Science and Mathematics Education Centre

MODELLING MATHEMATICS ACHIEVEMENT: AN AUSTRALIAN STUDY OF LEARNING ENVIRONMENTS IN EDUCATION

Beverley Joyce Webster

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DECLARATION

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

Signature

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ABSTRACT

This thesis describes a research study that investigated the relationships between school level environment and student outcomes. The study involved 620 teachers and 4.645 students from 57 Australian secondary schools in all states and territories. Student outcome measures included mathematics achievement, attitudes and beliefs toward mathematics and were collected as part of the Third International Mathematics and Science Study. Teachers perceptions of their school environment were measured using the School Level Environment Questionnaire and included variables such as student support, affiliation, professional interest, mission consensus, empowerment, innovation, resource adequacy and work pressure. Previous research has shown that factors at the school level, like environment, influence education at the classroom level and to further investigate this, data regarding the instructional practices of teachers was included in the analysis. The unique methodology used to investigate influences on student mathematics achievement is also described in this thesis. A two-step approach to modelling consisted of the analysis of two conceptually distinct models. The first was an analysis of the measurement model, which specifies the relationships between the observed variables and the latent variables. The second involved a structural equation model, which specifies the relationships among the latent variables as posited by theory and previous research. In addition, a multilevel analysis was included to further partition the variance in student outcomes between the student level, the classroom level and the school level.

The results of these analysis linked particular variables of interest to improved student outcomes. For example, teachers who felt supported and empowered were more likely to employ student-centred instructional practices and that work pressure and resource adequacy influenced the instructional approaches in the classrooms. The success attribution of students determined which method of instruction promoted positive outcomes. Furthermore, these results indicate relationships between student outcomes, attitudes and achievement, and the relationships between attitude and achievement were recursive with influences from student background variables. The multilevel analysis demonstrated the importance of the influence of factors at the classroom level in

influencing student outcomes and highlighted factors at the school level that explained differences in achievement.

The significance of this study is in the provision of evidence that demonstrates the effects on student outcomes and not only supports, but significantly adds to previous research. This thesis provides practical implications for teaching and for school policy that can be implemented to promote positive student outcomes. The thesis also provides a rationale for further research that would involve an investigation of the effects of change as suggested from the results of these analysis reported from this study.

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CHAPTER ONE

INTRODUCTION

It is a societal expectation that academic learning is a result of the provision of education in schools, and society continues to look for the 'good' schools while policy continues to dictate what constitutes the 'good' school. There is an obvious analogy between the concept of the effectiveness of an individual school, and the concept of the effectiveness of the national education system (Brown, 1998) and this is evident by the continuation of the practice of reporting students' measured achievements aggregated to the school-level in the form of league tables (Goldstein, 1997; Goldstein & Cuttance, 1998; Goldstein & Spiegelhalter, 1996; Rowe, 2000a). Whereas there is criticism of the more traditional ways of testing and reporting (Brown, 1998; Slee & Weiner, 1998), there are strong arguments for the value of both national and international student achievement studies as a basis for informing strategic policy (see Forster, 2000).

The purposes of international achievement studies are firstly to provide policy makers and educational practitioners with information about their education system in relation to other systems. Forster (2000) also indicates that the aim of these international studies is to assist policy makers and educational practitioners to understand the reasons for observed differences in the achievements of students from different educational systems. Researchers are mainly interested in using the information provided to explore associations between policies, instructional practices and student outcomes in order to provide strategic direction for improved student learning. Forster suggests that this is a result of the Governments conviction that future economic competitiveness depends upon high levels of knowledge and skills in the working population and this link between future economic performance and the current achievement of school populations is assumed by governments. Is there evidence for a causal link between the achievement of a country's school population and economic performance? It is likely there is evidence from multiple sources of a strong relationship but there is no conclusive empirical evidence of such a link. However, it is important to stress that the validity of results from such studies always lies heavily on the methodologies employed and the methods of analysis that are commensurate with the conceptual framework of the research questions being addressed.

In the international context, the provision of schooling and the search for what constitutes effective schooling appears no closer than the beginnings of school effectiveness research in the 1960's. The trail of school effectiveness research can be followed by reviewing the works of Bosker and Scheerens, 1994; Creemer and Scheerens, 1994; Mortimer, 1991, 1992, 1995; Reynolds and Cuttance, 1992; Reynolds et al, 1993; Reynolds, 1994; Scheerens, 1992, 1993; and Scheerens and Bosker, 1997. It would appear that despite all this previous research we are still no clearer about how effective the provision of school education is and how it can be improved for better student learning outcomes. What is also clear is that we have only just begun to see evidence the more appropriate question to ask is one of educational effectiveness and that 'quality teaching by quality teachers is what really matters' (Rowe, 2003, p.2).

In reality, the results of education are more specifically achieved in classrooms within schools. Individual students fill the classrooms and teachers teach in classes, a school with high scores does not necessarily have a school filled with high achieving students. The classroom is the nucleus where influences on the learning of students are found. Students do not achieve independent of the classroom or the teachers of those classrooms, nor do they achieve independent of themselves and their abilities and attitudes. It is not necessarily true that all individuals in high-rated schools are also themselves, high scoring students and the notion of school effectiveness being measured by key indicators that are packaged for the market place and for policy direction are and should continue to be questioned.

It is now well recognised that student and family background characteristics consistently explain a large proportion of the variance in student outcomes (Bosker, 1999; Creemers, 1994). These characteristics include student sex, socioecomonic background, prior ability, attitudes, aspirations, and beliefs about learning. Classroom influences include the students' opportunities to learn within the classroom which is often a measure of time exposed to a learning situation, the instructional practices that are employed in the classrooms, beliefs of the teacher about student learning and pedagogies of teaching, the climate and environment of the classroom, and teacher and peer relationships within the classroom (Marjoribanks, 1979; Mok & Flynn, 1997). At the school level, the size of the school, the leadership practices and beliefs, the school environment and even the socioeconomic status of the school which can be considered an aggregate of student socio-economic status are all factors that could influence student outcomes (Bosker & Scheerens, 1989; Carroll, 1989; Cuttance, 1992; Moos, 1979).

