the classes as students perceive them. Classroom environment instruments have been extensively used in this way and previous such uses are discussed in Chapter 2.

The use of Personal and Class forms (Fraser, Giddings & McRobbie, 1995) of instruments is, however, a more recent concept and classroom environment measures have not been used extensively in both forms. Traditionally, only the Class form has been used. Table 5.1 shows the item means for each scale and the standard deviations for both the Personal form and the Class form as used in this study.

Each scale consists of 6-8 items which students rated on a Likert Scale ranging from 1 to 5. Consequently, item mean scores have been calculated for each scale. Using the individual as the unit of analysis, item mean scores ranged on the Personal form from a high of 3.7 for both Task Orientation and Equity down to 2.6 for Investigation. Perception scores using the Class form, however, ranged from a high of 3.6 on the Emphasis on Understanding scale, down to the same score of 2.6 on the Investigation scale.

It is interesting to note that students, using either of the forms of the CEI, perceived a low level of investigation in their classrooms. These results differ from those of Fraser, Fisher & McRobbie (1996) who reported lowest responses for the Equity and Cooperation scales, but, similarly, their highest response was with Task Orientation. Perhaps the low Investigation score in this study is due to differences between the ways in

Table 5.1

Item Means and Standard Deviations for the Two Forms of the Classroom Environment Instrument

Scale	Personal Form		Class Form		Difference
	Item Mean	Standard Deviation	Item Mean	Standard Deviation	
Student Cohesion	3.3	0.6	3.1	0.6	0.2*
Teacher Support	3.3	0.8	3.5	0.8	-0.2**
Involvement/ Negotiation	3.0	0.7	3.5	0.6	-0.5**
Investigation	2.6	0.6	2.6	0.7	0.0
Task Orientation	3.7	0.7	3.4	0.7	0.3**
Cooperation	3.5	0.6	3.3	0.6	0.2**
Equity	3.7	0.8	3.5	0.9	0.2*
Emphasis on Understanding	3.4	0.6	3.6	0.7	-0.2*

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

N = 246 N = 244

which the student samples were constituted. The Fraser, Fisher and McRobbie (1996) student sample included science classes where investigation through practical work may have been more common. Consequently, one explanation for the different scores for Investigation may simply be the differences in the sample of students participating in the studies.

It is also the case that in mathematics, investigation frequently takes the form of problem solving, often at an abstract level, rather than at a practical level. This was confirmed in interviews when students commented that text book exercises, and problem solving exercises, usually consisted of 'made up' problems rather than 'real life' problems.

Students indicated that they investigated very few 'real life' problems. Consequently the scores on either form of the CEI were low for Investigation.

These results are also shown graphically in Figure 5.1 where the graph is based on the item mean scores for each scale. Where the difference is not significantly different, the average of the two scores is used for each graph. The results are presented in line graphs to provide consistency with previous research in learning environments. The line graph has been the traditional way of presenting item mean scores for the scales of learning environment instruments and enables an easy comparison between scales and between the two forms of the instrument.

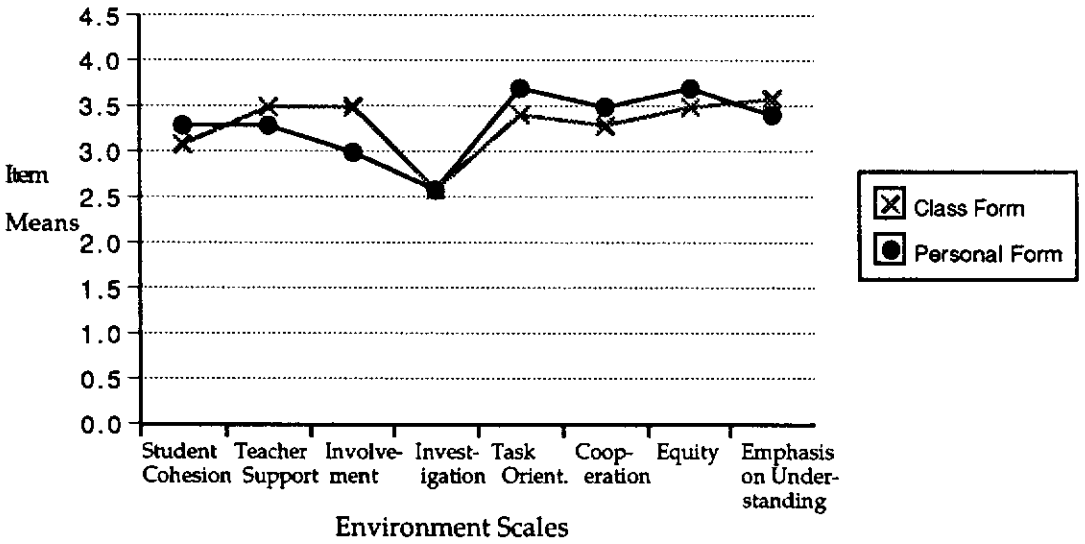


Figure 5.1 Mean individual responses for personal and class forms of the CEI.

Of particular interest in this study is the relationship between the perceptions of students using the Personal form and the perceptions of students who used the Class form. A multivariate analysis of variance (MANOVA) with repeated measures showed that the difference between the Personal and Class form scores for the eight scales was significant (Wilks' lambda < 0.01). Oneway ANOVAs were then used to determine the level of significance of the differences for each scale. Seven of the

eight scales were found to be significant to at least the 0.01 level. This is over 87 times that which would be expected by chance alone. The differences between the item mean scores for each scale using the Personal and Class forms, and their level of significance, are also shown in Table 5.1.

Where the significant differences are positive (Student Cohesion, Task Orientation, Cooperation and Equity), the perceptions using the Personal form are higher than those gained from the use of the Class form. For significant negative differences (Teacher Support, Involvement/ Negotiation and Emphasis on Understanding), the perceptions using the Class form are higher than those from the Personal form.

In each case the direction of the difference replicates the findings of Fraser, Fisher & McRobbie (1996) with their 54 item version of the CEI, with the exception of Cooperation where the difference in their data was minimal (-0.16), and not significant. However, the use of Personal and Class forms of the science laboratory environment instrument (SLEI) showed that in all cases where a significant difference occurred between the two forms, students' perceptions were higher on the Class form (Fraser, Giddings & McRobbie, 1995). This finding is not replicated here.

Differences in student perceptions as measured using the two forms of the CEI could reasonably occur because of the different focus of the questions in each form. For example, in the Student Cohesion scale, questions focus on the extent to which individuals make friends, help each other, or work together. Students report greater levels of cohesion when they answer about themselves and their own level of friendships, than when they answer about the cohesion of their classmates. Lack of cohesion, or divisive behaviour, is attributed to the class rather than to themselves as individuals.

This rationale was supported in interviews with students who frequently commented that the class "mucked around" and although interviewees admitted being dragged in on occasions, they generally saw themselves as

working well most of the time. The causes for a lack of cohesion were usually attributed to other students. This sort of rationale is also consistent with attribution theory (Weiner, 1972, 1986) which suggests that students attribute blame, in this case perceived divisiveness in the classroom, to external factors such as other students in the room. Consequently, students reported perceiving less cohesion in the class, than they themselves experienced as individuals.

Similar student comments and rationale can also be used to help explain the differences noticed in the other scales. For example, students perceived a lower level of Teacher Support for themselves than they did for the class. Students frequently made comments such as,

> He's always helping the kids who struggle.
>
> She wanders around the room helping people who need it.
>
> I don't ask many questions (when the class is working) because the teacher's always busy. I mainly ask my friends and they help me.

Consequently, the Personal form mean item score for Teacher Support was lower than the Class form. Effect sizes in the significantly different scales range from 24% to 58% of one standard deviation. The largest effect was in the Involvement/Negotiation scale where students perceived far more class involvement than personal involvement. For example, individual students perceive that other students answer questions put by the teacher, or their colleagues, more frequently they they do themselves.

The other two scales where perceptions based on the class, rather than the individual, were scored highly by students were Teacher Support and Emphasis on Understanding. In both of these scales students perceived that the teacher placed a greater emphasis on understanding and gave greater support to students other than themselves. The comments cited above possibly provide some of the explanation for these scales too.

As previously outlined, students from five of the classes in this study were interviewed about their responses and their perceptions of their

learning environments. Two of these classes were chosen because they represented classes at the extremes of questionnaire responses. These two classes, as described in Chapter 3, were taught by John and Peter. Their Personal form and Class form profiles are shown in Figures 5.2 and 5.3 below.

Figure 5.2 is the profile of John's class, which had low scores on each of the environment scales. In fact, on the Class form, the class rated itself with the second lowest score on the scales of Student Cohesion, Teacher Support and Emphasis on Understanding, third lowest on Cooperation, fourth lowest on Task Orientation and Equity, and fifth lowest on Involvement. On the Personal form the class was the lowest scoring on two of the scales; Teacher Support and Involvement. They were the second lowest on Task Orientation, fourth lowest on Emphasis on Understanding and fifth lowest on Equity.

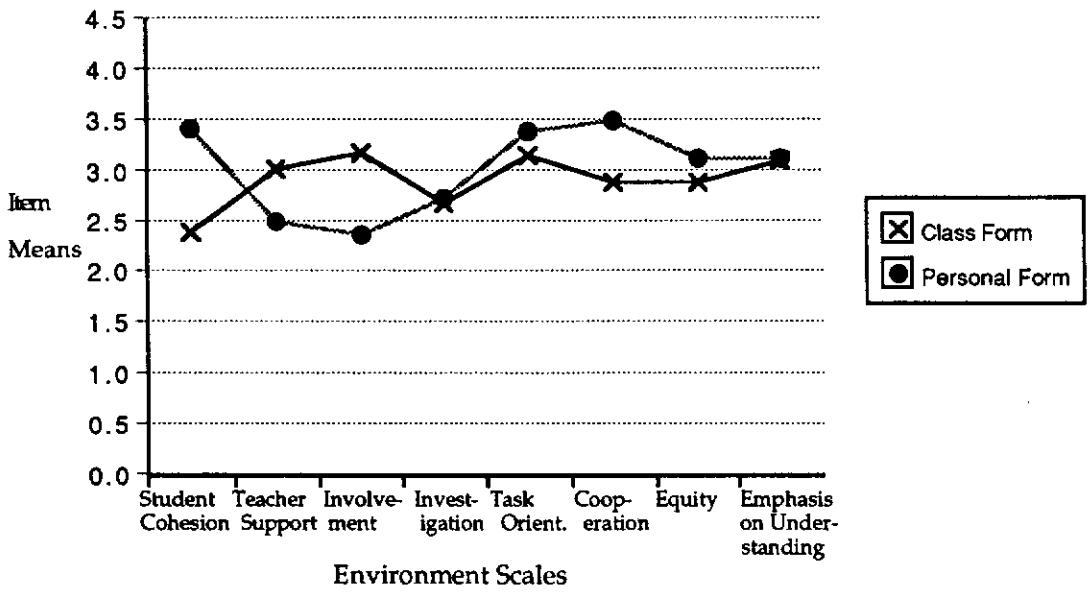


Figure 5.2 Personal and Class form profiles for John's class.

Consequently, students in John's class consistently expressed low perceptions of their classroom environment, as measured on these scales. The difficulties within the classroom learning environment were reinforced, in an incidental way, during the interview with students

from the class. At one stage whilst interviewing these students the researcher queried why they were smiling. They replied that it was because while they had been talking they had just seen the third of their colleagues go past the window on the way to the time out room. This had occurred even though a quarter of the class was absent in a different room with the researcher.

As can be seen in Figure 5.2, there is a large degree of divergence between the Personal and Class forms on some of the scales, particularly the scales which focus on peer or teacher interactions such as Student Cohesion, Teacher Support, Involvement/Negotiation and Cooperation. The direction of the divergence is interesting because students seem to perceive that other students are given more support by the teacher, and are more involved in the class, whereas they see themselves as more cohesive and cooperative. There is less divergence on the learning focus scales such as Investigation, Task Orientation, Equity and Emphasis on Understanding.

For example, on the topic of the amount of cooperation between students, students commented in interview;

> (Do students in the class cooperate well with each other?)
> We don't work as a class. We just work from the book. All the day we just have our books out and, like, figure out the answers...
> (Group work?)
> We don't have any, except we work with the person next to us.

Students perceived that at an individual level they were cohesive and cooperated with the person next to them, and that at the individual level they were task oriented. However, at the class level, they perceived far less cohesive and cooperative behaviour amongst students, and less task oriented activity.

The above comments also highlight the uniformity of work within the classroom. All students worked through the same book and consequently it is not surprising that the Class and Personal form showed the same perceptions on the Investigation scale.

On the other hand, Figure 5.3 portrays the perceptions of Peter's Class, a class of high achieving students. There is little divergence between the perceptions shown on the two forms of the CEI and the overall scores are considerably higher. In fact, on both the Personal form and the Class form, this class rated themselves the highest class on Task Orientation, and their remaining scale scores were also frequently amongst the highest class sores.

For example, on the topic of the class's Task Orientation, students in interview commented that,

> You just go on with your work and you go up and see him. At the start of the lesson he just puts the work on the black board and he explains it if we make mistakes.
> (Do you enjoy maths?)
> Most of us enjoy maths. I know I do, and I just work. Everyone pretty much works at the same pace.

This class constantly gave the impression of an able, confident group of students with a high work ethic.

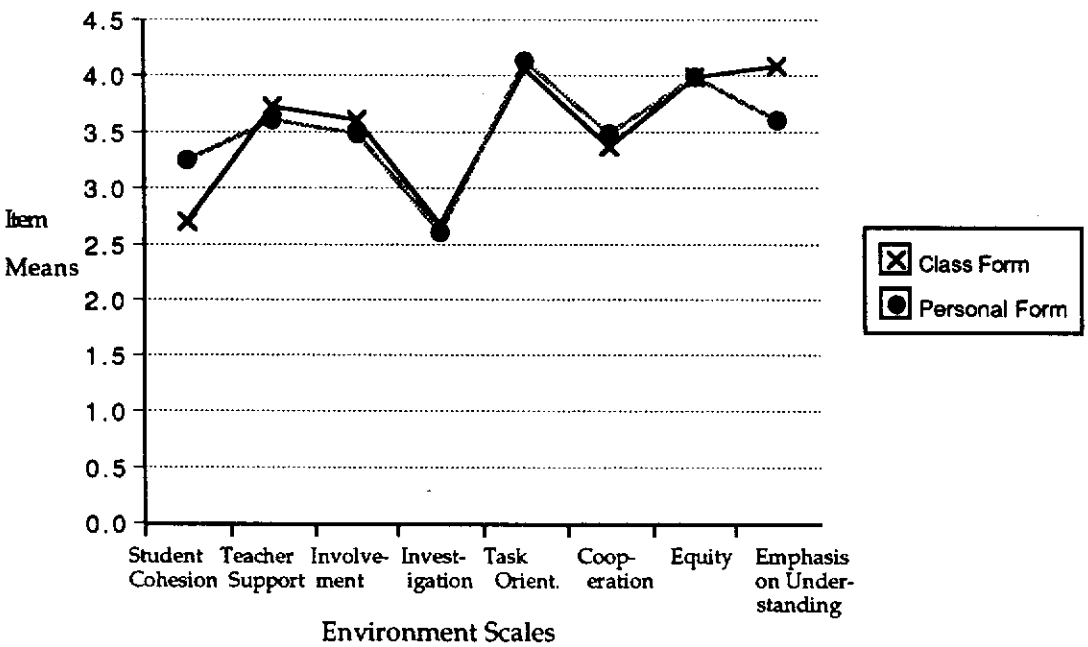


Figure 5.3 Personal and Class form profiles for Peter's class.

Another way of profiling classes using the classroom environment instrument is to compare them with each other. Figure 5.4 shows the comparisons of these two classes, firstly using the Personal form and then using the Class form.

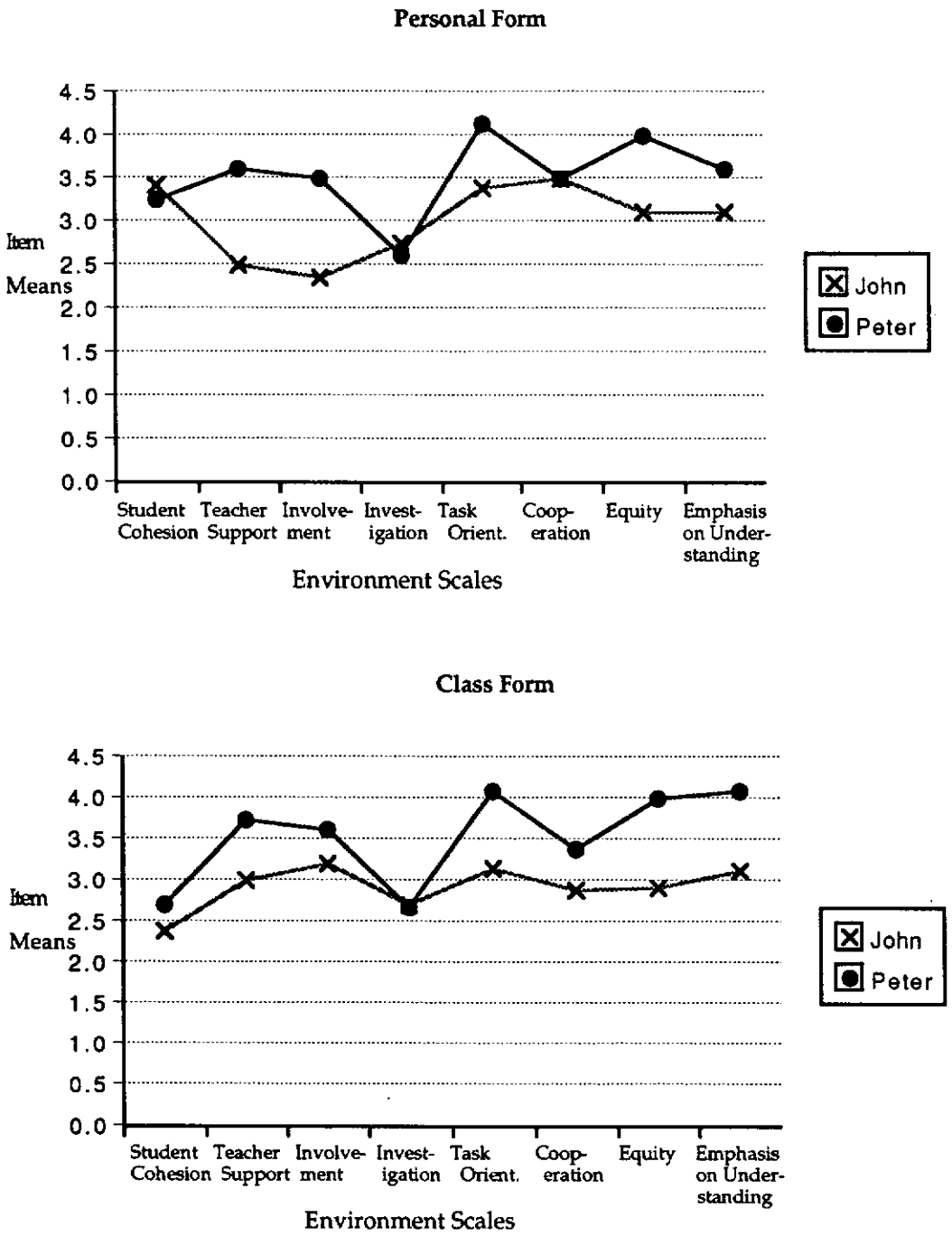


Figure 5.4 Comparison of John's and Peter's class profiles using the Personal and Class forms of the CEI.

In each of these two graphs, John's class viewed the learning environment less positively than did Peter's class on each of the scales where there was a difference. These pictures of the two classes were supported in the qualitative data which was collected.

Student's comments do not, of course, relate only to one scale. However, inferences about the scales can be drawn from their comments. In interviews, students in John's class lamented the predictability of the lessons, the uncertain moods of the teacher, the insufficient teacher support and the unequal treatment of students.

In their comments, students were critical of the level of their teacher's support and his emphasis on understanding in the classroom. They found it frustrating that John explained work so quickly without following up to see if they understood.

> He puts a sum on the board that we can't do. He rushes through it. He starts and doesn't stop. He rushes through it. He just tells us the answer. He doesn't tell us how to get it.
>
> He sees you can't do a sum, then explains it and says, 'alright', and then walks off.

They also had a low perception of their involvement in the learning in the classroom.

> It's really boring and you always have to do the same thing. It's just like, every time, we just do work out of the book, and just have to sit there and do it. We don't get activities and stuff like that.

The issue of equity caused much animated discussion too. Students were very concerned about the unequal treatment of some students within the room.

> Like in class, there's a boy named Joe who just walked past (on his way to the 'time out' room). There's a few boys who can joke with the teacher and, like, he doesn't mind. But if someone else jokes, that he gets annoyed with, like Joe, he jumps down their throat...He lets Sam get away with it but he just yells at Joe...He could be joking

one minute, then if someone else does something, he'll just go schitz.

These comments support the classroom environment instrument's findings that the class's perceptions were relatively low on most scales.

The contrast is quite marked when students' comments for Peter's class are considered alongside those from John's class. Peter's class saw their teacher as supportive, equitable, and with an emphasis on understanding in the classroom. They saw themselves as involved in their learning, very task oriented, cooperative and cohesive.

With regard to the teacher's support and the emphasis on understanding in the classroom, students commented;

> He doesn't push us too hard but he wants us to work to the best of our abilities.
>
> When someone goes really bad in a test he gets them to come out the front and he talks to them about it...just quietly.
>
> We just have to walk up the front and he'll explain something to us. If it's something really difficult he'll explain it to the whole class.
>
> If a couple of people go up and ask him the same question, he'll do it on the board.

Students also commented that he frequently took them beyond the usual work, which also kept them interested.

> Some of the time he just gets up there and does really pointless things, tells stories and stuff. He tells stuff that aren't even relevant to the chapter or the work you're doing...He's way more advanced than we are. He says stuff like, he said that these Martians landed, and the orbits of the planets, and the radius and stuff. It's impossible to work out. He gets off the track.
> (Would you prefer that he didn't?)
> No he makes it really funny.
> (What's he wanting you to learn from that?)
> What we learn in separate chapters, to put them all together, problem solving, working through the steps.

Through these discussion students were able to communicate a warmth and respect for their teacher, and for each other, which was lacking in the interviews with students from John's class. There was also a mutual trust and respect evident.

It is interesting to note, in the comments above, that whilst students recognised their teacher's desire for them to tackle problem solving activities, they did not see this as investigative work. Rather, they viewed problem solving exercises as made up problems designed to teach them to think, rather than real problems to be investigated. They also indicated that the whole class worked through the same problems. This helps explain the low score for Investigation shown by Peter's class on both the Personal and Class forms of the CEI.

The researcher's journal notes, which were written after each set of interviews, also highlight the differences between the two classroom environments. These differences were quite evident in the manner in which the interviews were set up by each teacher in the appointed lesson. In John's case the researcher noted,

> When I arrived I was shown to his class; students were silent and doing a test, which I later found out that they had not been told about. He knew students were coming to see me. Was it just a discipline measure to keep them quiet? He asked who I wanted to see and them called them out to the corridor one at a time. The students were not introduced to me or told the purpose of my visit. I was told by John where to take the boys to talk with them.
> ... I gained the impression of a teacher (late 20s) who was strict, autocratic, but perceived that he was doing a good job. He was confident and didn't have any hesitations about allowing me access to his students. I felt sorry for him because his students do not see him in the same way. They see him as admonishing and not a very effective teacher. When he was talking to me at the door of his room he was nervously watching his class and appeared not to trust them.

Peter, on the other hand, delegated responsibility to students.

> I was taken to Peter's class before the students arrived. Peter chatted to me outside the room. Students went in with friendly, quiet

chatter. They were relaxed and not boisterous.
2 boys and 2 girls, 1 in each case who liked maths and 1 who wasn't too keen, were interviewed. Peter introduced us and sent us off with instructions to a student to find an unused room. The instruction was confidently given and accepted. The students were happy to talk.

Peter exhibited behaviour which showed trust in his students. He was polite and explained what would happen, and asked if they would be happy to be interviewed. John told the students to go with the researcher without introducing them, asking if they would mind, or even telling them what would happen. The researcher was left to do these things.

Together, these student comments and the journal notes replicate and, consequently, confirm the picture painted by both the Personal form and the Class form of the CEI about each mathematics classroom environment. Peter's class saw their teacher as more equitable, more supportive, more task oriented and more understanding than did John's students. They also saw themselves as a more cooperative group, with the Personal form and Class form being far less divergent on this scale than in John's class.
These profiles can be used in a number of ways. They can be the basis for intervention by the teacher, in an attempt to improve the classroom learning environment. Similar uses have been cited in the literature review for the Actual and Ideal forms of instruments.

Teachers can use the comparisons, either within class comparisons of the Personal and Class form perceptions or the interclass comparisons, as a basis for decisions about altering the classroom environment. This could be done alone by the teacher, or the comparisons could be explained to students and their help sought.

Following attempts to alter the environment, the two forms of the CEI could be used again to profile any changes. Further research needs to be carried out in this area. It may be, for example, that attempts to improve Student Cohesion within a class will lead to less Task Orientation, or that

Task Orientation may be achieved at the expense of investigative work, or cooperative teaching.

Gender Differences in Perceptions Using the Personal and Class Forms of the CEI

Part of the focus of this study is to investigate the suitability of the Personal form and the Class form of the CEI in examining sub-populations of students. The sub-population of male and female students was chosen because it has been suggested (Fraser, Giddings & McRobbie, 1995; Giddings & Fraser, 1990; Lawrenz, 1987) that male and female students have different perceptions of the classroom environment. The research suggests that female students tend to view the classroom environment more positively than do male students.

The sample for this study consisted of students in single-sex classes as well as students in coeducational classes. Consequently, to avoid inconsistencies within the sample, data representing students from single-sex classes were deleted from this analysis. A multivariate analysis of variance (MANOVA) with repeated measures was used to explore the difference between the perceptions of male and female students in this study. A significant difference was found to exist (Wilks' lambda < 0.01) between the perceptions of male and female students in coeducational classes on the eight scales. Oneway ANOVAs were then used to determine the level of significance of the differences for each scale.

There were significant differences between male and female students' perceptions of their mathematics classroom environment ($p < 0.05$) on four of the scales on the Personal form and five of the scales on the Class form of the CEI. Three scales with significant differences were common to both forms. These were the scales of Student Cohesion, Teacher Support and Cooperation. In addition to these common significant gender differences the Personal form indicated significant gender differences on the Equity scale, whilst the Class form portrayed significant

gender differences on the Involvement/Negotiation Scale and the Emphasis on Understanding Scale. The effect size for these differences ranged from about 0.4 to 1 standard deviation and for each scale the effect was always in the same direction. Female students perceived significantly more of the behaviour represented by these scales than did male students, replicating the findings in the research cited above. These results are shown in table form in Table 5.2 and graphically in Figure 5.5 (where non-significant differences are shown by assigning the average of the two scores to the graph).

Table 5.2
Item Means and Standard Deviations for Male and Female Students Using Personal and Class Forms of the CEI

Scale	Statistic	Personal Form			Class Form		
		Males	Females	Diff.	Males	Females	Diff.
Student Cohesion	Mean	3.19	3.49	-0.30***	2.98	3.30	-0.31***
	St. Dev.	0.55	0.51		0.49	0.55	
Teacher Support	Mean	3.05	3.39	-0.34*	3.43	3.68	-0.26*
	St. Dev.	0.88	0.80		0.85	0.68	
Involvement/ Negotiation	Mean	2.96	3.05	-0.10	3.37	3.61	-0.24*
	St. Dev.	0.71	0.68		0.66	0.56	
Investigation/	Mean	2.34	2.17	0.17	2.32	2.40	-0.08
	St. Dev.	0.79	0.77		0.75	0.85	
Task Orientation	Mean	3.71	3.77	-0.06	3.23	3.46	-0.23
	St. Dev.	0.73	0.80		0.83	0.70	
Cooperation	Mean	3.34	3.88	-0.54***	3.26	3.69	-0.44***
	St. Dev.	0.67	0.49		0.57	0.61	
Equity	Mean	3.40	3.79	-0.39**	3.44	3.66	-0.22
	St. Dev.	0.86	0.96		0.91	0.88	
Emphasis on Understanding	Mean	3.48	3.56	-0.08	3.55	3.87	-0.32*
	St. Dev.	0.58	0.61		0.90	0.65	
		N = 69	N = 72		N = 76	N = 76	

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

The scales in which the two forms of the CEI both measured significant differences were the Student Cohesion, Teacher Support and the Cooperation scales. These scales focus on relationships, particularly with students' peers and with their teachers. In each case, female students perceived a more positive relationship than did male students. This means that female and male students perceive significant differences in the relationships in their mathematics classrooms both when they consider their personal sense of cohesion, teacher support and their cooperation with other students, and when they consider the level of cohesion, teacher support and cooperation in the class as a whole.

On the other hand, a significant difference in the level of Equity in the classroom only occurs when students consider their personal interaction rather than the equity in the class as a whole. Male students perceive that they are treated less fairly than do female students. Both male and female students perceive a similar level of Equity (or Inequity) in the class when the class, rather than the student, is the focus.

The reverse is true for the scales of Involvement/Negotiation and Emphasis on Understanding. A significant difference between male and female perceptions is only detected when students consider the class rather than themselves. In each case, once again, female students perceive that the class is involved more actively, and that there is a greater emphasis on understanding work, than do their male colleagues.

Male and female students both consider that they approach their academic work with the same task orientation and the same level of investigation, whether the measurement of the Personal or Class form is used. Consequently, it can be seen that differences occur primarily in the scales which examine relationships between people in the classroom.

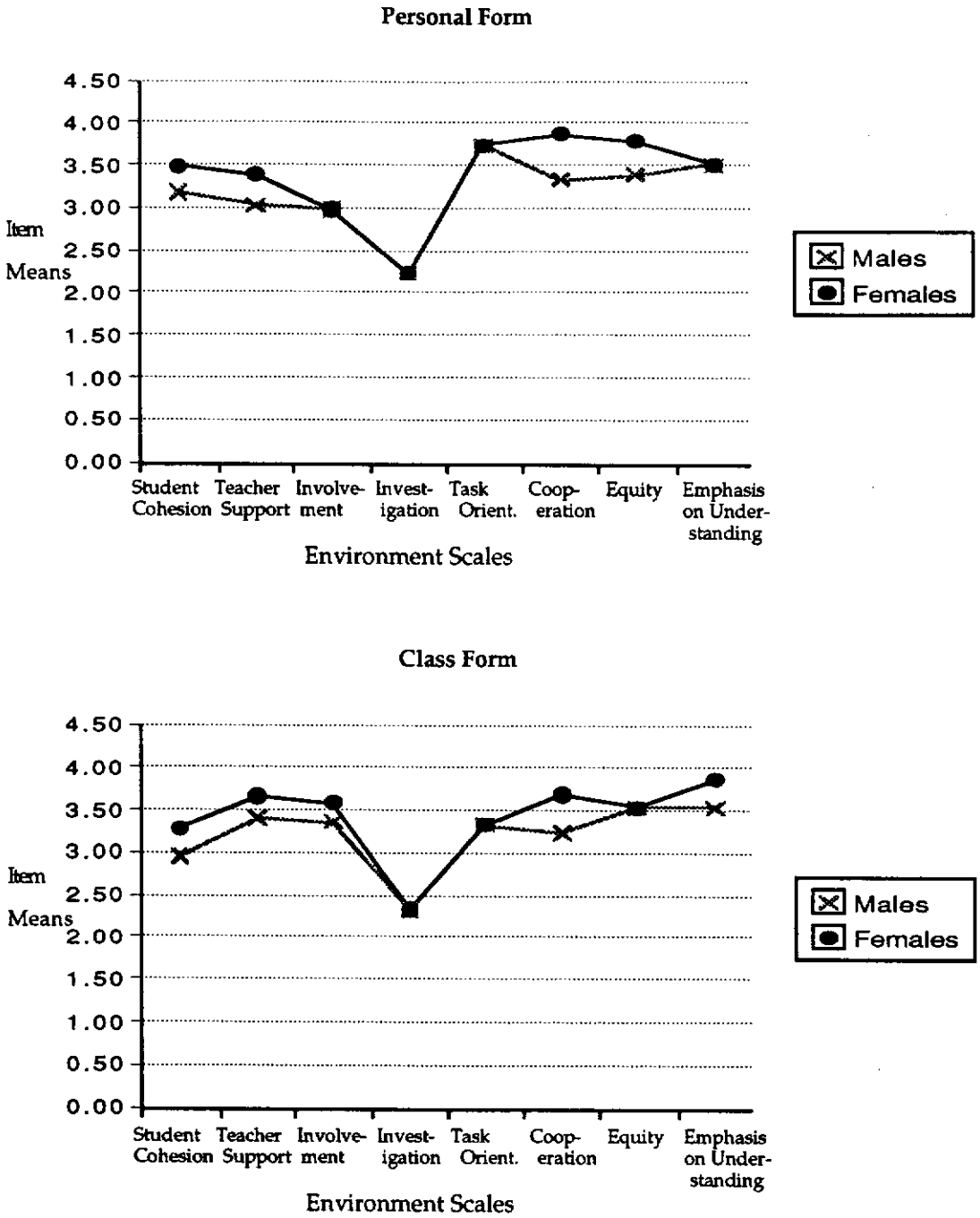


Figure 5.5 Male and female perceptions of their mathematics environment using the Personal and Class forms of the CEI.