Nonetheless, we know that learning and teaching take place primarily at the classroom level and are heavily if not totally influenced by the teachers of those classrooms however educational effectiveness means more than student outcomes in just one class. In the preface to their edited collection of school effectiveness research articles, Raudenbush and Willms (1991, p. xi) observed:

> 'An irony in the history of quantitative studies of schooling has been the failure of researchers' analytic models to reflect adequately the social organisation of life in classrooms and schools. The experiences that children share within school settings and the effects of these experiences on their development might be seen as the basic material of educational research; yet until recently, few studies have explicitly taken account of the effects of particular classrooms and schools in which students and teachers share membership.'

Clearly, educational effectiveness has to do with effective outcomes in multiple classes within a school and throughout a system. The classroom-level influence cannot alone guarantee adequate transitions between different classes and so effective education is more than effectiveness at the classroom level. There are influences at a school level that need to be considered in research of student outcomes and educational effectiveness. Bernstein (1980) and Aitkin & Longford (1986) argued that the key to methodological progress in studies of classroom and school effects depended on the development of appropriate models and methods for the analysis of multilevel data. More recently the problems of fitting single-level models to hierarchically structured data have been given prominence in the general methodological literature (Bryk & Raudenbush, 1992; Cheung, Keeves, Sellin, & Tsoi, 1990; Cuttance, 1992; Rowe & Hill, 1995).

In addition to the activities at the class level having an influence on student learning, the environment at the school level can influence the behaviour of staff and students and the consequent effective outcomes in teaching and in learning (Hughes, 1991). Creemers (1994), while involved in research that investigated classroom effects and the influence on student outcomes and *educational effectiveness*, observed that school-level environment factors influence education and outcomes at the classroom level. While evidence can be found that schools with favourable environments are academically more successful with students, some writers have argued that conclusions about these relationships are premature because the data on school-level environments and student outcomes have been confounded by several other issues including student background variables, different pedagogies and beliefs about learning (see Bosker, 1999).

The availability of the Third International Mathematics and Science Study data which include student-level, classroom-level and school-level factors, and the subsequently collected school-level environment data from 57 participating TIMSS schools, and the merging of these two data sets enables a comprehensive and exhaustive investigation of the associations between student outcome measures, classroom effects and the school-level environment effects. This thesis reports several layers of analysis and the results of those analyses and addressed questions raised in previous research about the inadequacy of single level, single dimensional influences on student outcomes.

Using the techniques of measurement modelling and structural equation modelling allows the researcher to report with degrees of confidence the direct and indirect influences on student outcomes. These techniques also allow the researcher to present composite variables that have been developed with a rigorous and systematic method of estimation. In addition, using the techniques of multilevel analysis allows for the partitioning of the variance between the student level, the classroom level and the school level and provides data that can be used to support the development of strategies for change in systems at both the classroom level and the school level. To date, very few studies have collected data that are distinct at all educational levels, student, classroom and school. Normally, empirical considerations about school-level factors lack information about the direct influence on student outcomes after controlling for the influence of classroom factors. The use of more complex structural equation modelling allows for the interdependencies of factors contributing to student outcomes to be estimated simultaneously and for direct and indirect effects to be measured and reported.

Research in the field of school effectiveness is often criticised (see Shereeens & Bosker, 1997; Stringfield & Teddlie, 1991), in particular the lack of accounting for the hierarchical nature of the data and that students are nested in classes that are nested in schools. Unfortunately, despite these criticisms, school-level factors have obtained a status, which is not sufficiently supported by empirical findings, the most likely reason being that they appeal to practitioners and school improvers as important or essential factors.

Whether school effectiveness findings can really be attributed to school-level factors or are confounded with classroom-level factors, and therefore should be attributed to some extent to classroom-level factors, previously has not been a regular topic for discussion. Although school factors are theoretically thought to influence student achievement indirectly through classroom factors, research studies that have concentrated on direct effects and as a consequence may have underestimated or overestimated the actual influence of school factors.

Since effectiveness of education is more than effectiveness at the classroom level, the following two questions are raised:

1. Which unique contribution, in terms of proportion of variance accounted for, can be expected from the school level when it is analysed simultaneously with the classroom level?
2. Taking the classroom level into account, which school factors contribute to educational effectiveness, and what is the relationship between factors at the school level and factors at the classroom level?

The strength and significance of this research is in the distinct measure of the school-level environment for each school in the study, the merging of this data with that from the TIMSS Australian data base for each of these schools and the simultaneous analysis and modelling of the data at all student, class and school level. The unique advantages of this selection of analysis is to enable a distinction between those effects that are direct and those that are indirect and also those variables at the classroom level and those variables at the school level which influence student outcomes.

1.1 BACKGROUND TO INTERNATIONAL STUDIES

Countries continue to participate in international education research and although there is argument against the information in international league tables as an accurate measure of national effectiveness, the first part of this discussion provides two good reasons why countries or educational systems should participate in international comparative studies which measure student achievement (Plomp, 1992). The second part of this discussion provides discussion given by authors such as Brown (1998) who provide arguments against the use of international comparative studies such as TIMSS. While not the opinion of this author it is deemed necessary to present the opinions of these academics who, albeit may appear to be quite political in their writings about school effectiveness are serious scholars who add to the debate.

Firstly, such studies are aimed at improving the understanding of a country's educational system. Since there are no absolute standards for educational achievement, comparative studies are essential to provide policy-makers and educators with information about the quality of educational system in relation to that of other national systems. In this way, studies contribute to setting realistic standards for educational systems as well as monitoring school quality. Secondly, comparative studies may also be helpful in understanding the causes of observed differences in student performance by exploring cross-national relations between school achievement and such factors as curricula, amount of time spent on school work, teacher training, class enrolment, parental involvement, and many other possible explanatory measures.

It has been recognised in America that measuring and evaluating student success in the classroom requires both national and international perspectives (Griffith, 1993). International achievement studies can give information on a great variety of issues and it may be appropriate to abandon the insular view of schooling that has left many countries on the periphery of the international educational community. In this regard, Bradburn and Gilford, (1990 p.4) of the National Research Council, America, wrote:

> '...comparative research on education...increased the range of experience necessary to improve the measurement of educational achievement; it enhances confidence in the generalisability of studies that explain the factors important in educational achievement; it increases the probability of dissemination of new ideas to improve the design or management of schools and classrooms; and it increases the research capacity of the United States as well as that of other countries. Finally it provides an opportunity to chronicle practices and policies worthy of note in their own right'.