This was reflected in the interview with students in Peter's class. Even though it was a class of positive, capable students who enjoyed their mathematics, they perceived differences in the way in which Peter related

to male and female students. This is illustrated in the transcript below where students were discussing the strictness of their teacher.

Female	He doesn't let us talk at all. He says, when we talk he says, "Get back to work. Get down to it." And he says, "Who wants to go to detention?"
Researcher	How often does he send someone to a detention?
Male	He never sends the girls.
Female	He's probably sent about three people this year.
Male	He never sends the girls though.
Female	He just threatens (to send people to detention)
Researcher	Does he treat everyone the same?
Male	Nup. (Laughter) I don't reckon he does because the girls are always the ones who are talking but the guys are always the ones who get told off.
Male	Yep.
Researcher	That's interesting because the questions in here (the survey results) show that in comparison to other schools he treats people far more equally than in other schools. I felt that that was what your class was saying; "All students are treated the same in this class". (Moderate agreement)
Male	He favours the girls a bit. When they talk, For example, yesterday Joanne and Debby talked for the whole lesson. Then at the end of the lesson he says, "You two can go to detention". Then he said, "Do you think I'm joking?" They said, "I don't know". Then he said, "Well I was" and lets them off for nothing.
Female laughter	We were only talking though.
Male	Yes but if it was us though - a week's detention.

While the male student knew that he was overstating the last line, he also perceived a marked difference in the relationship between Peter and female students, and Peter's relationship with male students.

Fraser & Tobin (1991) argued that the development of a Personal form would enhance the profiling of sub-populations within the classroom environment. It is evident in this study that when the Personal form was used, significant differences were detected on four of the eight scales whilst five of the eight scales on the Class form detected significant differences. Rather than argue that the Class form is more sensitive to

differences in the sub-population, it is probably more reasonable to argue that the two forms highlight different aspects of students' perceptions. These depend upon whether the individual's or the class's relationship with the classroom environment is considered. The fact that male and female students see some aspects of the environment similarly is also important.

The direction of the difference on the Cooperation scale is at odds with research by Terwel et. al. (1994). They found when they used the QTI that the number of boys in the class correlated with mean student perceptions of the level of cooperation in the classroom. They found that as the number of boys in the class increased, so did the student's perceptions of cooperation.

However, a study by Steinbeck and Gwizdala (1995) found that the introduction of boys to a classroom lead to girls perceiving increased competition, feelings of intimidation, and feelings of embarrassment if they did poorly.

The findings shown in Table 5.2 indicate that female students perceived significantly more cooperation in the classroom than did male students. (Further analysis shows that single-sex female classes perceived the most cooperation and single-sex male classes, the least cooperation.)

It is not the place of this study to address the reasons for these differences. The CEI has not been used to profile classes by gender before and these graphs are illustrative of the way in which sub-populations of the sample can be profiled. (These results will be addressed again later in this chapter when examining the results obtained using the QTI to profile the population by gender.)

Summary of Class Profiles Using the CEI

The qualitative data presented in the previous sections of this chapter have supported the class profiles as described by the CEI, further validating the instrument and explaining some of the differences in perceptions found using the Personal and Class forms. Significant differences between the two forms of the CEI were found to exist and the direction of the differences replicated earlier findings with a similar form of the CEI (Fraser, Fisher & McRobbie, 1996). Differences between the Personal and Class forms were more pronounced in John's class which consisted of weaker students, than in Peter's class of more able students. The sub-populations of male and female students were also profiled. Four scales detected significant differences on the Personal form whilst five scales detected significant differences on the Class form.

The two forms of the CEI appear to fulfil a useful role in profiling different classrooms. Teachers using this instrument could address the different perceptions revealed by the Personal form and the Class form. Alternatively they could make comparisons with the perceptions of students in another class, particularly if the other class was taught by someone whom they respected as an effective teacher.

Class Profiles Using the Questionnaire on Teacher Interaction (QTI)

Teacher student interpersonal behaviour in the classroom can be profiled using the QTI in a similar fashion to that of the CEI. However, the resulting profile is circumplex in nature. This is because strong positive correlations exist between adjacent scales and strong negative correlations exist between opposite scales. In the QTI, students are indicating their perceptions of the teacher-student interpersonal relationship in the classroom. Consequently, it measures aspects of the relationship dimension (Moos,1974; Trickett & Moos, 1973) rather than all three dimensions of the classroom environment.

Each scale of the QTI consists of 6 items, each of which is rated by students on a scale of 0 to 4. Table 5.3 indicates the item mean score and the standard deviation for each scale.

Table 5.3
Item Means and Standard Deviations for the QTI

Scale	Item Mean	Standard Deviation
Leadership (DC)	2.6	0.8
Helping/Friendly (CD)	2.6	0.9
Understanding (CS)	2.8	0.9
Student Responsibility/ Freedom (SC)	1.6	0.7
Uncertain (SO)	1.0	0.8
Dissatisfied (OS)	1.1	0.9
Admonishing (OD)	1.7	0.7
Strict (DO)	1.9	0.7

N = 490

This table indicates that students perceived relatively more leadership, helping friendly and understanding behaviour than other types of behaviour. They perceived a moderate amount of admonishing and strict behaviour and behaviour which gives students responsibility and freedom. The behaviours which they perceived least were uncertain and dissatisfied behaviours.

These data are shown graphically in Figure 5.6 and represent the data in the circumplex nature of the model where the relationship between the scales and the Influence and Proximity dimensions can be easily grasped.

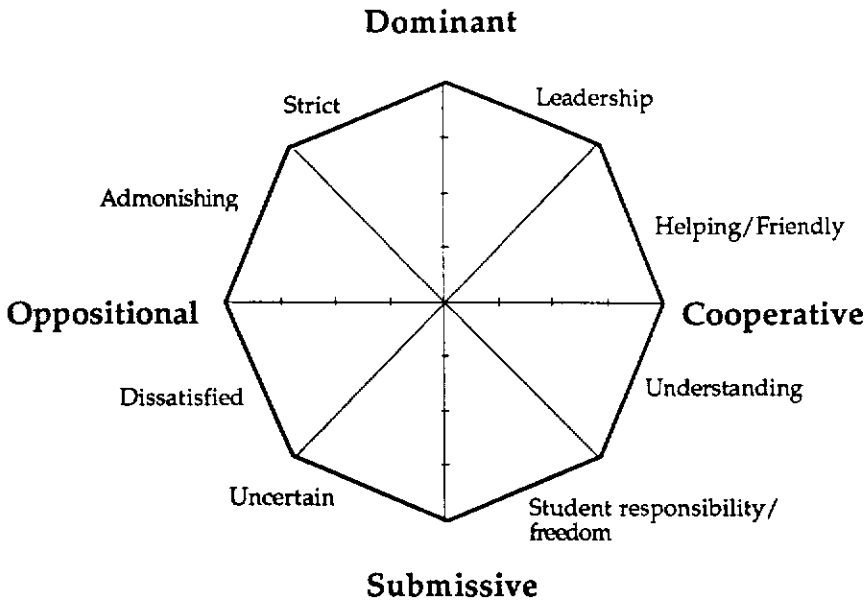


Figure 5.6 Mean QTI responses of 490 grade 9 mathematics students in 23 classes.

The overall pattern of this profile is consistent with the published research involving other Australian students (Henderson, 1996; Fisher, Fraser, Wubbels & Brekelmans, 1993). However, there are some differences of emphasis. The study by Henderson involved 489 students in 28 grade 12 biology classrooms. The study by Fisher, Fraser, Wubbels & Brekelmans (1993) examined the classrooms of 46 teachers, involving 792 students in 7 schools. Unlike these other Australian studies, this study focusses purely on mathematics classrooms at grade 9 level.

Table 5.4 shows a comparison of the results from the two published Australian studies which have used the QTI, and the results from this study. The above studies reported their findings of the item mean score for each scale as a decimal score between zero and one, rather than as a score on a scale of one to five. Consequently, for ease of direct comparison, item mean scores from this study have been converted to a decimal consistent with the published results in the other studies.

It can be seen from the table that students in this study perceived less cooperative behaviour and less dominant behaviour than students in the

other two studies. They reported the lowest level of Leadership, Helping/Friendly and Understanding behaviour of the three studies, and the highest level of Admonishing behaviour.

Table 5.4
A Comparison of Three Australian Studies Using the QTI, Showing Item Mean Scores for Each Scale

Scale	Item Mean Scores for Each Scale		
	Fisher, Fraser, Wubbels & Brekelmans	Henderson	This Study
Leadership	0.70	0.77	0.62
Helping/Friendly	0.75	0.83	0.63
Understanding	0.73	0.82	0.66
St. Resp./Freedom	0.35	0.50	0.38
Uncertain	0.20	0.33	0.24
Dissatisfied	0.21	0.35	0.27
Admonishing	0.23	0.35	0.40
Strict	0.45	0.60	0.46
	N = 792	N = 489	N = 490

In the Proximity dimension it can be seen that the grade 9 mathematics students in this study perceived less cooperative behaviour; i.e. less Helping/Friendly, Understanding behaviour, and more oppositional behaviour, particularly in the Admonishing sector. On the Influence dimension, they perceived less Dominant behaviour; i.e. only a small amount of Strict behaviour but considerably less Leadership and Helping Friendly behaviour.

This profile aligns most closely with the profiles of the 'Authoritative Teacher' and the 'Directive Teacher' in the typology of teacher interpersonal behaviour reviewed in Chapter 2 (Figure 2.3, page 44). The 'Cooperative' half of the profile shows the authoritative profile. However, the 'Oppositional' half shows higher levels of Strict, Admonishing, Dissatisfied and Uncertain behaviours, which reflect more characteristics of the directive teacher than the authoritative teacher.

Wubbels, Brekelmans & Hooymayers (1991) commented that in the authoritative classroom,

> The lessons of this type of teacher are well structured and the atmosphere is pleasant, but also achievement- and task-oriented. Rules are clear in these lessons and now and then the teacher reminds students of these rules. Students pay good attention and the number of times that the teacher has to correct students' behaviour is lower than with the directive teacher...The favourite teaching method of these teachers is lecturing, but the teacher uses other methods as well. (p. 149)

The profile of mathematics teachers shows a slightly higher level of oppositional behaviour than the authoritative profile represents, and is more like that of the Directive teacher who,

> is sometimes rather admonishing and tries to keep the reins tight. He or she has high standards for student achievement, is rather demanding, and can hold students' attention. Order and smoothness of procedures are not automatically present. The teacher has to correct students' behaviour every now and then and has to insist on rules and procedures. Students follow these teacher interventions. (p. 148)

Consequently, 'Authoritative' and 'Directive' interpersonal behaviours are reflected in the profile of the Australian grade 9 mathematics teachers more than other interpersonal behaviours from the typology.

Levy, Creton & Wubbels (1993) found in an American study that mathematics teachers were perceived to be the most dominant teachers. This finding was not replicated here. The findings for these mathematics classes place them as slightly less dominant in the cooperative sectors but similarly dominant in the Strict scale and the highest of any of the groups in the Admonishing scale. Whilst the Admonishing scale reflects oppositional behaviour, its second component is that of dominance.

One possible explanation for the evident differences, when this data is compared with the previously reported Australian uses of the QTI, lies in the nature of the samples involved. The sample of teachers and classes

involved in this study was a cross section of class and teacher abilities. When the classes were first identified, a range of class types was sought. A number of mathematics coordinators indicated to the researcher that they were complying with the request not to just ask the most effective teachers in their schools to participate in the study, but to ask a range of teachers.

On the other hand the teachers who participated in the Fraser, Fisher, Wubbels and Brekelmans study selected their own classes for the study. In selecting their own classes many teachers may have selected classes with whom they felt that they had a healthy rapport. It may be that the nature of this sample was more of a volunteer group and therefore the results suggested more positive teacher student interactions. Levy, Creton and Wubbels (1993) noted that from their research, "Volunteer teachers show slightly more Leadership, Helpful/Friendly and Understanding behaviour than the teachers in the random sample and they are perceived by their students as less admonishing" (p. 31). These comments summarise to a large extent the differences found between the research data which is the focus of this study and the data from the Fisher, Fraser, Wubbels & Brekelmans study.

A second possible explanation for the differences may lie in the nature of mathematics teaching. It may be a function of mathematics classes that teachers more frequently exhibit oppositional behaviour. Mathematics offers less points of departure or scope for individuals in the classroom, it is a compulsory subject at grade 9 and, as mentioned in Chapter 3, it is frequently linear and hierarchical in nature in the sense that each year relies upon, and builds upon, the knowledge gained in previous years. This may lead, in practice, to tighter control or direction by the teacher which students perceive as oppositional. However, the higher perceptions of student responsibility in the mathematics classes cast an element of doubt on this explanation.

A third possible explanation is that the differences are a function of the grade 9 nature of the sample group. Grade 9 students are frequently

questioning, developing their identity and their friendships, and testing the boundaries of behaviour. Often they have not found the academic or vocational focus which senior grades provide and the novelty of grade 8, the first grade of secondary schooling in South Australia, has been left behind.

Students in these grade 9 mathematics classes clearly see less cooperative behaviour and more admonishing behaviour by their teachers than do students in the other two research studies. This may have implications for teachers of mathematics and further use of the QTI in Australian mathematics classrooms would be helpful in drawing the larger picture.

Gender Differences in Perceptions Using the QTI

As with the CEI it is possible to profile sub-populations of the sample. A multivariate analysis of variance (MANOVA) with repeated measures showed that the difference between the male and female perceptions of teacher-student interpersonal behaviour for the eight scales was significant (Wilks' lambda < 0.01). Oneway ANOVAs revealed that there were significant differences on six of the instrument's eight scales to at least the 0.05 level, which is 15 times greater than that which chance alone would suggest. Male students perceived more Uncertain, Dissatisfied, Admonishing and Strict behaviour than did female students. Female students, however, perceived more Helping/Friendly and Understanding behaviour than did their male colleagues. Whilst the effect size of these differences is small, ranging from about one quarter to one half of a standard deviation, the direction of the effect is consistent in each of the significant scales and shows a significant male student perception of more oppositional and less cooperative behaviour. The results are shown in Table 5.5.

There are obvious similarities between the scales of the QTI and those of the CEI in which significant gender differences were found to exist. In the CEI, female students, using either the Personal form or the Class form,

perceived a greater degree of Student Cohesion, Teacher Support and Cooperation in the classroom. Similarly in the QTI, female students perceived significantly less oppositional behaviour from their teacher in the Uncertain, Dissatisfied, Admonishing and Strict scales and significantly more cooperative behaviour in the Helping/Friendly and Understanding scales.

Table 5.5
Item Means and Standard Deviations for Male and Female Students Using the QTI

Scale		Males	Females	Difference
Leadership (DC)	Item Mean	2.52	2.68	-0.16
	St. Dev.	0.87	0.75	
Helping/ Friendly (CD)	Item Mean	2.54	2.82	-0.28**
	St. Dev.	0.97	0.88	
Understanding (CS)	Item Mean	2.57	2.96	-0.38***
	St. Dev.	0.96	0.83	
Student Resp./ Freedom (SC)	Item Mean	1.66	1.66	0.00
	St. Dev.	0.65	0.67	
Uncertain (SO)	Item Mean	1.09	0.84	0.26**
	St. Dev.	0.86	0.71	
Dissatisfied (OS)	Item Mean	1.38	0.98	0.39***
	St. Dev.	0.94	0.82	
Admonishing (OD)	Item Mean	1.74	1.56	0.18*
	St. Dev.	0.75	0.71	
Strict (DO)	Item Mean	2.02	1.79	0.23**
	St. Dev.	0.71	0.67	
*$p < 0.05$		N = 145	N = 155	
**$p < 0.01$				
***$p < 0.001$				

Conversely boys perceived significantly more oppositional behaviour and less cooperative behaviour in these scales. This again confirms earlier findings (Fraser, Giddings & McRobbie, 1995; Giddings & Fraser,

1990; Lawrenz, 1987) that female students view the classroom environment more favourably than do male students.