According to some authors there are problems with international comparative studies and these include sampling problems, reporting problems and curriculum match. In their report, *Worlds Apart*, Reynolds and Farrell (1996) list all of the above as problematic, however according to Brown (1998) these particular authors, although recognising and raising the problems, proceed to largely ignore them in drawing conclusions which are sometimes inconsistent. Brown states a major problem of international studies being one of ensuring comparability between samples and argues that in the first three mathematics studies, The First International Mathematics Study, (FIMS), the Second International Mathematics Study (SIMS) and The Third International Mathematics and Science Study (TIMSS) conducted by the IEA and those of the IAEP (International Assessment of Educational Progress), there is a recurring problem about the definition of the sample. Brown in *The Tyranny of the International Horse Race* reports a clear international disagreement as to whether what is being sampled is a particular age cohort, or a particular grade cohort. It is acknowledged that having valid and efficient samples in each country is crucial to the quality and success of any international comparative study. The accuracy of the survey results depends on the quality of sampling information available, and particularly on the quality of the samples. TIMSS developed procedures and guidelines to ensure that the national samples were of the highest quality possible (Beaton, Mullis, Martin, Gonzalez, Kelly & Smith, 1996).

International achievement data are used for several reasons and reported in different ways that can have an impact of which not all id positive. Forster (2000) indicates that the data from international achievement studies are used to motivate 'improvement', confirm performance expectations, inform policy making and to initiate further within-country enquiry. While Forster acknowledges that there are problems with the publication by the media of crude league tables, countries shown in rank order according to the mean achievement without qualifiers she also raises the importance of the test development and data analysis stages of such studies to enable the provision of quality and meaningful results.

Both policy makers in the field of education and educational scientists show a strong interest in international assessment studies such as those of the International Association for the Evaluation of Educational Achievement (IEA). However, the reasons for this interest vary. Very early, Bosker & Shereens (1989) suggested that policy makers like to see the performance of the system for which they are responsible compared with those in other countries. They suggest that it can be by seeing systems and outcomes in other educational systems one can use this information to improve ones own educational systems. On the other hand, educational scientists seek to determine the reasons for the variation in achievement across different systems. Educational scientists take a more empirical view of educational research and use outcomes to demonstrate changes and to indicate success. From a national perspective, most researchers are also interested in the causes of within-country variation in achievement. Why do some students in some schools achieve higher than students in other schools? What are the factors that are having either positive or negative influences on achievement and what strategies can be implemented to improve outcomes? The International Association of the Evaluation of Educational Achievement is an organisation that is involved in research to address these questions and is described in the next section.

1.2 THE INTERNATIONAL ASSOCIATION FOR THE EVALUATION OF EDUCATIONAL ACHIEVEMENT

The International Association for the Evaluation of Educational Achievement (IEA) is a non-government organisation of research institutions which cooperate in conducting cross-national educational research. The members of the IEA are research institutions, usually the main institution for educational research in a given country or sub-national educational system. Each participating system has its own committee to co-ordinate the study in that country.

Written in the IEA annual guidebook Rosier (1985, p. 8) described the beginnings of the IEA in the following way:

> 'In the late 1950s researchers from leading educational research institutions in about a dozen countries met under the auspices of the UNESCO Institute for Education in Hamburg. These researchers felt a strong need for an empirically oriented, comparative research program in education that should investigate problems common to many national systems of education. For a long time many ideas had been advanced about the relative failings and virtues of the various national systems. The group felt that it should be possible to conduct quantitative evaluations of these systems by means of modern survey techniques. The study could be conceived as a huge educational laboratory where different national practices lent themselves to comparison that could yield new insights into determinants of educational outcomes'.

International Educational Achievement studies have as a central aim the measurement of student achievement in school subjects, with a view to learning more about the nature and extent of student achievement and the context in which it occurs. The ultimate goal is to isolate those factors directly related to student learning that can be manipulated through policy changes in, for example, curricular emphasis, allocation of resources, and instructional practices (Robitaille, 1997). Clearly, an adequate understanding of the influences on student leaning can come only from careful study of the nature of student achievement and from the characteristics of the learners themselves, the curriculum they follow, the teaching methods of their teachers, and the resources in their classrooms and their schools. Such school and classroom features are of course embedded in the community and the educational system, which in turn are aspects of society in general (Creemers, 1994).

The First International Mathematics Study (FIMS), sponsored by the IEA from 1966 to 1972, involved complex sampling techniques to evaluate various national educational systems and to explore those variables associated with educational achievement. The Second International Mathematics Study (SIMS) was conducted in 1983 and 1984. Both of these studies experienced serious problems with financial and time restrictions on the researchers involved (Raudenbush & Willms, 1991). In general, it was not possible to produce the range of social and home background (socioecomonic status) instruments necessary to cover the social and educational traditions in the international study. The SIMS included a much broader range of attitude and socioecomonic status items than the FIMS and included much improved mathematics test items. However, there remained a lack of variables at the class level to use in the investigation of the effects of the curriculum, opportunity to learn, and teaching practices on student mathematics achievement (Robitaille & Maxwell, 1996). The Third International Mathematics and Science Study was developed with the limitations of the previous IEA studies taken into consideration to enable an improvement on the range of data collected to provide opportunities to investigate those factors that were noted as missing from previous studies.

1.3 THE THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

The Third International Mathematics and Science Study (TIMSS) was the largest and most ambitious international comparative study of student achievement to date (Martin, 1996). TIMSS was conducted in 1994 and 1995 and sampled students from three population groups in 50 countries. Thus, TIMSS greatly improved on previous studies in that researchers are now able to combine the study of student opportunity to learn and classroom practices with student achievement in an international setting in addition to countries being able to investigate within country differences and relationships. TIMSS includes data on both science and mathematics outcomes in the one study and brought together educational researchers from 50 countries to design and implement this international study of the teaching and learning of mathematics and science in each country (Robitaille, 1997; Lokan, 1997).