The QTI profiles of teacher-student interpersonal behaviour as perceived by male and female students therefore supports the profiles formed by each of the forms of the CEI. As such it further confirms the CEI as a valid instrument in the profiling of classroom environments.

Summary

The qualitative data presented in this chapter support the profiles of the classrooms in this research as identified by the CEI and the QTI. This was particularly evident in the example profiles of John's and Peter's classrooms. The congruence of the qualitative data and the quantitative data adds weight to the authentification of the instruments described in Chapter 4.

Differences between the Personal and Class forms of the CEI were presented. Personal form responses were higher on the scales of Student Cohesion, Investigation, Task Orientation and Equity and lower on the scales of Teacher Support, Involvement/Negotiation and Emphasis on Understanding. All of these differences between the Personal and Class forms were significant except for the differences in the Investigation scale. The direction of these differences replicates the findings of the only other reported use of Personal and Class forms of the CEI (Fraser, Fisher & McRobbie, 1996). However, a study involving a Personal form and a Class form of the Science Laboratory Environment Instrument reported only differences where the Class form was higher (Fraser, Giddings & McRobbie, 1995).

The Personal and Class forms were also used to portray the sub-populations of male and female students. It has been suggested by Fraser & Tobin (1991) that the Personal form would be particularly useful in profiling sub-populations because it reflected the perceptions of student's

personal interaction with the learning environment rather than their perceptions of the class's interactions. Both forms detected significant gender differences on three of the scales (Student Cohesion, Teacher Support and Cooperation). The Personal form detected a significant difference on one other scale (Equity) whilst the Class form detected significant differences on two additional scales (Involvement/ Negotiation and Emphasis on Understanding). The direction of these differences, that female students view their classroom environments more positively, replicates previous research. This finding was also supported in the analysis of QTI responses when these were considered according to the sex of the respondent.

This chapter also profiled the interpersonal behaviour of teachers in mathematics classrooms in the first reported use of the QTI with a large sample of mathematics classes. The teachers in these classrooms were perceived to be more oppositional, and to offer less Leadership, Helping/Friendly and Understanding behaviour, than teachers in the two other reported Australian studies using the QTI.

Consequently, this chapter has extended the validation of the instruments in Chapter 4 by the inclusion of the qualitative data. The profiles of classrooms using data gained with the CEI and the QTI were supported, and to some extent explained, by the qualitative data. Differences between the Personal and Class forms of the CEI were identified and examples of profiles of gender sub-populations from coeducational classrooms were given.

Chapter 6 extends this further by addressing associations between students' perceptions of their classroom environments and student outcomes as measured by the attitudinal and cognitive tests.

CHAPTER 6

ASSOCIATIONS BETWEEN THE CEI, THE QTI, AND STUDENT OUTCOMES

Introduction

The previous chapters have demonstrated the reliability and validity of the two environment measures used in this research, and have described the profiles of the mathematics classrooms. This chapter focusses on associations between student perceptions of their classroom learning environment and students' attitudinal and cognitive outcomes.

The two student outcomes considered here are the attitudinal outcome, as measured with the scale detailed in Chapter 4, and the cognitive outcome for each student determined by the use of two tests of grade 9 work given during the year. This test was discussed in Chapter 3.

The QTI and the CEI have not previously been used together. Consequently, a section of this chapter also addresses associations between the findings of each instrument. It will focus on what is unique and what is common between the QTI and each form of the CEI in explaining the variance in student outcomes. It will also address the associations between the scales of the two instruments. Thus, this chapter consists of two main sections. The first will address associations between student perceptions of their classroom environment, both with data from the CEI and the QTI, and student outcomes. The second will determine associations between the QTI and the Personal and Class forms of the CEI.

Associations Between Student Perceptions of the Classroom Environment, Using the CEI, and Student Outcomes

One of the uses of classroom environment instruments reviewed in Chapter 2 was as independent variables. This study addresses associations between the mathematics classroom environment and the dependent variables of attitudinal and cognitive outcomes. Associations are measured between the perceptions of students about aspects of their mathematics classroom learning environment, and their attitudes towards the mathematics class and their cognitive outcomes in their understanding of their mathematics.

Both forms of the CEI are addressed in this analysis because they have differing predictive values in terms of student outcomes. As has already been shown in Chapter 5, there are significant differences between the two forms on some of the scales. The results of this analysis were indicated in Table 5.1.

Attitudinal Outcomes

Associations between the Personal form and the Class form of the CEI, and students outcomes are shown in Table 6.1. Simple correlations were used to measure the strength of the associations between each of the scales and each of the outcomes. On the Personal form 6 of the 8 scales were significantly related to students attitudes towards their mathematics ($p < 0.001$) and a seventh scale was significant at the 0.05 level. This is more than 15 times the amount which would be expected by chance alone at the 0.05 level of significance. All of the scales on the Class form were significant to at least the 0.01 level in their correlation with student attitudes which is 100 times that which chance alone would yield.

Table 6.1

Associations Between Classroom Environment Scales and Students' Attitudinal and Cognitive Outcomes in Terms of Simple Correlation (r) and Standardised Regression Coefficient (β)

Scale	Strength of Environment - Outcome Association							
	Attitude to Class				Cognitive Achievement			
	Personal Form		Class Form		Personal Form		Class Form	
	r	β	r	β	r	β	r	β
Student Cohesion	0.09	0.03	0.28***	0.20**	-0.05	-0.19	0.11	0.15
Teacher Support	0.39***	0.11	0.35***	0.00	-0.10	-0.11	-0.10	-0.33*
Involvement /Negotiation	0.28***	-0.06	0.35***	0.11	0.00	0.03	0.04	0.14
Investigation	0.32***	0.17**	0.37***	0.18**	-0.02	-0.04	-0.15	-0.30**
Task Orientation	0.47***	0.31***	0.38***	0.17*	-0.01	0.02	0.05	0.03
Cooperation	0.12*	-0.06	0.18**	-0.17*	0.09	0.26	0.13	0.05
Equity	0.31***	0.07	0.34***	0.18*	-0.04	-0.07	-0.08	-0.04
Emphasis on Understanding	0.38***	0.12	0.34***	0.05	-0.01	0.00	0.13	0.31*
Multiple Correlation, R		0.54***		0.52***		0.22		0.39*
Variance , R^2		0.29		0.27		0.05		0.16
	N = 246		N = 244		N = 102		N = 105	

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

Using the more conservative standardised regression coefficient (β) which measures the association when the effect of the other scales is held constant, two regression coefficients were found to be significant ($p < 0.01$) on the Personal form, which is 25 times greater than the significance suggested by chance alone. These significant correlations were in the scales of Task Orientation and Investigation. These two scales were also found to be significant ($p < 0.05$) when the Class form was used. Other significant scales on the Class form were the scales of Student Cohesion,

Cooperation and Equity. The Cooperation scale was negatively correlated. The correlations using the class form were over 12 times higher than by chance alone.

The multiple correlation R is significant for both forms of the instrument and shows that when the scales are considered together there is a significant ($p < 0.001$) association with the attitudinal outcome. 27% to 29% of the variance in student attitudes is explained by the scales in these two forms of the instrument.

Consequently, in classes where students perceive that they have a high level of cohesion, that they frequently use investigative methods, that they are on task, that the class operates equitably and that there is a low level of cooperation, students show a more positive attitude towards their mathematics.

The negative correlation between student perceptions of the level of cooperation and their attitudes towards mathematics bears further comment. A study by Hattie, Byrne & Fraser (1987), to which reference was made in Chapter 2, focussed on the preferred environment for students in grades 7, 9 and 11. The researchers found that students in grade 9 were more disposed to friction and competitiveness, and that this was more pronounced in male students.

This latter point is confirmed in Table 5.2 which showed the item means and standard deviations for male and female students using the CEI. The largest significant difference between male and female perceptions of the environment was on the Cooperation scale where male students perceived far less cooperative behaviour than did female students. The effect size of this difference is about 1 standard deviation. Similarly male students saw their environment as significantly less cohesive, with an effect size of about half a standard deviation.

If the conclusions by Hattie, Byrne & Fraser (1987) that grade 9 students are more disposed to competition are generalisable, then the small but

significant negative correlation between cooperation and a positive attitude towards mathematics may be explained. When a small amount of competition is emphasised in the classroom, grade 9 students, particularly male students, may find this more enjoyable than an emphasis on cooperation, and, consequently, they may develop a more positive attitude towards the subject in less cooperative classrooms.

This is the first use of this environment instrument to examine associations with students' attitudinal outcomes therefore direct comparisons with previous studies are not possible. Indirect comparisons rely on the use of similar scales in other instruments. However, there are limited reported data on associations between classroom environment variables and student attitudes towards mathematics. The studies by Haladyna, Shaughnessy & Shaughnessy (1983) and Terwel et. al. (1994) each acknowledge the important role of the learning environment but focus on different variables from those of this study.

Cognitive Outcomes

Table 6.1 also presents the data showing correlations between the scales on each of the forms of the instrument, and students' cognitive outcomes. There are fewer significant correlations for the cognitive outcomes than for the attitudinal outcomes. The Personal form in fact shows no significant correlations, either when the scales are considered in simple correlations or when the effect of each scale is considered in turn with the effect of the other scales being held constant. Similarly, the multiple correlation (R) is not significant.

On the Class form, no significant correlations exist when each scale is considered using simple correlations. However, the standardised regression indicates there is a significant association between the cognitive outcomes of students and three of the scales, at least to the 0.05 level, which is over seven times that which would be expected solely by chance. However, the correlations with both Teacher Support and

Investigation are negative, whilst the correlation with Emphasis on Understanding is positive.

The measure used for the cognitive outcome was the average of two tests of grade 9 work given during the year. This takes into account increases during the year but is also a measure of mathematical understanding rather than purely mathematical gain during the year.

The negative correlation between the perceived level of Teacher Support and students' cognitive outcomes would appear to be disappointing news for teachers. It could be interpreted that less Teacher Support correlates with higher student outcomes. However, closer examination of the data reveals that the negative correlation is due to the effects of the perceptions of students in one of the surveyed classes.

Susan's class is a class of able girls who scored as the 3rd. highest class on the two tests of mathematical understanding. This was in spite of the fact that Susan placed a time constraint on students when they completed the second test (contrary to the researcher's instructions). However, they scored as the 3rd. lowest class on their attitude towards mathematics. The profile of this classroom environment is presented in Figure 6.1 along with the mean perceptions of all grade 9 students in the 23 classes.

These graphs clearly show the considerably lower perceptions of Teacher Support and Equity evident in the classroom. Susan, as the mathematics coordinator, was an experienced senior teacher, in her first year in this particular school. However, students perceived that she did not provide them with the appropriate level of support. They perceived a level of Teacher Support which was almost 1.6 standard deviations below the mean responses for all classes.

As mathematics coordinator in the school, Susan terminated the research in her colleague's class half way through the year because she believed that her colleague's students would use the opportunities provided by the CEI and the QTI to ridicule their teacher. However, she

was happy for her own class to continue to participate, but later declined the researcher's request to interview some of her students.

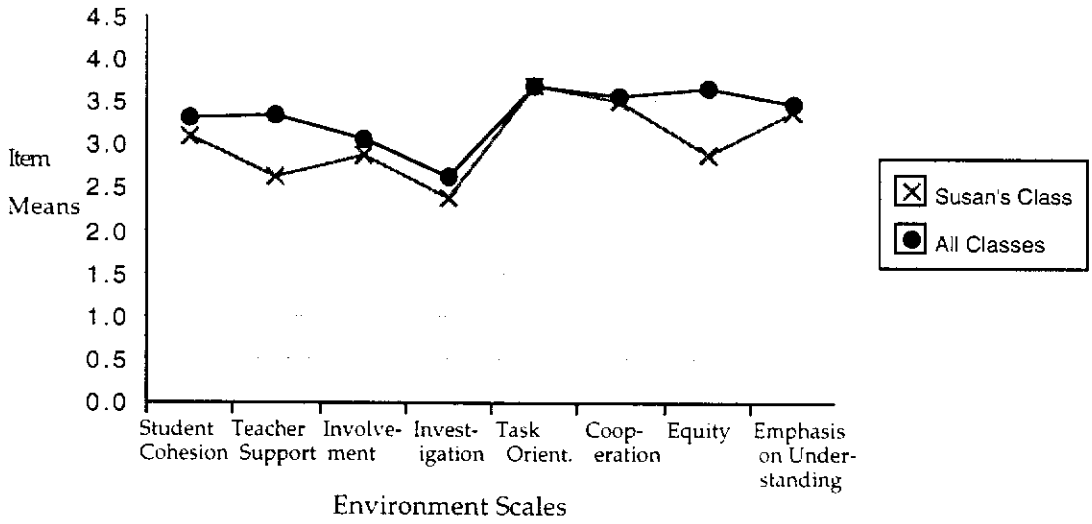


Figure 6.1 Comparison of classroom environments in Susan's class with the mean responses for all classes.

If the results of this class of high achieving students are ignored, the standardised regression coefficient for the remaining classes is not significant on the Teacher Support scale. It is the effect of this class which determined the significant negative correlation.

The scale of Investigation was also negatively correlated with students' cognitive outcomes. This association suggests that students who have the highest cognitive outcomes perceive that they are involved in less investigative work in their mathematics classes. Conversely those students who perceive that they are involved in more investigative activities scored lower on the cognitive tests.

It may be that too much investigative work sidetracks students from the central coursework which was tested in the two mathematics tests given to each student. This would seem to be countered by students' comments from one of the 'A' Stream classes who scored highly on the cognitive

tests. Students commented that their teacher, "was always going off on a tangent somewhere. The other day he had us working out stuff about how to get to the moon." Other students quickly supported this with their own anecdotes, as did the teacher who said that he liked "to make the students think". He saw variety of presentation and investigative work as his methods for achieving this end.

It may also be that lower cognitive outcome students are involved in more investigative work in an attempt by their teachers to ground the mathematics in reality in order to diminish the abstract nature of the work. For example, one of the lower ability classes went on an excursion to the Central Markets as part of an investigative activity to provide some reality and interest for students.

The final scale which correlated with the cognitive outcomes of students was the Emphasis on Understanding scale. This means that students who perceive that there are high levels of Emphasis on Understanding of mathematics in their classroom scored more highly on the cognitive tests. This is a correlation which is supportive of the efforts of teachers.

Because the tests were set by the researcher, instead of the classroom teacher, students may have been faced with familiar problems but with slightly different wording or in a slightly different situation. Consequently, students who understood the work at a deeper level would have been more likely to answer the questions correctly.

The scales on the Class form, when taken together, were significant predictors of cognitive achievement. This is indicated in the multiple correlation (R) of 0.39 ($p < 0.01$). The scales also accounted for 16% of the variance in the cognitive scores.

Summary of Associations Between the CEI and Student Outcomes

There is a high correlation between the behaviour represented in the scales of the CEI and students' attitude towards their learning of mathematics. This high correlation was evident on both the Personal form and the Class form of the CEI. The most positive attitudes towards mathematics learning were found in classes where students perceived a class sense of student cohesion and equitable treatment of students, and where students were involved in investigative work, and oriented clearly on their task. The small, but significant negative correlation with the Cooperation scale suggests that at the grade 9 level a small amount of competition may be valued by students more than an emphasis on cooperation.

Higher cognitive achievements were found in classes where there was a strong emphasis on students understanding their work, but only a minimal amount of investigative activity. The negative correlation with Teacher Support is explained by the perceptions of one of the classes.

This study confirms the findings of Fraser, Fisher & McRobbie (1996) who commented that the Personal form is able to show student perceptions of their personal relationship to the classroom environment variables, rather than their perceptions of the class's relationship. However, the Personal form of the CEI had less predictive validity in this study with regard to student outcomes than did the Class form.