A project of the magnitude of TIMSS necessarily had a long life cycle. Planning for this study began in 1989 with meetings beginning in 1990 between coordinators from different countries. The data collection took part in 1994 and 1995 and the first reports were released in 1996. The development of the TIMSS study involved specialists from all areas of educational assessment and included policy analysis, curriculum design, survey research, test construction, psychometrics, survey sampling and data analysis. The achievement survey used in TIMSS passed through several stages of rigor. The development stage focused on defining the aims of the study, establishing parameters of the survey, designing and developing the data collection instruments, and developing data collection methods. The next stage was an operational one where sampling was a significant issue. In this stage the surveys were distributed, the data was collected, checked, coded and scored and entered. In the final stage of analysis and reporting the data went through rigorous processing, was summarised and presented.

Although the IEA had conducted separate studies of student achievement in mathematics and science on two earlier occasions (mathematics in 1965 and 1980-82, and science in 1970-71 and 1983-84), TIMSS was the first study from IEA to test mathematics and science together. This did however constrain the number of questions that could be asked due to time and hence limited the amount of information that could be collected from any one student.

TIMSS was designed with a view to learning more about the nature and extent of student achievement and the context in which it occurs and in response the items used to assess student knowledge and abilities were designed to be as authentic as possible with the questions asked and the problems posed in a form that students were usd to in their everyday school experience (Martin, 1996). In addition there was a requirement that test items made use of a variety of task types and response formats, and not be exclusively multiple choice.

The ultimate goal was to isolate the factors directly relating to student learning that can be manipulated through policy changes in, for example, curricular emphasis, allocation of resources, or instructional practices (Robitaille, 1997).

The designers of TIMSS chose to focus on curriculum as a broad explanatory factor underlying student achievement (Robitaille, 1997). From that perspective, curriculum was considered to have three manifestations: what society would like to see taught (the intended curriculum), what is actually taught in the classroom (the implemented curriculum), and what the students learn (the attained curriculum). This conceptualisation (see Figure 1.1) was first developed for the IEA's Second International Mathematics Study (Travers & Westbury, 1989).

Considering the curriculum as a channel through which learning opportunities are offered to students leads to a number of general questions that can be used to organise inquiry about that process. In TIMSS, four general research questions helped to guide the development of the study:

- What are students expected to learn?
- Who provides the instruction?
- How is instruction organised?
- What have students learned?

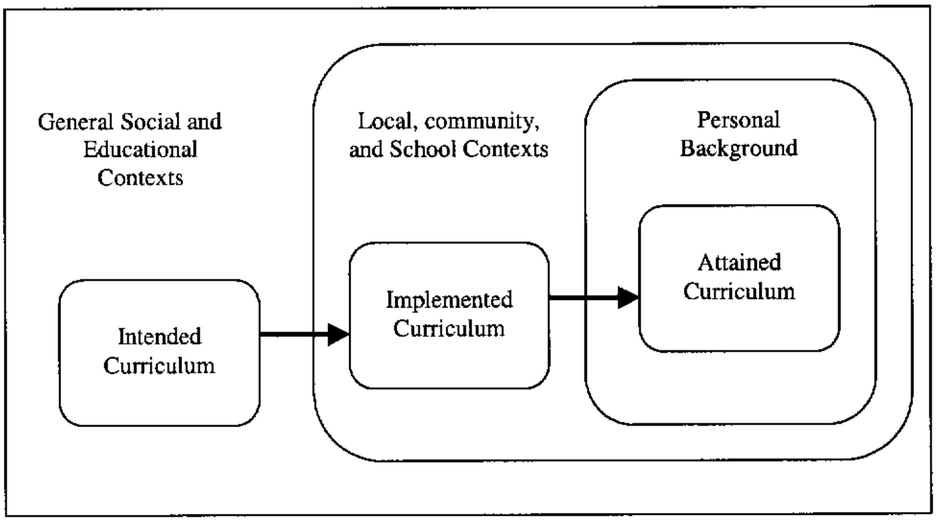


Figure 1.1. TIMSS curriculum conceptualisation

1.4 SCHOOL-LEVEL ENVIRONMENT STUDIES

Over the past decade, the concept of school climate or environment has appeared with increasing frequency in the educational literature. Along with curriculum, resources, outcomes and leadership, the school environment is considered to make a major contribution to the effectiveness of a school (Creemers, Peters, & Reynolds, 1989; Fisher & Fraser, 1990). Also, for many years there has been an inference in educational literature that a good school environment is linked with student outcomes. It has been suggested that every school has a pervasive environment, one which influences the behaviour of staff and students to succeed in teaching and learning and the quality of the school environment may influence the behaviour of all participants and especially students' academic performances (Brookover, Beady, Flood, Schweitzer, & Wisenbaker, 1979). Creemers (1994) also observed that factors at the school level, such as school environment, influence both teaching and learning at the classroom level. Thus, if teachers have a good working environment, which includes strong and consistent support structures, collaboration, professional development and a sense of empowerment, then student staff outcomes including student achievement will be more positive (Fisher & Cresswell, 1999). Fisher and Fraser (1990) indicated that the school-level environment could be assessed by measuring a teachers' relationship with other teachers, senior staff and the school Principal (Fisher & Fraser, 1990).

While other support can be identified for the hypothesis that schools with favourable climates or environments are academically more successful for students, it has been argued that conclusions about these relationships are premature because of the limited research both conceptually and methodologically that has combined the study of school-level environments and student outcomes (Evans, 1992). In this present study, data including factors that have previously been shown to affect student mathematics achievement, such as student background (socio economic status and sex of student) and classroom-level factors (instructional practices and opportunity to learn) are combined with school-level environment data that have been collected specifically for the purpose of this study. The effects and associations between these school level environment variables and student outcomes is fully investigated and this investigation involves the manipulation of the data using sophisticated analytical procedures not consistently used in educational research of this nature.

1.4.1 Rationale for this Study

The focus of this study is to further investigate factors that influence student achievement using methodologies that extend previous research and add new knowledge to results from earlier educational research in this area of student outcomes. Many researchers have reported student-level variation in achievement (Carroll, 1989; Masters & Keeves, 1999; Creemers. 1994) and more recent studies report classroom-level and school-level variation but the analysis in these studies has not been conducted simultaneously and as a result does not take into account the hierarchical nature of the data nor the direct and indirect effects evident in the modelling of educational data (Scheerens & Bosker, 1997; Scheerens, 1993; Goldstein, 1997). Little research has focused on this present type of investigation where the variance in student achievement at the classroom level and the school level is considered simultaneously with the student-level variables so that the unique relationships that exist between all levels can be more fully understood.