Associations Between Student Perceptions of their Teacher's Interpersonal Behaviour, Using the QTI, and Student Outcomes

The QTI examines the interpersonal behaviour between teachers and students, as perceived by the students. This study is the first to administer the QTI to an Australian sample of mathematics students and to report on the associations between student perceptions of the teacher-student interpersonal relationship and student outcomes.

Attitudinal Outcomes

Data from the study are summarised in Table 6.2. The simple correlations show that each of the scales correlate significantly with the attitudinal outcome, which is over 100 times more than would be expected purely by chance, whilst the standardised regression coefficient showed that the scales of Leadership, Helping/Friendly and Admonishing behaviour significantly correlated when the effect of the other scales was held constant ($p < 0.01$, over 37 times that expected by chance alone). The multiple correlation (R) was significant at the 0.05 level and the scales together accounted for 28% of the variance in attitude.

The scales of Leadership, Helping/Friendly, Understanding and Student Responsibility/Freedom each had positive correlations with students' attitudes towards the mathematics class. Conversely the remaining four scales of Uncertain, Dissatisfied, Admonishing and Strict interpersonal behaviour each had negative correlations. This is consistent with the findings reported with students in The Netherlands and the USA (Brekelmans, Levy and Rodriguez, 1993; Wubbels, Brekelmans & Hooymayers, 1991). These previous studies indicated that when students perceive strong behaviour typified by the behaviour on the right of the vertical axis in the circumplex model, i.e. in the cooperative part of the Proximity axis, there is a high correlation with development of positive attitudes. Strong behaviour on the left of the vertical axis was shown to have a negative correlation with the development of positive attitudes.

The scales which correlate most strongly with the attitudinal outcomes in this study were Leadership, Helping/Friendly and Understanding. The first two of these were also significantly correlated using the standardised regression coefficient, as was the Admonishing scale. This means that 11 out of a possible 16 correlations between the QTI scales and students' attitudes towards their mathematics were significant ($p < 0.05$). This is over 13 times that which would occur by chance alone.

Table 6.2
Associations Between QTI Scales and Students' Attitudinal and Cognitive Outcomes in Terms of Simple Correlation (r) and Standardised Regression Coefficient (β)

Scale	Strength of Environment - Outcome Association			
	Attitude to Class		Cognitive Achievement	
	r	β	r	β
Leadership	0.47***	0.33***	-0.02	0.03
Helping/Friendly	0.46***	0.21**	-0.14*	-0.22
Understanding	0.44***	-0.08	-0.07	-0.05
Student Responsibility/ Freedom	0.10*	0.00	-0.22**	-0.12
Uncertain	-0.28***	0.08	-0.08	-0.04
Dissatisfied	-0.36***	-0.06	-0.09	-0.31**
Admonishing	-0.36***	-0.19***	0.05	0.11
Strict	-0.18***	0.03	0.04	0.00
Multiple Correlation, R	0.53*		0.31**	
Variance , R^2	0.28		0.10	
	N = 490		N = 207	

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

Cognitive Outcomes

The QTI scales correlated significantly with students' cognitive outcomes in 3 of the 16 possible correlations ($p < 0.05$), which is over three times the correlation at this level of significance which could be expected by chance alone. Students' perceptions of their teacher's Helping/Friendly behaviour and their teacher's Student Responsibility/Freedom behaviour correlated negatively with students' cognitive outcomes using the simple correlations. With the standardised regression coefficient,

students' perceptions of their teacher's Dissatisfied behaviour correlated significantly, once again negatively, with students' cognitive outcomes.

Whilst Student Responsibility/Freedom correlated positively with the attitude outcome, it correlated negatively ($p < 0.01$) with the cognitive outcome which confirms the findings of earlier research (Brekelmans, Levy and Rodriguez, 1993; Wubbels, Brekelmans & Hooymayers, 1991) and points once again to the dilemma highlighted by Wubbels, Brekelmans & Hermans (1987). Trying to achieve both positive attitudinal and positive cognitive outcomes creates a dilemma in regard to the behaviour typified by this scale. Giving students responsibility and decision making opportunities contains both the elements of submission and cooperation. However, whilst it correlates highly with personal growth and attitudinal outcomes, its opposite behaviour, that of strictness, correlates with cognitive outcomes.

It was noted in the previous discussion of the CEI that the Investigation scale correlated positively with students attitudes but negatively with their cognitive outcomes. One possible reason for this is that investigative activities may be one of the activities which offer students freedom and responsibility. As such it aids their personal development as they accept the responsibility to plan and carry out investigations, but lessens their focussed academic learning.

The Helping/Friendly scale was also significantly correlated with student cognitive outcomes. However, the correlation was negative and therefore runs counter to previous research (Brekelmans, Levy and Rodriguez, 1993; Wubbels, Brekelmans & Hooymayers, 1991). As with the explanation for the negative correlation of Teacher Support with student achievement, the perception of students in Susan's class is also responsible for this significant negative correlation. When Susan's class is omitted from the analysis the standardised regression coefficient for this scale is not significant. The profile of Susan's interpersonal behaviour, as perceived by her students, is shown in Figure 6.2.

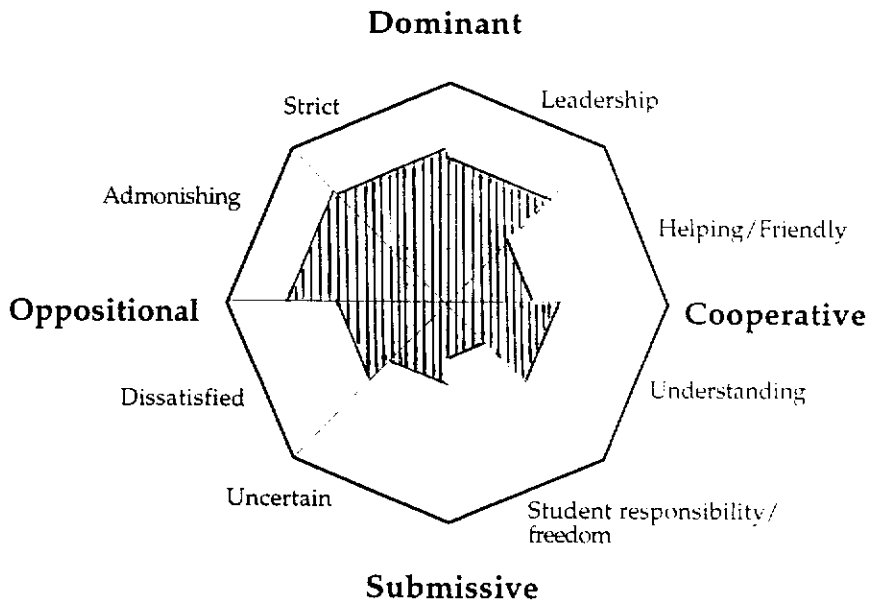


Figure 6.2 QTI profile of Susan's interpersonal behaviour

The typology of teacher interpersonal behaviour, reviewed in Chapter 2 (Figure 2.3 page 44), to which Susan's profile is most similar is that of the 'Repressive Teacher'. Wubbels, Brekelmans & Hooymayers (1991) comment that in this type of classroom,

> Students seem to be afraid of the teacher and they have every reason to be. These teachers can react very angrily to the minor misbehaviours or small mistakes of children. They behave sarcastically towards students and put them down...The classroom atmosphere is very strained and unpleasant...the teacher seems to repress every initiative of students...The teacher usually doesn't help the students if they don't understand. (p. 150)

It can clearly be seen in this graph that students only perceived a small level of Helping/Friendly behaviour. In fact the mean score for this class was 2.75 standard deviations below the mean for all classes. Consequently, the significant negative correlation between the Helping/Friendly scale and students' cognitive outcomes is a distortion due to the effects of one class's perceptions.

The negative correlation of the perceived Dissatisfied behaviour with

students' cognitive outcomes replicates previous research (Brekelmans, Levy and Rodriguez, 1993; Wubbels, Brekelmans & Hooymayers, 1991). As the teacher is perceived to be more dissatisfied in the classroom, so students show less cognitive outcomes. As has already been mentioned in the literature review, it may be that the low cognitive outcomes produce the dissatisfied behaviour, or it may be the other way around.

When considered together the QTI scales explained 10% of the variance in students' cognitive outcomes and the multiple correlation (R) was 0.31, significant to the 0.01 level.

Summary of Associations Between the QTI and Student Outcomes

Consequently, the use of the QTI in this study replicated previous findings, showing a strong correlation between students' perceptions of their teacher's interpersonal behaviour and their attitudes towards the mathematics class. The correlations with students' cognitive outcomes were not as strong, with two of the three significant correlations replicating previous findings. The third significant scale, Helping/Friendly, showed a small negative correlation whereas past research has indicated positive correlations. However, this is explained through the negative perceptions of one class. As in previous research the Student Responsibility/Freedom scale correlated positively with the development of positive attitudes, but negatively with students' cognitive outcomes.

This study confirms the importance of interpersonal behaviour which shows strong leadership, coupled with helpful, friendly and understanding behaviour, and shows that this is also relevant within the context of the secondary mathematics classroom.

Associations Between the QTI and the Two Forms of the Classroom Environment Instrument

In this study the Personal and Class forms of a classroom environment instrument, and the QTI, were used to profile grade 9 mathematics classrooms and to identify associations with student outcomes. Part of this study is also to determine associations between the two instruments. Two aspects of the relationship between the CEI and the QTI are addressed in this section. Firstly this section addresses the unique and common contributions of the two instruments to determine the value of administering both of them in further research. If the instruments each predict unique aspects of students' outcomes, then there is value in using both of the instruments.

It was outlined in Chapter 2 that this study is co-relational. As such it examines relations between students' perceptions of various aspects of the classroom environment. However, because teachers bring to class their considerable experience in a variety of classrooms, a fixed agenda of establishing relationships within the classroom and a clear idea of what is to be taught and how it is to be taught, it does not seem unreasonable to assume that their interpersonal behaviour is a large determinant of the classroom environment. Consequently, this section examines associations between students' perceptions of their teacher's interpersonal behaviour and perceptions of their mathematics classroom environment, the latter being considered as the dependent variable.

Simple correlations (r) are calculated between the scales of the two instruments. The standardised regression coefficient (β) is determined using the scales of each form of the CEI as dependent variables and the scales of the QTI as independent variables. This measures the association between each of the QTI scales in turn, with the remaining scales being kept constant, with each of the CEI scales. It is a more conservative measure than simple correlations. Finally the multiple regression (R) is calculated to show the combined association of the CEI scales with each QTI scale.

Commonality Analysis

The unique and common contributions of the QTI and each of the forms of the CEI in explaining variance in student outcomes is determined using a commonality analysis (Pedhazur, 1982). The coefficient of determination (R^2) is used to determine the amount of variance in student outcomes explained by each of the instruments.

For example, the Personal form of the CEI explains 29% of the variance in students' attitudinal outcomes (Table 6.1), whilst the QTI, for the same sample group of students, explains 33% of the variance. This figure is similar to the figure in Table 6.2 (28%) but the difference occurs because it only considers those students who also completed the Personal form of the CEI. When the 16 scales of the CEI and the QTI are considered together the coefficient of determination (R^2) indicates that the amount of variance explained by them is 43%. Consequently, the two instruments (QTI - 33% of variance, CEI - 29% of variance) explain an overlap of 19% when considered in relation to students' attitudinal outcomes. This is illustrated in Figure 6.3.

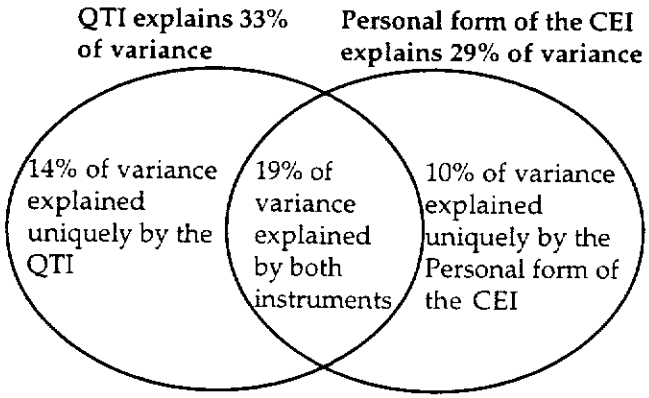


Figure 6.3 Unique and common contributions of the QTI and the Personal form of the CEI in explaining variance in students' attitudinal outcomes

The same procedure was also used to determine the unique and common contributions of the QTI and the Personal form of the CEI in explaining the variance in students' cognitive outcomes - likewise with the QTI and the Class form of the CEI for both cognitive and attitudinal outcomes. Table 6.3 reports these results and shows that there is more overlap between the two instruments when explaining the variance in attitudinal outcomes than cognitive outcomes. However, in each situation, the two instruments make unique contributions. In fact, when explaining the variance in cognitive outcomes, the Personal form of the CEI, and the QTI, are each unique and there is no commonality.

Consequently, it would be beneficial to use both instruments in further research. Each offers something unique in explaining student outcomes.

Table 6.3
The Unique and Common Contributions of the QTI and the CEI to Variance in Attitudes and Achievement (shown separately for the Personal and Class Forms of the CEI)

	Personal Form of the CEI		Class Form of the CEI	
Variance	Attitude to Mathematics	Cognitive Achievement	Attitude to Mathematics	Cognitive Achievement
Unique to QTI Scales	0.14	0.21	0.08	0.07
Unique to CEI Scales	0.10	0.05	0.06	0.12
Common to QTI & CEI	0.19	0.00	0.21	0.04
Total Contribution to Variance in Outcome	0.43	0.26	0.35	0.23
	N = 246	N = 102	N = 244	N = 105

Associations Between the Personal and Class Forms of the CEI, and the QTI

This section is predicated on the assumption that the teacher's interpersonal behaviour is a determinant of the classroom environment. As such it examines the relationship between students' perceptions on the CEI and the QTI and treats the CEI scales as dependent variables. These associations are shown in Table 6.4.

The simple correlations (r) reveal that the CEI scales are associated with the teacher interpersonal behaviour reflected in the QTI scales. With the Personal form 50 out of a possible 64 associations are significant to at least the 0.05 level, which is about 16 times that which would occur by chance alone, whilst on the Class form 57 out of the possible 64 are significant, which is about 18 times that of chance alone. The more conservative standardised regression coefficient (β) is significant in 11 of the possible 64 associations in the Personal form and 16 in the Class form, which is 3 times and 5 times respectively that of chance alone. Personal perceptions of Student Cohesion, Cooperation and Investigation correlate less strongly than perceptions of class behaviour on these scales. It may be that at the personal level, students see their own level of Cohesion, Cooperation and Investigation as less influenced by teacher behaviour than perceptions of the class's Cohesion, Cooperation and Investigation. Perhaps a personal sense of Cohesion, Cooperation and Investigation is more influenced by peer relations than teacher interpersonal behaviour.