The variables of particular interest in this study are students' attitudes towards mathematics, success attribution, opportunity to learn within the classroom, and the way the teacher delivers the curriculum have on student outcomes. The relationship between the school-level environment and the instructional practices of the teachers and the outcomes of students, including attitudes and success attribution, are investigated to give insights into the kinds of teaching and learning which are most likely to be effective in promoting student achievement.

The investigation into students' opportunity to learn mathematics and the effects of these opportunities to learn and the classroom teaching practices have on achievement is possible due to the large number of variables available in the Third International Mathematics and Science Study. It was possible to include in the analysis of this data student background variables (socio-economic status) and school environment variables. Central to the concept of an effective school is the promotion of student learning, and effective learning occurs principally in effective classrooms operated by effective teachers (Evans, 1992). Previous research indicates that effective teaching is influenced by a climate that promotes and protects an institutional focus on leaning (Creemers, 1994; Reynolds & Cuttance, 1992; Strignfield & Teddlie, 1991). Stringfield and Teddlie (1991) have described significant interactions between school effects and class effects, they report that what happens at the school level can influence what is happening at the class level and that both school level and class level issues can influence students' achievement. What they indicate is not clear is the nature of these interactions and where changes should occur to result in the most positive outcomes for students in terms of achievement. Stringfield and Teddlie (1991) propose one reason for this void in the educational literature is that previous studies on schools and classrooms have been conducted separately. With the additional collection of the school-level environment data in this research study, it was possible to conduct simultaneous analyses of these effects and to fully investigate the interactions and relationships between classroom level and school level factors.

While studies of factors influencing student mathematics achievement have previously been carried out, many of these studies have failed to account for the inherent multilevel structure of the data and in addition limit the investigation to direct effects on student outcomes and don't extend the analysis to investigate and report indirect or recursive effects. This is especially the case for the analysis of educational performance data and in studies of teacher and school effectiveness (Bosker, Creemers, & Scheerens, 1994; Bryk & Raudenbush, 1989; Cuttance, 1992; Goldstein, 1987; Hill & Rowe, 1996; Raundenbush & Willms, 1991; Reynolds & Cuttance, 1992; Rowe, 1990a, 1990b, 1995; Scheerens, 1993; Scheerens & Bosker, 1997). Results from the Second International Mathematics Study (SIMS) indicated that school and classroom effects contributed 32 per cent of the variance in student achievement (Lockheed &

Longford, 1991). Results such as those reported by Lockheed and Longford indicate a need for further studies to allow the researcher to further isolate the nature of the variance in achievement, whether the influences are positive or negative and whether the effects are direct or indirect. This research also provides evidences about the placement of that variance in achievement, whether it is at the student level, the class level or the school level. Research of this nature provides helpful information to educators when developing policy and for teachers and school leaders when considering strategies to promote positive student outcomes and productive working environments.

The learning experiences that children share within school settings as a whole and the effects of these learning experiences on their educational development might be seen as the basic material of educational research, yet, until recently, few studies have explicitly taken account of the effects of the particular classrooms and schools in which students and teachers share membership. The grouping of students, classes and schools occurs in a hierarchical or clustering order with each group influencing the members of the other groups in terms of beliefs and behaviours (Raudenbush & Bryk, 1998). The nature of these hierarchical structures produces multilevel data that should be investigated for answers to research questions using appropriate methodologies that consider the particular structure of the data. The multilevel analysis used in this study addresses the problem of quantitative studies of schooling that fail to reflect the hierarchical, social and cultural organisation of schooling.

Thorough investigation of the influence on achievement of factors such as opportunity to learn and teaching practices and beliefs, while taking into account student socio-ecomonic status and school contextual variables, requires an adequate database which is National and which samples students from all types of schools and states within the country. The Third International Mathematics and Science Study provided such a database and therefore was chosen for use in the present study as the most logical and comprehensive data to address the particular research questions proposed in this study (see Section 1.4.4).

A strong economic argument for improving basic education is founded on the premise that failure to educate the future work force of a nation threatens a nation's ability to compete internationally in the global marketplace. In many countries, education and issues relating to education, teaching and learning, curriculum and legislation, has a high priority for policy makers. Children have to acquire basic knowledge and skills that they will need in future life and in their chosen professional careers. From the perspective of curriculum specialists, educators need to refine the understanding of the relationship between curriculum and learning. One way this may be accomplished is by accurately measuring achievement outcomes relative to opportunities to learn and by studying educational patterns, identifying those school and classroom variables which have an influence on student outcomes. This study employed the most relevant methods of analysis to answer the proposed research questions, which accommodated both the complex sample design and the multilevel nature of the data. In addition adjustment for students' individual characteristics and home background and the context of the school were considered in the analysis of the data in this study providing stronger support for the interpretation of the results in Chapters 4, 5 and 6.

1.4.2 Objectives

The purpose of this research study were to use the Third International Mathematics and Science Study (TIMSS) database merged with the school-level environment data collected from participating Australian schools and to address the following objectives.
To:

- investigate relationships between classroom-level factors such as opportunity to learn, and student outcomes;
- identify instructional practices that promote student achievement;
- investigate the unique contribution, in terms of proportion of variance in student achievement, accounted for by the school level when it is analysed simultaneously with the classroom level;
- identify school-level factors that contribute to and promote student achievement while accounting for student background and classroom-level factors; and
- investigate and identify relationships between factors at the school level and factors at the classroom level that affect student achievement

To date, studies using TIMSS data have reported results from descriptive and qualitative analysis. Few researchers have used the TIMSS data in their countries and collected further data to enable an exhaustive investigation into the unique variation in student achievement at the school level and the classroom level, and no studies have attempted to identify relationships between these two levels. Bosker (1999) explored factors affecting mathematics achievement using TIMSS data collected with grade 8. In this study a general path model was used to explain the variation in achievement, however, there was no accounting in the analysis for the hierarchical nature of the data. The model by Bosker explained 19 per cent of the variation in mathematics achievement but we have no way of knowing from these results whether the variation that is greatest is a the student level, the class level or the school level. In this particular study Bosker was also not able to determine whether the confounding issues such as the students sex, socio-economic status and attitudes in this single-level analysis would have altered the results that were reported.

The research reported in this thesis included allowing in the analysis for the hierarchical structure of the data and included unique school-level data. The multilevel analysis disseminated the variation to student, class and school level. This study also investigated by use of structural equation modelling the relationships between student outcomes and teacher and student variables, classroom practices, teachers' beliefs, and students' opportunity to learn. The direct and indirect relationships are reported in the results. These particular variables had not yet been included in previous analysis of these data at the depth and complexity of this analysis. It should be noted here that the significant uniqueness of this research in addition to the methodological issues is seen in the collection and inclusion of the school-level environment measures in the investigation of factors affecting student outcomes.

1.4.3 Conceptual Framework

A conceptual framework has been developed based on the literature review which is presented in Chapter Two. It is hypothesised that the factors that contribute to student achievement include:

Student-level factors	(sex, socio-economic status, attitudes toward mathematics, beliefs about success)
Classroom-level factors	(instructional practices, teachers' attitudes, and opportunity to learn)
School-level factors	(socio-economic status of the school, school environment and school size)

The macro conceptual framework presented in Figure 1.2 summarises how the relationship between the three groups of factors and student outcomes in terms of achievement is broadly envisaged. This represents a simplified conceptual model for describing these relationships because the contributing factors within each level and student achievement are presented as groups, and possible or likely relationships between the individual contributing variables and achievement components are in this conceptual model omitted.

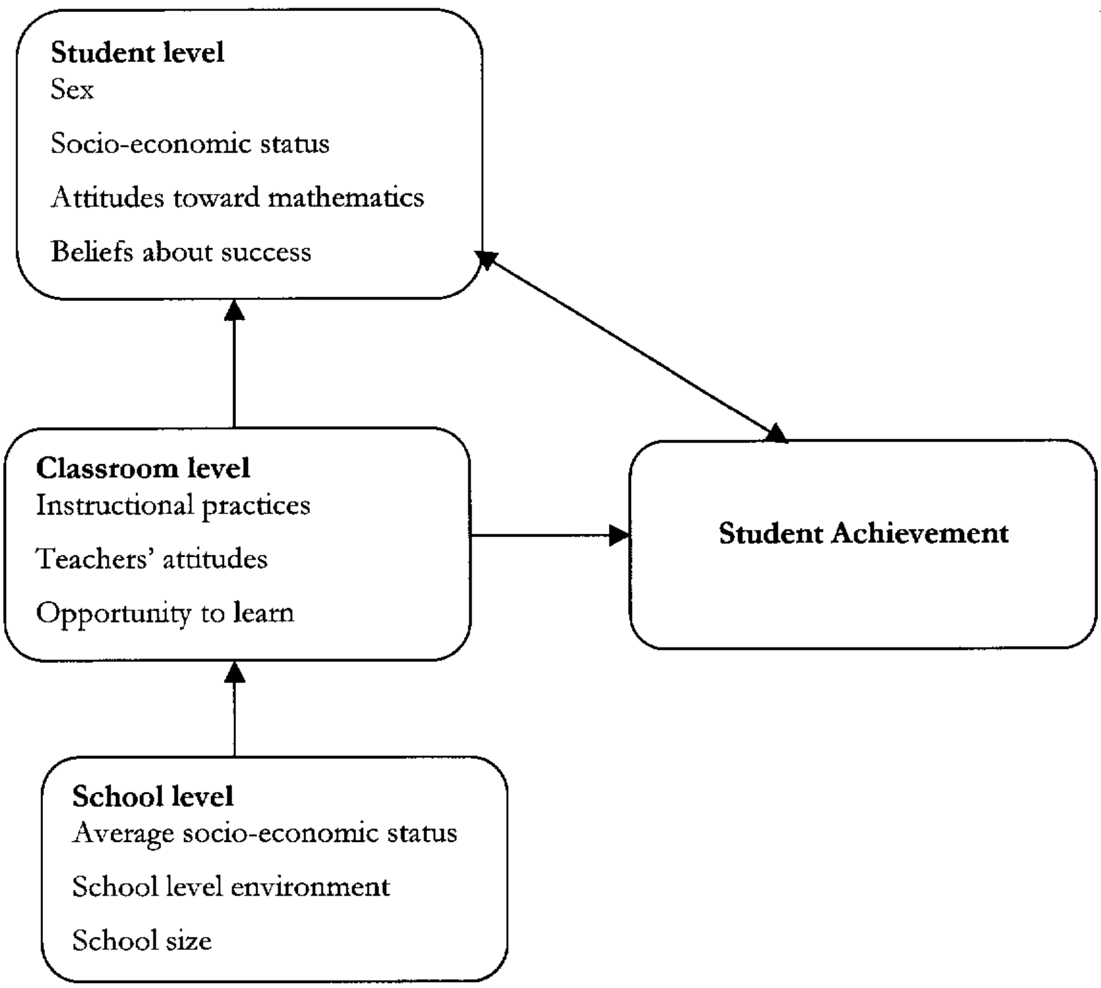


Figure 1.2. **Conceptual framework.**

The model presented in figure 1.2 suggests that **classroom-level factors** can affect student achievement directly (for example, particular teaching practices suit some students better than others and can promote higher achievement outcomes) and indirectly through affecting student-level factors (for example, teachers' attitudes towards teaching can affect student beliefs about success in mathematics and also student attitudes toward mathematics and this in turn can have an effect on student achievement outcomes). **School-level factors** directly affect classroom-level factors (for example, the school-level environment can have an effect on teachers' attitudes and influence the teaching practices of the teacher). School-level environment can affect student achievement indirectly (for example, school size and average socio-ecomonic status of the school can influence the teaching practices of the teacher). The model also suggests that some relationships between student-level factors and student achievement are recursive (for example, achievement outcomes can influence attitudes towards mathematics and attitudes towards mathematics can influence achievement outcomes for the student).

1.4.4 Research Questions

Based on the current literature and the conceptual framework presented in figure 1.1, five research questions were proposed in this study and they are reported below.