The eight scales of the CEI are positive scales in the sense that they reflect desirable behaviour, rather than undesirable behaviour. Consequently, given the circumplex nature of the QTI model, it is no surprise that four scales correlate positively and four negatively. Where the four QTI scales of Leadership, Helping/Friendly, Understanding, and Student Responsibility and Freedom correlate significantly with CEI scales, the correlation is almost always positive when either the simple correlation (r) or the standardised regression coefficient (β) is considered. The

Table 6.4
Simple Correlations (r) and Standardised Regression Coefficients (β) for the QTI and the Personal and Class Forms of the CEI

Personal form

	Student Cohesion		Teacher Support		Involvement Negotiation		Investigation		Task Orientation		Cooperation		Equity		Emphasis on Understanding	
	r	β	r	β	r	β	r	β	r	β	r	β	r	β	r	β
Leadership	0.03	-0.16	0.62***	0.15*	0.31***	0.07	0.26***	0.15	0.48***	0.37***	0.08	-0.17	0.43***	-0.09	0.52	0.12
Helping/Friendly	0.17**	0.24*	0.66***	0.19*	0.35***	0.18	0.24***	0.09	0.40***	0.04	0.19**	0.06	0.56***	0.16	0.57***	0.23*
Understanding	0.12	-0.01	0.71***	0.38***	0.34***	0.20	0.25***	0.16	0.42***	0.03	0.23***	0.25*	0.65***	0.40***	0.59***	0.24*
St.Resp/Freedom	0.13*	0.03	0.22***	-0.06	0.16*	0.00	0.05	-0.08	0.09	-0.03	0.06	-0.03	0.18**	-0.03	0.19**	0.00
Uncertain	-0.04	0.00	-0.38***	-0.02	-0.14*	0.01	-0.08	0.08	-0.34***	-0.07	-0.11	0.01	-0.37***	0.00	-0.37***	-0.10
Dissatisfied	-0.10	0.00	-0.50***	-0.04	-0.16**	0.11	-0.11	0.07	-0.33***	0.00	-0.21***	-0.02	-0.58***	-0.16*	-0.42***	0.00
Admonishing	-0.13*	-0.06	-0.38***	-0.05	-0.19**	-0.11	-0.09	-0.05	-0.28***	-0.09	-0.21***	-0.10	-0.49***	-0.15**	-0.35***	-0.06
Strict	-0.15*	-0.05	-0.30***	-0.03	-0.08	0.06	-0.02	0.03	-0.16**	-0.05	-0.18**	-0.03	-0.42***	-0.08	-0.26***	-0.02
Multiple Corr.(R)	0.23		0.73***		0.39***		0.30**		0.52***		0.29**		0.71***		0.63***	
(R^2)	0.05		0.54		0.15		0.09		0.27		0.08		0.50		0.40	

N = 246

Class form

	r	β	r	β	r	β	r	β	r	β	r	β	r	β	r	β
Leadership	0.26***	-0.04	0.60***	0.11	0.46***	-0.04	0.34***	0.40***	0.56***	0.40***	0.30***	0.04	0.55***	0.21*	0.63***	0.18*
Helping/Friendly	0.35***	0.28*	0.69***	0.37***	0.53***	0.14	0.26***	0.10	0.46***	0.18	0.37***	0.15	0.55***	0.15	0.56***	-0.01
Understanding	0.31***	0.01	0.68***	0.26*	0.58***	0.49***	0.26***	-0.12	0.48***	-0.03	0.36**	0.08	0.58***	0.18	0.67***	0.46***
St.Resp/Freedom	0.13*	0.07	0.10	-0.05	0.13*	0.00	0.04	-0.08	0.07	-0.07	0.06	-0.04	0.45	-0.04	0.06	-0.12*
Uncertain	-0.15*	0.02	-0.38***	0.07	-0.27***	0.07	-0.15*	0.22*	-0.39***	0.03	-0.22***	0.06	-0.38***	0.04	-0.48***	-0.04
Dissatisfied	-0.25***	-0.02	-0.56***	-0.03	-0.43***	0.01	-0.20**	0.00	-0.39***	-0.01	-0.34***	0.00	-0.48***	0.01	-0.54***	-0.04
Admonishing	-0.23***	-0.07	-0.47***	-0.07	-0.40***	-0.13	-0.26***	-0.23**	-0.42***	-0.20**	-0.34***	-0.17*	-0.50***	-0.22**	-0.46***	-0.06
Strict	-0.14*	0.05	-0.34***	-0.01	-0.23***	0.06	-0.04	0.08	-0.10	0.14*	-0.30**	-0.14	-0.30***	-0.04	-0.27***	0.00
Multiple Corr.(R)	0.36***		0.73***		0.60***		0.40***		0.60***		0.43***		0.63***		0.71***	
(R^2)	0.13		0.53		0.36		0.16		0.36		0.18		0.40		0.50	

N = 244 *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

exception is the negative correlation between perceived Student Responsibility and Freedom interpersonal behaviour and the Emphasis on Understanding as expressed using the Class form of the CEI. It may be that too much responsibility and freedom takes students away from focussed academic understanding and learning into other areas. This is consistent with previous findings that the Student Responsibility and Freedom scale correlates negatively with students' cognitive outcomes (Brekelmans, Levy & Rodriguez, 1993; Wubbels, Brekelmans & Hooymayers, 1991).

The Personal form, however, does not show the same negative correlation. Rather it shows a significant, positive, simple correlation ($p < 0.01$) between Student Responsibility and Freedom and the Emphasis on Understanding. Perhaps when individuals consider their own level of emphasising understanding they consider that they are able to exercise personal responsibility and freedom without being sidetracked from their learning, unlike a more detached view of their peers represented on the Class form.

The four remaining QTI scales representing perceived Uncertain, Dissatisfied, Admonishing and Strict teacher interpersonal behaviour each correlate negatively with CEI scales, apart from two exceptions which also appear on the Class form of the CEI. Perceived Uncertain teacher interpersonal behaviour correlates positively with perceived levels of Investigation in the classroom. Perhaps when a teacher is very uncertain, students perceive that the class undertakes more investigation in order to complete or to learn their mathematics. Similarly where students perceive that a teacher exhibits minimal uncertain behaviour they may also perceive that the class is directed in most activities and therefore perceive less independent investigation. The Strict scale correlates positively with students' perceptions of the class's Task Orientation. This too would be expected. The research cited above with regard to the Student Responsibility and Freedom scale concluded that students' cognitive outcomes correlated positively with the scales of Strict, Leadership, Helping/Friendly and Understanding, and negatively

with the remainder. Consequently, these findings would appear to replicate this conclusion.

The CEI scales with which there are the least significant correlations with the QTI scales, (as shown by the number of significant correlations and the value of the multiple correlation *R*), and hence a low correlation with students' perceptions of their teacher's interpersonal behaviour, are the Student Cohesion scale, the Investigation scale and the Cooperation scale. This is the case for both the Personal and Class forms of the CEI. Because these three CEI scales correlate least significantly with students' perceptions of their teacher's interpersonal behaviour it is perhaps the case that other factors are a larger determinant of these aspects of the classroom environment.

It may be that peer relationships play a larger part, particularly in the case of Student Cohesion and Cooperation. It is evident that less significant correlations appear for these scales on the Personal form than on the Class form. This suggests that when students consider their personal sense of cohesion or cooperation, they view the teacher's role less significantly than when they consider the class's sense of cohesion and cooperation. At the personal level, Investigation is only significantly associated with positive teacher behaviour (Leadership, Helping/Friendly and Understanding behaviour).

The CEI scales with which there are large significant correlations with the QTI scales are the scales of Teacher Support, Equity and Emphasis on Understanding. This is the case for both the Personal and Class forms of the CEI. On the surface these three scales would each appear to be heavily dependent upon the teacher's interpersonal behaviour and the high statistical correlations support this observation.

The multiple correlations (*R*) shows that the QTI scales together are significantly related to each of the CEI scales except for the Student Cohesion scale on the Personal form. As already mentioned, it may be that a student's sense of personal cohesion with other students is more

dependent on peer relationships than his or her teacher's interpersonal behaviour.

It is important to note that students' perceptions of their teacher's interpersonal behaviour explain a considerable amount of the variance on the CEI scales, (ranging from 8% to 54%). This suggests that the teacher's interpersonal behaviour is an important underlying aspect, and predictor, of the classroom environment as measured by the CEI. This is more pronounced when the Class form is used than when the Personal form is used. It may be that, once again, peer influences are more important factors in the variance at the personal level than at the class level. The commonality analysis shown in Table 6.3 also confirms this point that the personal form has less in common with the QTI than does the Class form. The converse way of expressing this point is that students take into account factors other than their teacher's interpersonal behaviour to a greater degree when using the Personal form than when using the Class form.

It can be seen that there are many significant correlations between students' perceptions of their teacher's interpersonal behaviour and their classroom environment. This is more pronounced when students consider the class's relationship to the classroom environment than when they consider their personal relationship. The directions of the associations confirms previous research relating the QTI to students' outcomes.

Summary of Associations Between the QTI and the CEI

The QTI and the Personal and Class forms of the CEI each make significant contributions in the measurement of the classroom environment. Whilst each instrument makes somewhat overlapping contributions to the variance in student outcomes, each instrument also makes a unique contribution.

When the CEI scales are considered as dependent variables, many significant correlations exist with the scales of the QTI, particularly with the Class form. Student Cohesion, Cooperation and Investigation appear to relate least significantly with perceptions of the teacher's interpersonal behaviour. The primarily positive correlations of the Leadership, Helping/Friendly, Understanding and Student Responsibility and Freedom scales, and the primarily negative correlation of the remaining four QTI scales with the CEI scales confirms the circumplex nature of the QTI model, as well as replicating previous findings with regard to students' attitudinal and cognitive outcomes.

Chapter Summary

This chapter has consisted of two main parts. The first section of the chapter discussed class profiles in relation to student outcomes. Both attitudinal and cognitive outcomes were addressed. Significant associations were found to exist between students' attitudinal outcomes and the scales on each of the Personal form, the Class form and the QTI. Associations with the cognitive outcomes were only found to be significant when the QTI or the Class form of the CEI were used.

Overall, the Class form of the CEI was found to yield a higher number of significant associations with student outcomes than the Personal form. Murray's concept of the alpha and beta press (1938), reviewed in the literature section of this thesis, highlighted the importance of personal perceptions in governing behaviour. It appears from this study that perceptions involving the student's class, rather than perceptions of the individual directly, appear to be the more significant predictors of student outcomes.

The second section of this chapter showed that each of the Personal form and the Class form of the CEI contribute uniquely to the variance in student outcomes when used with the QTI. Whilst there is an element of commonality, the use of the two instruments together yields a greater

picture of the classroom environment. Associations between the two instruments were also examined and a high number of significant associations were found to exist, with the Class form yielding the slightly stronger association. The direction of these associations confirmed the circumplex nature of the QTI.

The final chapter draws together the findings of this study. It firstly discusses the use of these two forms of this new instrument for measuring the classroom environment and indicates how they might be used by teachers. It also examines the findings of this study and the implications for grade 9 mathematics teachers who are concerned about their students' attitudinal and cognitive outcomes.

The final chapter also addresses the limitations of this study and identifies areas of possible further research.

CHAPTER 7

CONCLUSION

Introduction

This thesis reports the findings of research into the classroom environments of grade 9 mathematics classes in Adelaide, South Australia. Over the two and a half decades of classroom environment research, little research has been conducted into the classroom environments of mathematics classes and consequently little is known in this area.

This study has profiled mathematics classrooms and has reported associations between aspects of the classroom environment and students' attitudinal and cognitive outcomes. As part of the research, a new instrument for measuring students' perceptions of their classroom environment has also been validated in both a Personal and Class form. An additional aspect of the mathematics classroom environment which was specifically investigated was the teacher's interpersonal behaviour. The QTI, which was used to measure students' perceptions of their teacher's interpersonal behaviour, was also validated for the first time with a large sample of mathematics classes.

This study has been unique in a number of ways. It has made a distinctive contribution to the field of classroom environment research through the use, for the first time, of a 64 item version of a new classroom environment instrument (CEI). It is further significant in that two forms of the CEI were developed and used; a Personal form and a

Class form. The study of classroom environments with the use of Personal forms is an emerging research area. Both forms of the instrument were shown to be reliable and valid, and to differentiate adequately between classes in their measuring of students' perceptions of their classroom environments.

A second significant contribution to the area of classroom environment research was through the concurrent use of the Questionnaire on Teacher Interaction (QTI) to measure students' perceptions of their teacher's interpersonal behaviour. The QTI has never before been used in a large sample of mathematics classes and its use has only been reported in Australian schools in three previous studies. The commonality analysis and the reporting of associations between the data from the two instruments is unique to this study. The QTI has not previously been associated in this way in research with general classroom environment instruments such as the CEI.

The third way in which this study is significant is in its contribution to the understanding of mathematics classroom environments. Little research has been conducted in this area and there are no reported studies which parallel this study in examining students' perceptions of their mathematics classroom environment, their perceptions of their mathematics teacher's interpersonal behaviour, and which examine associations between these perceptions and students' attitudinal and cognitive outcomes in mathematics classrooms. This study also uses qualitative data gathered from students to support and explain the quantitative data.

Consequently, this study is distinctive in its contributions to the field of classroom environment research, and in its contributions to the understanding of classroom environments of mathematics classes.

Overview of the Study

The research context of this study is the field of classroom environment research. This research began in the early 1970s and has become firmly established since then. Chapter 2 outlines the literature in this area and traces the development of the instruments which have been used in classroom environment research. It also reports previous research into classroom environments and notes that this research has frequently involved science classes, sometimes humanities classes, but rarely mathematics classes. Attention is given to the development of a range of related but more specific instruments which have been developed in recent years for use in specific classrooms such as laboratories or computing classrooms.

Particular attention is given to the recent development of the QTI and to research in which it has been involved. As in other classroom research, its use has frequently centred around science classrooms. The review of the literature on classroom environment research highlighted the need for the development of a new instrument for general classroom use and the need for further study in mathematics classrooms.

The methodology to achieve those ends is described in Chapter 3. As part of the description of the quantitative data gathering instruments, the development and trialling of the new general classroom environment instrument used in this study was described. This instrument was used in both its Personal form and its Class form. Chapter 3 also identifies the sample of mathematics students who participated in the study and identifies the measures used for their attitudinal and cognitive outcomes.

Four instruments were used in the gathering of data; the CEI, the QTI, an attitude scale and a cognitive test of grade 9 mathematics. Qualitative data also were gathered through interviews with students and through the researcher's journal. Chapter 4 reports the descriptive statistics which show the quantitative instruments to be reliable and valid. The

descriptive statistics for the QTI also confirmed the reliability and validity of the model, and its circumplex nature. The profiles of the mathematics classrooms as indicated by the CEI and the QTI are reported in Chapter 5. This chapter also combines the mathematics classroom profiles with qualitative data from student interviews and examines the sub-populations of male and female students to provide a richer insight into the mathematics classrooms. It also highlights and examines the significant differences between the Personal form and the Class form of the CEI.

Underlying the research is a desire to improve the teaching of mathematics. Consequently, Chapter 6 describes associations between students' perceptions of their mathematics classroom environment and their attitudinal and cognitive outcomes. It also addresses associations between students' perceptions of their mathematics teacher's interpersonal behaviour and their attitudinal and cognitive outcomes. These are important focusses of the study because they add to the limited knowledge base of mathematics classroom environments.

The variance in students' outcomes is partly explained by the CEI, in each of its forms, and partly by the QTI. The commonality analysis is also reported in Chapter 6. Finally, the chapter reports associations between the CEI and QTI scales, i.e. between students' perceptions of their mathematics teacher's interpersonal behaviour and their perceptions of their mathematics classroom learning environment.

Major Findings of the Study

The first research question of this study was

> *Is the recently developed Classroom Environment Instrument (CEI) used in this study, in both its Personal and Class forms, a reliable and valid measure of students' perceptions of their classroom environment?*

The CEI was developed to measure the classroom environments of general classes because previous such instruments were somewhat dated and did not take account of changes in educational philosophy and practice over the past 25 years. It was developed in both the Personal and the Class form, and each form consisted of 64 items spread across eight scales.

The statistical validation of the instrument is reported in Chapter 4. Each scale's internal consistency was shown to be above minimum acceptable levels for both the Personal and Class forms through the use of the Cronbach alpha coefficient with both the individual and the class mean as units of analysis. The mean correlation of each scale with other scales was used to show that each form of the instrument had a satisfactory level of discriminant validity. A one-way analysis of variance (ANOVA) showed that each scale differentiated satisfactorily between classes to at least the 0.01 level with the exception of the Investigation scale on the Personal form. Finally a principal components factor analysis with varimax rotation determined the factors underlying the items in the instrument. Whilst both the Personal and Class forms of the instrument showed a satisfactory division into eight factors, the two scales of Teacher Support and Equity appear to overlap in their measurement of one of the factors, as do the two scales of Student Cohesion and Cooperation on another factor. Continued development of the instrument may minimise this duplication. Nevertheless, the descriptive statistics showed that the CEI displays satisfactory levels of reliability and validity.

The conclusions drawn from the descriptive statistics were confirmed in Chapter 5 when the qualitative data were considered. Comments by students in interviews, and notes from the researcher's journal, confirmed the class profiles as drawn by the CEI. Two classes in particular, John's class and Peter's class, were examined to tie together the quantitative and qualitative data. The congruence of these different forms of data adds to the sense of confidence with which this new instrument can now be used.

The second research question was

> *What differences exist between profiles of the mathematics classroom learning environment when measured by the Personal form of the CEI and when measured by the Class form of the CEI?*

The Personal form of the CEI measured students' perceptions of their personal relationship with the classroom environment whereas the Class form measured students' perceptions of the class's relationship to the classroom environment. The two forms were found to be statistically different on seven of the eight scales. The CEI scores for John's class, whose students held low overall perceptions of their classroom environment, showed wider differences between the Personal and Class forms than was the case in Peter's class where students held higher perceptions of the classroom environment.

Students using the Personal form indicated significantly higher perceptions of Student Cohesion, Task Orientation, Cooperation and Equity than students who used the Class form, but significantly lower perceptions of Teacher Support, Involvement/Negotiation and Emphasis on Understanding. The qualitative data suggested that individual students frequently saw their classmates as being responsible for a lack of cohesion or cooperation, or a lack of focus on the task, or inequity in the classroom, rather than themselves. They saw their individual involvement in the classroom environment more favourably than they saw the class's involvement as a whole. Similarly, they perceived their classmates receiving more support from the teacher, being more involved, and being shown a greater emphasis on understanding than they did themselves. These perceptions are reasonably consistent with attribution theory which suggests that students frequently attribute their successes to themselves, (e.g. higher personal Cohesion, Cooperation, Task Orientation and Equity) and their failures to external conditions (lower Teacher Support, Involvement and Emphasis on Understanding).

The third research question was

> *What differences exist between the perceptions of male and female sub-populations of mathematics students in their perceptions of their mathematics classroom environment and their mathematics teacher's interpersonal behaviour?*

It was the contention of Fraser & Tobin (1991) that Personal forms of instruments would, by the personal focus of the items, be more suitable to profiling sub-populations of the class. Consequently, Chapter 5 also reported the statistics for the sub-populations of male and female students. Significant differences were detected on four scales on the Personal form (Cohesion, Teacher Support, Cooperation and Equity) and five scales on the Class form (Cohesion, Teacher Support, Involvement/ Negotiation, Cooperation and Emphasis on Understanding). In each instance where male and female students had significantly differing perceptions, female students viewed the environment more favourably. These differences were more pronounced on relationship scales. The two work oriented scales of Task Orientation and Investigation were perceived similarly by male and female students. Because the two forms measure slightly different perceptions, i.e. Personal and Class interactions with the environment, the use of the two forms together perhaps provides more information than the use of only the Personal or Class form in profiling the male and female sub-populations.

The QTI also showed that where significant differences exist between the perceptions of male and female students about their mathematics teacher's interpersonal behaviour, female students viewed the behaviour more positively. Female students perceived greater amounts of Helping/Friendly and Understanding behaviour from their teacher whilst male students perceived greater amounts of Uncertain, Dissatisfied, Admonishing and Strict behaviour. Male and Female students perceived similar amounts of Leadership and behaviour which gives Student Responsibility & Freedom.

Consequently, the use of the Personal and Class forms of the CEI in this study shows that female students tend to view the mathematics classroom environment more favourably than do male students, particularly on the relationship scales. The QTI indicated that they view their mathematics teacher's interpersonal behaviour more positively also.

Therefore, both the Personal form and the Class form of the CEI were shown to display satisfactory levels of reliability and validity. Statistically significant differences were found between the two forms and both forms were shown to be useful in describing sub-populations of students.

The fourth research question of the study was

> *What associations exist between students' attitudinal and cognitive outcomes and their perceptions of their mathematics classroom environments and of their mathematics teacher's interpersonal behaviour?*

Students' perceptions of their mathematics classrooms were measured using the CEI. Their attitude towards their mathematics was measured using an attitude scale of 8 items, whilst their cognitive outcomes were measured using two tests of grade 9 mathematics. The scales on the Personal form of the CEI were significantly associated with students' attitudes towards their mathematics in 9 of the 16 possible associations whilst the scales on the Class form were significantly associated in 13 of the 16 possible associations.

Classes in which students displayed the most positive attitudes towards their mathematics were classes in which students perceived a highly supportive teacher who was equitable, placed a high emphasis on understanding the work and involved the class in high levels of investigative activity. Students in such classes also saw themselves as being very involved and cohesive in class. The only significant association which was negative was found on the Cooperation scale and

suggests that more positive attitudes are found in classes with a small amount of competition. A large emphasis on cooperation has a negative relationship with the forming of positive attitudes. This is consistent with research into the preferred environments of grade 9 students (Hattie, Byrne & Fraser, 1987).

The associations between students' perceptions of their mathematics classroom environment and their cognitive outcomes were less significant than with their attitudinal outcomes. Classes with the highest cognitive outcomes were classes in which students perceived few investigations and in which they perceived a high emphasis on understanding the work. Investigations were significantly and positively associated with positive attitudinal outcomes, but significantly and negatively associated with cognitive outcomes.

The associations reported in this study show that the Class form of the CEI is associated more significantly with student outcomes than is the Personal form. The literature reviewed in Chapter 2 contended that students' perceptions of their classroom environment, whether accurate or not, are considered to be determinants of their behaviour (Fraser, 1994). The findings of this study are that students' perceptions of their mathematics classroom environment are greater predictors of students' outcomes when they are based on perceptions of the class's relationship with the environment than when they are based on a personal relationship with the environment.

Perceptions of the mathematics teacher's interpersonal behaviour were significantly associated with students' attitudes towards their mathematics in 11 of the 16 possible associations. The most positive attitudes were found to be associated with strong leadership and helping, friendly behaviour, and with minimal admonishing behaviour. The greatest cognitive gains were found to be associated with teachers who displayed minimal dissatisfied behaviour and who gave their classes minimal responsibility and freedom. The Student Responsibility and Freedom scale was found to be positively associated with the

development of students' attitudes but negatively associated with students' cognitive gains.

Although the associations reported here replicate the findings of previous research with the QTI (Brekelmans, Levy & Rodriguez, 1993; Fraser, Fisher & Wubbels, 1993; Henderson, 1996; Wubbels, Brekelmans & Hooymayers, 1991), the findings vary slightly from the other two reported uses of the QTI in the Australian context. The teacher's interpersonal behaviour in this study of mathematics classes was seen to be more admonishing and to offer less leadership and helping, friendly behaviour than was evident in previous research in general classrooms. It also was perceived to offer students slightly more responsibility and freedom. This may be a function of the fact that this sample consisted of mathematics students and/or of grade 9 students, or that it was more random than the other samples. Further research is necessary before sound conclusions can be drawn.

The fifth research question of this study is

> *What is common and what is unique in the use of the Questionnaire on Teacher Interaction (QTI) and the Personal and Class forms of the Classroom Environment Instrument (CEI) in their explaining of the variance in students' attitudinal and cognitive outcomes?*

It was reported in Chapter 6 that the QTI and each form of the CEI made substantial unique contributions to the variance in students' attitudinal and cognitive outcomes. The unique contribution made by the CEI ranged from 5% to 12% whilst the unique contribution of the QTI ranged from 7% to 21%. The two instruments contributed little in common to the variance in students' cognitive outcomes but contributed more in common to the variance of students' attitudinal outcomes. Consequently, this study has found that the use of the two instruments together will provide substantially more information than the use of only one of the instruments.

The final research question of the study was

> *What associations exist between students' perceptions of their mathematics teacher's interpersonal behaviour and their perceptions of their mathematics classroom environment?*

This study found that there are many significant associations between students' perceptions of their mathematics teacher's interpersonal behaviour and their perceptions of their mathematics classroom environment. These are more pronounced with the Class form of the CEI than with the Personal form. Students' perceptions, on both forms, of the class's Cohesion, Cooperation and Investigation are the least significantly associated scales with the teacher's interpersonal behaviour, whilst the scales of Teacher Support, Equity, and Emphasis on Understanding show the highest significant associations.

The QTI scales of Leadership, Helping/Friendly, Understanding and Student Responsibility/Freedom interpersonal behaviour are, in the main, positively associated with the CEI scales, whilst the scales of Uncertain, Dissatisfied, Admonishing and Strict scales are, in the main, negatively associated. Exceptions within the general directions of these associations confirm the paradox of the Strict and Student Responsibility/Freedom scales which have been shown to correlate in different directions for attitudinal and cognitive outcomes (Brekelmans, Levy & Rodriguez, 1993; Wubbels, Brekelmans & Hooymayers, 1991).

Implications for Teachers of Mathematics

The most immediate implication of this study is that a new instrument for measuring the classroom environment has been validated and shown to be reliable. Mathematics teachers can confidently use the instrument for the measuring of students' perceptions of their mathematics classroom environment, for example in action research

(Grundy, 1987; Kemmis & McTaggart, 1988; McNiff, 1993) within their classroom.

The findings of the instrument can be used to profile the mathematics classroom so that strategies can be put in place to improve the classroom environment. However, this is of most value in a comparative sense. For example, teachers can use both the Personal form and the Class form so that the differences may become a point of reflection and discussion. Alternatively, they may compare the findings in their class with the data presented in this study or the data gained from a colleague's class, particularly if their colleague is known to be an effective teacher of mathematics.

The instrument can also be used in a monitoring sense to profile the classroom before, during, or after intervention programs. Intervention programs could range from deliberate attempts to change the classroom environment to the introduction of a new course.

A second implication for teachers of mathematics is that students develop the most positive attitudes towards their mathematics, and show higher achievement scores, in classes where they perceive that particular aspects of the classroom environment are present, and that particular teacher interpersonal behaviour occurs.

The most positive attitudes develop when students perceive that the class is cohesive, where there is a small amount of competition, where the class is involved in investigative activities, has a high work orientation and where the teacher is perceived to be treating students equitably. They particularly occur when students perceive strong leadership, helping, and friendly interpersonal behaviour. Behaviour which demonstrates understanding and the giving of responsibility and freedom is also important. Negative attitudes develop in classes where students perceive uncertain, dissatisfied, admonishing and strict interpersonal behaviour.

On the other hand, higher cognitive achievement occurred in classes where students perceived a strong emphasis on understanding of the mathematics and a low level of investigative activity. Interpersonal behaviour which gives students responsibility and freedom, or which reflects dissatisfaction, is evident in classes with low achievement.

A third implication of the study is that positive classroom environments, as measured by the two forms of the CEI, were associated significantly with strong leadership, helpful, friendly, and understanding interpersonal behaviour, and behaviour which also gives students some responsibility and freedom. Positive classroom environments were negatively associated with uncertain, dissatisfied, admonishing and strict interpersonal teacher behaviour. Exceptions to these associations indicate that strict behaviour and behaviour which gives students responsibility and freedom are associated positively with cognitive and attitudinal outcomes respectively. Teachers need to identify their own priorities in these areas and tailor their interpersonal behaviour accordingly.

Limitations of the Study

An obvious limitation of this study is that conclusions drawn from this sample relate only to this sample. It should be with caution that any inferences are made with regards to the wider population of mathematics students. This sample was weighted disproportionately in favour of independent schools in Adelaide, primarily because they agreed more readily to be involved in the study. In addition, the sample consisted of only grade 9 students and therefore conclusions relating to other grade levels would be purely speculative. However, the sample is not confined to volunteer teachers but consists of a range of teachers, in a range of differing ability classrooms.

A second limitation lies in the smaller sample of students for whom a cognitive score was calculated. Of the 490 students who completed the CEI and the QTI in term 3, only 207 students in 12 classes also completed the

two tests of grade 9 work in both terms 1 and 4, and had their name on all three data gathering instruments to enable them to be combined together. Five classes changed teacher after the first test was given in first term, four classes did not name one of the tests, three teachers did not give the test in term 4 because they believed their classes were too unruly, and a few students from each class either forgot to write their name, or were absent, on at least one of the occasions. Consequently, the data for the cognitive scores is based on a smaller sample of 207 students.

A third limitation of the study is that it is co-relational, not causal. Consequently, caution should be exercised in drawing conclusions about teacher interpersonal behaviour or classroom environments causing particular attitudinal or cognitive outcomes. Whilst it was sometimes inferred in the literature reviewed in Chapter 2 that student outcomes were the consequence of a particular classroom environment or of a particular teacher interpersonal behaviour style, it should be recognised that teacher behaviour within a classroom is frequently influenced by the attitudes and abilities of students.

Suggestions for Further Research

There are seven areas of further research which arise out of this study. Firstly, it was noted in the factor analysis of the CEI (Table 4.2) that the Teacher Support and Equity scales substantially measure the same factor, and that the Student Cohesiveness and Cooperation scales measure the same factor. Further development of the instrument is necessary so that each scale substantially measures a different factor.

A second area for further research is to extend the work of this study by examining the causal aspect of the classroom relationships. Determining more accurately the extent to which teacher behaviour causes specific classroom environments to develop, or leads to specific student outcomes, would aid mathematics teachers in their teaching. Alternatively, determining the extent to which the student and

classroom characteristics determine the teacher's behaviour would also be valuable knowledge.

A third interesting and useful follow up study would be a comparative study which addresses the classroom environments and teacher interpersonal behaviour across a range of subjects. This study has shown a particular profile of students' perceptions of their mathematics classroom environments and of the interpersonal behaviour of their mathematics teachers. However, there is insufficient data available to draw conclusions about the similarities and differences between these results and similar results from other subject areas.

This study has found strong associations between students' perceptions of their mathematics classroom environments, or their mathematics teacher's interpersonal behaviour, and students' attitudes towards their mathematics. However, the associations with cognitive achievement were not as strong. Consequently, a fourth area of further study would be to focus on identifying the factors of the classroom environment which have stronger associations with students' cognitive achievements. This would be particularly useful for teachers of the subject.

The profiles and associations found in this study are related to grade 9 mathematics classes. Studies have shown that different grade levels prefer different environments (Hattie, Byrne & Fraser, 1987). A fifth area of study would be to research the profiles and classroom environments of other grade levels so that the changes in the way students perceive their mathematics classroom environment during their school years can be taken into account by teachers.

A sixth area of research could involve the multilevel analysis of the data gathered in this research. Data have been analysed at the student level. However, this does not take account of the nesting effect of students and classes within schools.

Finally, further insights into classroom environments could involve

further determination of the relative usefulness of the Personal and Class forms of instruments. This study found statistically significant differences between the forms on seven of the eight scales. Furthermore, the Class form was associated more strongly with students' attitudinal and cognitive outcomes than the Personal form and it was also more significantly associated with the QTI scales. It would also be useful to determine the unique and common contributions of the Personal and Class forms in explaining students' attitudinal and cognitive outcomes. Consequently, further investigation of the Personal and Class forms of classroom environment instruments is warranted.

Final Comments

This study has identified associations between students' perceptions of their mathematics classroom environment and their attitudinal and cognitive outcomes, and between their perceptions of their teacher's interpersonal behaviour and their attitudinal and cognitive outcomes. It has also shown that the CEI, in both its Personal and Class forms, is a reliable and valid instrument for the study of classroom environments, The study has also addressed associations between the CEI and the QTI.

The results reported in this thesis have implications for teachers of mathematics who are interested in the development of positive attitudes in their students and in their students' levels of achievement. It also adds significantly to the small amount of data so far available about mathematics classroom environments.

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APPENDICES

Appendix A Letter sent to parents of students participating in the survey.

28th. Feb. 1995

re Year 9 Mathematics Survey

Dear parents,

A survey is to be conducted in your son or daughter's year 9 mathematics class. This will involve 3 short questionnaires. The first will be given in the next few days and involves some typical year 9 mathematics problems. The second questionnaire will be given towards the end of second term. This questionnaire will involve student's perceptions of their mathematics learning environment. The final questionnaire will be given early in term 4 and will once again involve only some typical year 9 mathematics problems.

This research is being conducted in about 34 year 9 mathematics classes in 17 Adelaide secondary schools. It will form part of a PhD research project into the learning of mathematics in different classrooms.

All questions in the questionnaire relate to mathematics. Nothing of a personal nature will be asked of students and all information will be treated confidentially. No student, teacher or school will be identified in any way in the report.

Naturally I would appreciate your support in this endeavour. However should you wish your son or daughter not to participate would you please notify his or her teacher.

Thank you in anticipation.

Yours sincerely

David Rawnsley

Survey of Mathematics Classrooms

School _____ **Teacher** _____

Name _____

Thank you for your help with this mathematics learning survey. Please attempt the questions over the page . *You may use calculators* if necessary, but not your text books. You may also do your working in the spaces provided.

Some of the questions are easier than others. Some may be too difficult because they are general year 9 questions and you will not have covered all of the work at this stage of the year. Do as much as you can.

When you have worked out as many as you can would you please enter your answers in the spaces below. This is simply to make the marking of so many papers a little easier.

Question	Answer	Question	Answer
1.		7.	
2.		8.	
3.		9.	
4.		10.	
5.		11.	
6.		12.	