1. Does mathematics achievement vary systematically among schools?
2. To what extent do sex, socio-economic status, and student attitudes and beliefs account for differences in mathematics achievement?
3. Does instruction affect the average achievement of students within the same class?
4. How are student outcomes in mathematics influenced by opportunity to learn and different instructional practices?
5. Does instruction interact with school-level factors to influence mathematics achievement?

This research study involved the analyses of the Third International Mathematics and Science Study (TIMSS) data in combination with school-level environment data that was collected from 57 Australian schools. The schools were a sample of the total population of schools that participated in the TIMSS and were selected on the basis of the willingness to participate in the extended research study. The combination of these two sources of data allowed a comprehensive investigation into student mathematics outcomes. To this end, an examination of the differences in student-level, classroom-level and school-level characteristics was conducted in order to identify relationships between the variables of interest within and between the three levels of schooling and in addition to identify the effects of these relationships on student outcomes, both direct and indirect.

1.5 PROBLEMS RELATED TO METHODOLOGY

This present study takes into account broad considerations by including a number of variables, but there are, inherent in the methodology, some limitations. The cross-sectional methodology restricts the generalisability of the study findings (Burnstein, 1992; Davies, 1999). As in other cross-sectional research, causality cannot be established and the results can only be interpreted in terms of associations, of direct and indirect effects. There are also limitations associated with using a purely quantitative approach to student achievement research. This approach allows limited scope for providing qualitative information that could serve as a basis for changes or corrective action (Donabedian, 1988, 1992). The inclusion of open-ended questions within quantitative surveys is one way of collecting qualitative comments from responses. Focus group discussions can also generate rich information (Denzin & Lincoln, 1994). However, as this study involved secondary analysis of previously collected data these options were not available.

Although a qualitative approach allows the research to obtain rich information from teachers and students for improving student outcomes, what constitutes the best approach is largely dependent on the objectives of the particular research study or the questions the research is designed to address and seek answers. For example, if a study required a large sample, a purely qualitative approach would not be appropriate, or if it were appropriate it would be too expensive to conduct. In addition, if a study were designed to assess the factor structure of school-environment constructs, to explore the relationship between different school-environment constructs, or to explore the relationship between different school-environment constructs and a set of other variables, again a qualitative approach would not be appropriate mainly because this too would require large samples providing enough data to model using specific statistical techniques.

Secondly, the majority of educational studies fail to control for confounding variables or mediating factors (Kruzich, Clinton, & Kelber, 1992). For example, the level of student achievement can be confounded with variables associated with a student's background, class-level influences and students' beliefs and attitudes which research studies often fail to take into account.

Of particular importance, complex latent variables, such as school-level environment and student attitudes, are measured using a larger number of indicator variables (items), which are commonly summed or averaged to form a composite score. This technique, called unit-weight approach, is based on the assumption that each of the indicator variables contributes the same to the overall construct. This assumption fails to account for the possibility that some indicators may contribute more to the measurement of the underlying latent trait than others; and in addition, use of the unit-weight approach may invalidate the composite scale if one or more of the indicator variables measures a latent trait other than the one under consideration (Hill & Rowe, 1998; Holmes-Smith & Rowe, 1993).

Most importantly, learning environment studies in education have generally ignored measurement error associated with these environment measures in the collection and analysis of the learning environment data and the construction of the learning environment scales. What this means is that the majority of researchers in the field of student achievement and education or environments assume that these factors are perfectly measured without errors. This limitation is mainly due to the way educational environments have been conceptualised and measured, and the study design or statistical analysis method used.

Finally, the majority of student achievement studies have only considered the relationship between a small set of contributing variables and a single aspect of student achievement. Failure to consider a broader set of contributing factors and all important student achievement components simultaneously, results in fragmented information and limits the researcher's ability to have a comprehensive understanding of factors that could contribute to student achievement. These may be due to limited resources and time, methodological constraints and the difficulty of obtaining large samples required to study a variety of variables, and the fact that larger numbers of variables are statistically more difficult to manage. In referring to resident satisfaction in aged care residential facilities, Aharony and Strasser (1993) in a research study designed to investigate those factors influencing the satisfaction of residents in aged care facilities, suggested that more methodologically sophisticated and accurate research designs are needed so that the antecedents of resident satisfaction and the variables that moderate this relationship can be better specified and examined. This suggestion is also appropriate for educational research.

The overall desired outcome of the study was to establish a model linking each of the variables previously demonstrated to influence student achievement into a single holistic picture for all students irrespective of gender or socio-economic status and one that accounted for the unique contribution of classroom-level and school-level factors to the variation in students' mathematics outcomes. The multilevel modelling approach provided the opportunity to achieve this outcome.

The use of Structural Equation Modelling (SEM) provides a significant opportunity to explore more fully the underlying relationships between the three levels of factors affecting student achievement. In addition, this methodology enables the examination of student- level factor structures classroom-level factor structures and school-level factor structures and the assessment of the validity and reliability of the particular instruments used in the research study. The SEM approach used in this study is discussed in detail in Chapter Four.

KEY CAVEATS

There are several caveats that must be emphasised at this point, and borne in mind throughout what follows in this thesis. Firstly it is not intended that generalisations about educational research can be drawn from this work in its entirety as the author has a firm belief that generalisations from any research which is not of a scientific in nature is not possible nor very often necessary or relevant, particularly in educational research. However the rigour with which both the TIMSS data and the subsequent school learning environment data where collected provide substantive evidence with which the results and conclusions from this study are drawn. The sampling methods, instrument development and data collection along with the precision and depth in the statistical analysis also add to the weight of evidence of these findings.

Secondly, it is acknowledged that there are conflicting opinions on the value of international achievement studies and in particular those which are cross sectional in nature. The author makes every effort to present both sides of the argument as reported in the literature, much of which is supported for the purpose of this thesis only that falling into the category that is backed up by evidence is reported. The author, although recognising the limitations of these studies, clearly states her position in this debate, one which is confirmed by the use of TIMSS data in this doctoral study. Thirdly, it must be stated up front that although ideally the school level environment data would have been collected at the same time as the TIMSS data, this was not possible and so the subsequent data was collected at a later date to the TIMSS data.

Lastly the issue of school effectiveness is continually under debate and although the author is of the belief that school effectiveness is about the quality of the teacher and the way the teacher delivers the curriculum she does not intend to answer the question but rather add to the debate and by this thesis provide additional support for school effectiveness being at least more than the school and at worst nothing to do with the school.