1. Find v in the formula
   $v = ut + \frac{1}{2}at^2$
   if $u = 2$, $t = 3$ and $a = 8$

2. $-7 + {}^{-}8 =$

3. Re-arrange the formula
   $a = bc + d$ so that it is in the form
   $c =$

4. What percentage of 80 is 4?

5. Expand and simplify the expression $2(x - 5)$

6. Factorise the expression
   $6x + 12$

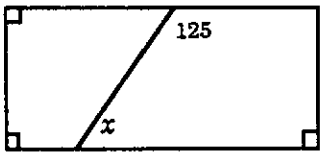
7. Find x if; $3x + 2 = 20$

8. Find x if; $\frac{4x + 3}{5} = 3$

9. If a year 9 student runs a 100m race in 15 seconds, how many Kms/Hr does this represent?

10. Find the volume of a cylinder which has a radius of 5 cm and a length of 8 cm. (Vol = $\pi r^2 h$) You may leave your answer as a multiple of π.

11. Find the value of angle x



12. If there are 3 roads from town A to town B, 2 roads from town B to town C and 4 roads from town C to town D, how many different ways is it possible to travel from A to B to C to D?

Appendix C Personal form of the classroom environment instrument (CEI) (including attitude scale)

YEAR 9 MATHEMATICS SURVEY

Thank you for your help with this survey.

In this survey there are no 'right' or 'wrong' answers.

The survey consists of a number of statements about what happens in this mathematics class. You are asked to indicate how often these things happen by circling a number from 0 to 4.

Circle **0** if the practice in the statement **almost never** happens.
Circle **1** if the practice in the statement **seldom** happens.
Circle **2** if the practice in the statement **sometimes** happens.
Circle **3** if the practice in the statement **often** happens.
Circle **4** if the practice in the statement **almost always** happens.

Be sure to answer all questions, even though some questions are fairly similar to other questions.

If you make a mistake, simply cross it out and circle another number.

Example
Circle the answer which shows how often the following occurs.

	Almost never				Almost always
Students in this class use computers	0	1	2	3	4

Please complete the section below.

Name_____ Male ☐
Female ☐

School _____

Teacher's Name _____

Thank you for your help.

What is happening in this class?

		Almost never				Almost always
1	I get to know other students in this class well.	1	2	3	4	5
2	I do favours for members of this class.	1	2	3	4	5
3	Members of this class are my friends.	1	2	3	4	5
4	It's difficult for me to get a group together for a project.	1	2	3	4	5
5	I work with other students on projects in this class	1	2	3	4	5
6	Students help me with my homework.	1	2	3	4	5
7	Some students in this class don't like me.	1	2	3	4	5
8	It takes a long time for me to get to know each students.	1	2	3	4	5
9	The teacher takes a personal interest in me.	1	2	3	4	5
10	The teacher goes out of his/her way to help me.	1	2	3	4	5
11	The teacher considers my feelings.	1	2	3	4	5
12	The teacher helps me when I have trouble with the work.	1	2	3	4	5
13	The teacher talks with me.	1	2	3	4	5
14	This teacher 'talks down' to me.	1	2	3	4	5
15	The teacher is interested in my problems.	1	2	3	4	5
16	The teacher is unfriendly to me.	1	2	3	4	5
17	I discuss ideas in class.	1	2	3	4	5
18	I give my opinions during class discussions.	1	2	3	4	5
19	The teacher asks me questions.	1	2	3	4	5
20	My ideas and suggestions are used during classroom discussions.	1	2	3	4	5
21	I ask the teacher questions.	1	2	3	4	5
22	I sit and listen to the teacher.	1	2	3	4	5
23	Students ask me to explain my ideas.	1	2	3	4	5
24	Students talk with me about how to solve problems.	1	2	3	4	5
25	I carry out investigations to test ideas.	1	2	3	4	5
26	I carry out investigations to answer questions coming from discussions.	1	2	3	4	5
27	I explain the meaning of statements, diagrams and graphs.	1	2	3	4	5
28	I carry out investigations to answer questions which puzzle me.	1	2	3	4	5
29	I carry out investigations to answer the teacher's questions.	1	2	3	4	5
30	I solve problems by obtaining information from the library.	1	2	3	4	5
31	I find out answers to questions from the teacher rather than from investigations.	1	2	3	4	5
32	I find out information from books rather than from investigations.	1	2	3	4	5
33	I know what has to be done in this class.	1	2	3	4	5
34	Getting a certain amount of work done is important to me.	1	2	3	4	5
35	Class assignments are clear so I know what to do.	1	2	3	4	5
36	I do as much as I set out to do.	1	2	3	4	5
37	I know the goals for this class.	1	2	3	4	5
38	I am ready to start this class on time.	1	2	3	4	5
39	I spend more time discussing what I do outside the classroom than class related material.	1	2	3	4	5
40	I know what I am trying to accomplish in this class.	1	2	3	4	5

	What is happening in this class?	Almost never				Almost always
41	Students cooperate with me in this class.	1	2	3	4	5
42	I compete against other students.	1	2	3	4	5
43	I cooperate well with other class members.	1	2	3	4	5
44	I try to make my work better than my friends' work.	1	2	3	4	5
45	Some class members try to do better than me.	1	2	3	4	5
46	I cooperate with other students when doing assignment work.	1	2	3	4	5
47	When I work in groups in this class, there is teamwork.	1	2	3	4	5
48	In this class, I help students who are having trouble with their work.	1	2	3	4	5
49	The teacher pays more attention to some students' questions than to my questions.	1	2	3	4	5
50	I get less help from the teacher than do other students.	1	2	3	4	5
51	Some students have more say in this class than me.	1	2	3	4	5
52	I am treated the same as other students in this class.	1	2	3	4	5
53	The teacher encourages some students more than me in this class.	1	2	3	4	5
54	The teacher expects the same standard of work from me as from other students.	1	2	3	4	5
55	The teacher is as friendly to me as to other students.	1	2	3	4	5
56	I get the same opportunity to contribute to class discussions as other students.	1	2	3	4	5
57	The teacher tells me that I am wrong without saying why.	1	2	3	4	5
58	The teacher's questions help me to understand.	1	2	3	4	5
59	I must understand the work to get good marks on class tests.	1	2	3	4	5
60	When starting a new topic, I discuss what I already know about it.	1	2	3	4	5
61	The teacher asks me to explain how I solve problems.	1	2	3	4	5
62	I discuss different answers to a question.	1	2	3	4	5
63	The teacher wants me to solve problems his/her way.	1	2	3	4	5
64	It is alright for me to tell the teacher when I do not understand.	1	2	3	4	5
65	Maths lessons are fun.	1	2	3	4	5
66	I dislike maths lessons.	1	2	3	4	5
67	Maths lessons bore me.	1	2	3	4	5
68	Maths is one of most interesting subjects.	1	2	3	4	5
69	I really enjoy going to maths lessons.	1	2	3	4	5
70	I would prefer to solve a problem myself than have someone tell me the answer.	1	2	3	4	5
71	In solving maths problems, I like to use new methods which I have not used before.	1	2	3	4	5
72	I find it interesting to hear about new mathematical ideas.	1	2	3	4	5

Appendix D Class form of the classroom environment instrument (CEI) (including attitude scale)

YEAR 9 MATHEMATICS SURVEY

Thank you for your help with this survey.

In this survey there are no 'right' or 'wrong' answers.

The survey consists of a number of statements about what happens in this mathematics class. You are asked to indicate how often these things happen by circling a number from 0 to 4.

Circle **0** if the practice in the statement **almost never** happens.
Circle **1** if the practice in the statement **seldom** happens.
Circle **2** if the practice in the statement **sometimes** happens.
Circle **3** if the practice in the statement **often** happens.
Circle **4** if the practice in the statement **almost always** happens.

Be sure to answer all questions, even though some questions are fairly similar to other questions.

If you make a mistake, simply cross it out and circle another number.

Example
Circle the answer which shows how often the following occurs.

	Almost never				Almost always
Students in this class use computers	0	1	2	3	4

Please complete the section below.

Name_____ Male ☐
Female ☐

School _____

Teacher's Name _____

Thank you for your help.

	What is happening in this class?	Almost never				Almost always
1	Students in this class get to know each other well.	1	2	3	4	5
2	Members of this class do favours for one another.	1	2	3	4	5
3	Members of this class are friends.	1	2	3	4	5
4	It's difficult to get a group together for a project.	1	2	3	4	5
5	Students work together on projects in this class	1	2	3	4	5
6	Students help each other with homework.	1	2	3	4	5
7	Some students in class don't like each other.	1	2	3	4	5
8	It takes a long time for students to get to know each other well.	1	2	3	4	5
9	The teacher takes a personal interest in students.	1	2	3	4	5
10	The teacher goes out of his/her way to help students.	1	2	3	4	5
11	The teacher considers students' feelings.	1	2	3	4	5
12	The teacher helps students when they have trouble with the work.	1	2	3	4	5
13	The teacher talks with students.	1	2	3	4	5
14	This teacher 'talks down' to students.	1	2	3	4	5
15	The teacher is interested in students' problems.	1	2	3	4	5
16	The teacher is unfriendly to students.	1	2	3	4	5
17	Students discuss ideas in class.	1	2	3	4	5
18	Students give their opinions during class discussions.	1	2	3	4	5
19	The teacher asks students questions.	1	2	3	4	5
20	Students' ideas and suggestions are used during class discussions.	1	2	3	4	5
21	Students ask the teacher questions.	1	2	3	4	5
22	Students sit and listen to the teacher.	1	2	3	4	5
23	Students ask one another to explain their ideas.	1	2	3	4	5
24	Students talk with each other about how to solve problems.	1	2	3	4	5
25	Students carry out investigations to test ideas	1	2	3	4	5
26	Students carry out investigations to answer questions coming from discussions.	1	2	3	4	5
27	Students explain the meaning of statements, diagrams and graphs.	1	2	3	4	5
28	Students carry out investigations to answer questions which puzzle them.	1	2	3	4	5
29	Students carry out investigations to answer the teacher's questions.	1	2	3	4	5
30	Students solve problems by obtaining information from the library.	1	2	3	4	5
31	Students find out answers to questions from the teacher rather than from investigations.	1	2	3	4	5
32	Students find out information from books rather than from investigations.	1	2	3	4	5
33	Students know what has to be done in this class.	1	2	3	4	5
34	Getting a certain amount of work done is important to this class.	1	2	3	4	5
35	Class assignments are clear so everyone knows what to do.	1	2	3	4	5
36	Students do as much as the class sets out to do.	1	2	3	4	5
37	Every students knows the goals for this class.	1	2	3	4	5
38	Students are ready to start this class on time.	1	2	3	4	5
39	The class spends more time discussing what students do outside the classroom than class related material.	1	2	3	4	5
40	Students know what they are trying to accomplish in this class.	1	2	3	4	5

	What is happening in this class?	Almost never				Almost always
41	Students cooperate with one another in this class.	1	2	3	4	5
42	Students compete against one another.	1	2	3	4	5
43	Students cooperate well with other class members.	1	2	3	4	5
44	Most students try to make their work better than their friends' work.	1	2	3	4	5
45	Some class members try to do better than the others.	1	2	3	4	5
46	Students cooperate with each other when doing assignment work.	1	2	3	4	5
47	When students work in groups in this class, there is teamwork.	1	2	3	4	5
48	Students help other students who are having trouble with their work.	1	2	3	4	5
49	The teacher pays more attention to some students' questions than to other students' questions.	1	2	3	4	5
50	Some students get less help from the teacher than do other students.	1	2	3	4	5
51	Some students have more say in this class than do other students.	1	2	3	4	5
52	All students are treated the same in this class.	1	2	3	4	5
53	The teacher encourages some students more than others in this class.	1	2	3	4	5
54	The teacher expects the same standard of work from all students.	1	2	3	4	5
55	The teacher is equally friendly to all students.	1	2	3	4	5
56	Each student gets the same opportunity to contribute to class discussions as other students.	1	2	3	4	5
57	The teacher tells students that they are wrong without saying why.	1	2	3	4	5
58	The teacher's questions help students to understand.	1	2	3	4	5
59	Students must understand the work to get good marks on class tests.	1	2	3	4	5
60	When starting a new topic, the class discusses what they already know about it.	1	2	3	4	5
61	The teacher asks students to explain how they solve problems.	1	2	3	4	5
62	Students discuss different answers to a question.	1	2	3	4	5
63	The teacher wants the class to solve problems his/her way.	1	2	3	4	5
64	It is alright for students to tell the teacher when they do not understand.	1	2	3	4	5
65	Maths lessons are fun.	1	2	3	4	5
66	I dislike maths lessons.	1	2	3	4	5
67	Maths lessons bore me.	1	2	3	4	5
68	Maths is one of the most interesting subjects.	1	2	3	4	5
69	I really enjoy going to maths lessons.	1	2	3	4	5
70	I would prefer to solve a problem myself than have someone tell me the answer.	1	2	3	4	5
71	In solving maths problems, I like to use new methods which I have not used before.	1	2	3	4	5
72	I find it interesting to hear about new mathematical ideas.	1	2	3	4	5

Appendix E Questionnaire on teacher interaction (QTI)

	Never Always	Teacher Use
1. This teacher talks enthusiastically about her/his subject.	0 1 2 3 4	Lea
2. This teacher trusts us.	0 1 2 3 4	Und
3. This teacher seems uncertain.	0 1 2 3 4	Unc
4. This teacher gets angry unexpectedly.	0 1 2 3 4	Adm
5. This teacher explains things clearly.	0 1 2 3 4	Lea
6. If we don't agree with this teacher, we can talk about it.	0 1 2 3 4	Und
7. This teacher is hesitant.	0 1 2 3 4	Unc
8. This teacher gets angry quickly.	0 1 2 3 4	Adm
9. This teacher holds our attention.	0 1 2 3 4	Lea
10. This teacher is willing to explain things again.	0 1 2 3 4	Und
11. This teacher acts as if she/he does not know what to do.	0 1 2 3 4	Unc
12. This teacher is too quick to correct us when we break a rule.	0 1 2 3 4	Adm
13. This teacher knows everything that goes on in the classroom.	0 1 2 3 4	Lea
14. If we have something to say, this teacher will listen.	0 1 2 3 4	Und
15. This teacher lets us boss her/him around.	0 1 2 3 4	Unc
16. This teacher is impatient.	0 1 2 3 4	Adm
17. This teacher is a good leader.	0 1 2 3 4	Lea
18. This teacher realises when we don't understand.	0 1 2 3 4	Und
19. This teacher is not sure what to do when we fool around.	0 1 2 3 4	Unc
20. It is easy to pick a fight with this teacher.	0 1 2 3 4	Adm
21. This teacher acts confidently.	0 1 2 3 4	Lea
22. This teacher is patient.	0 1 2 3 4	Und
23. It's easy to make a fool out of this teacher	0 1 2 3 4	Unc
24. This teacher is sarcastic.	0 1 2 3 4	Adm
25. This teacher helps us with our work.	0 1 2 3 4	HFr
26. We can decide some things in this teacher's class.	0 1 2 3 4	SRe
27. This teacher thinks that we cheat.	0 1 2 3 4	Dis
28. This teacher is strict.	0 1 2 3 4	Str
29. This teacher is friendly.	0 1 2 3 4	HFr
30. We can influence this teacher.	0 1 2 3 4	SRe
31. This teacher thinks that we don't know anything.	0 1 2 3 4	Dis
32. We have to be silent in this teacher's class.	0 1 2 3 4	Str
33. This teacher is someone we can depend on.	0 1 2 3 4	HFr
34. This teacher lets us fool around in class.	0 1 2 3 4	SRe
35. This teacher puts us down.	0 1 2 3 4	Dis
36. This teacher's tests are hard.	0 1 2 3 4	Str
37. This teacher has a sense of humour.	0 1 2 3 4	HFr
38. This teacher lets us get away with a lot in class.	0 1 2 3 4	SRe
39. This teacher thinks that we can't do things well.	0 1 2 3 4	Dis
40. This teacher's standards are very high.	0 1 2 3 4	Str
41. This teacher can take a joke.	0 1 2 3 4	HFr
42. This teacher gives us a lot of free time in class.	0 1 2 3 4	SRe
43. This teacher seems dissatisfied.	0 1 2 3 4	Dis
44. This teacher is severe when marking papers.	0 1 2 3 4	Str
45. This teacher's class is pleasant.	0 1 2 3 4	HFr
46. This teacher is lenient.	0 1 2 3 4	SRe
47. This teacher is suspicious.	0 1 2 3 4	Dis
48. We are afraid of this teacher	0 1 2 3 4	Str