1.6 OVERVIEW OF THESIS

The literature review discussed in Chapter Two gives a background to International Achievement Studies and the rationale for such studies. The Third International Mathematics and Science Study is discussed in detail in Chapter Two and includes the participant involvement and data collection procedures. Background and development detail of the School Level Environment Questionnaire (SLEQ) is also included in Chapter Two and the validity of this instrument is documented. Chapter Three gives an overview of the methodology employed in this study and involves a discussion of the use of secondary analysis with international achievement studies, measurement models, structural equation modelling and multilevel modelling. The advantages of using these methodologies in this study are highlighted in Chapter Three.

The results of the measurement models are discussed and presented in Chapter Four and includes a discussion on the validity and reliability of the SLEQ used in this study; the reliabilities of the student-level variables used in subsequent analysis; the items and reliabilities of the instructional practices; and a description of the items used to create these variables. Chapter Five presents the results of the structural equation modelling, the method use to investigate the effects of student background variables, student attitudes and attribution and school-level environment variables on student achievement. In Chapter Six the results of the multilevel modelling are presented. These results show the differences in the variance in student achievement at the student level, the class level and the school level, and a discussion of the partitioning of the variance at these three levels is given.

A discussion of the implications for teaching and learning of the results of the analysis of the data in this study is presented in Chapter Seven. Recommendations for changes in practice involving instructional practices and the possible effects of these changes on student outcomes, and the relationship between these teaching practices and student attitude towards mathematics, beliefs about success and achievement outcomes is also discussed in Chapter Seven. The influence of the school environment at the class level, as indicated by the results of the multilevel analysis, is further discussed in this final chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter places the study into context by providing a review of the existing literature relating to the research questions proposed in Chapter One. The first part of the review examines literature relating to school effectiveness studies and includes student background effects, classroom effects and school-level effects. Following this, the study of human environments, in particular educational environments, is examined. Particular attention is paid to the development and use of the *School Level Environment Questionnaire* (SLEQ), which is described fully in this chapter. Student attitudinal measures included in school effectiveness studies such as attitude towards mathematics and beliefs about success in mathematics are discussed in this review. Instructional practices and whether they are more student-centred or teacher directed, and the effects that these instructional practices have on student achievement are also discussed in this chapter. Alternative means of describing educational environments are considered and an examination is made of the associations between educational environments and student outcomes.

2.2 SCHOOL EFFECTIVENESS

The reporting of league tables is alive and well and still used by parents to decide where to send their children. This discourse of effective schools being measured by performance of students in pencil and paper limited and culturally specific tests is, according to Ball (1996) 'incoherence and perverse'. If education policy continues to be founded on school effectiveness research then the argument about what really constitutes school effectiveness should continue to be raised. The point of this section is not to be negative about research in school effectiveness but to present the arguments of serious and highly regarded academics who, although not always in agreement provide sound rationale and solid evidence for their points of view. The intent here is also to provide rationale for the methodological path of this particular investigation of factors that influence student achievement and include those factors at all levels of schooling. The strong message in this section if that school effectiveness is not independent of those in the school being student, teachers and leaders.

No one argues that defining an effective school or a good quality teacher is difficult (see Mortimore, 1991; Sammons, 1996) and it is well known that the school effectiveness research has been predominantly focussed on finding ways to measure the quality of a school which has historically been defined in terms of students' academic achievement progress in Literacy and Numeracy (Rowe, 2000). Mortimore (1991, p. 216) suggests 'an effective school is one in which pupils progress further than might be expected from consideration of its intake'. The past couple of decades has seen the concern about quality of school education become a priority policy issue in all OECD countries where attention has focused on ways of assessing the quality of schools, of identifying factors associated with effective schooling that can then be used to promote continued improvements in such quality (Banks, 1992; Chapman *et al*, 1991; Coleman & Collinge, 1991; Creemers & Scheerens, 1989; Cuttance, 1992; Hill *et al*, 1996; McGaw, Piper, Banks & Evans, 1992; Reynolds & Cuttance, 1992; Rowe, Holmes-Smith & Hill, 1993).

According to many authors, school effectiveness research grew out of studies of *educational effectiveness* focusing on production functions (Fraser, Walberg, Welch & Hattie, 1987; Hanushek, 1979, 1985, 1986; Monk, 1992), and in particular out of the initial sociologically oriented input-output studies by Coleman *et al.* (1966) and by Jencks *et al.* (1972) whose emphasis was on the student's ability to learn and family background characteristics, in determining academic performance. The findings from these studies suggested that the importance of the school and the teacher was relative to the home background and general social influences on student performance. Based on these studies authors like Hattie (1992, p.9) came to rather depressing conclusions that studies such as those from Coleman *et al* (1966) and Jencks *et al* (1972) "...provided evidence that schools and teachers are not effective in enhancing achievement". Fortunately however, a growing number of researchers critical of findings from studies such as Coleman *et al.* And Jencks *et al.* have since provided evidence to the contrary. There now exists literature supporting the belief that the effects of schooling on student outcomes are noteworthy (see for some examples Bosker et al, 1994; Creemers, 1994 & 1997; Goldstein & Sammons 1997; Hill, 1998;Rowe, 1991, 1995 & 1997). The main reason for these authors to be critical was that the hierarchical nature of the data had not been taken into account ignoring the fact that students are nested within classes and classes are nested within schools and that students in schools do not perform independently of the factors within the class or the school.

Even though we now know that measuring school effectiveness is really an attempt to answer the question about educational effectiveness and what it is we can do to improve student learning and hence student outcomes. With this knowledge and the acceptance that school effectiveness research has not in essence moved too far in the past forty years (Biddle, Good & Goodson, 1997; Hughes *et al.*, 2000) it is disappointing that the research that continues to be driven is at a system or collective school level where the focus is on improving student learning outcomes but the process rarely involves any methodology that goes beyond the classroom door.

Studies of school effectiveness such as those by Brookover et al., (1979), Edmonds, (1979a) and Rutter, Maughan, Mortimer, Ouston and Smith (1979) were in response to the findings and conclusions of Coleman and Jencks. In all these studies, after adjusting for the effects of intake characteristics, concentrated on the school context in which students were higher performers than those students in comparable schools. The findings from these studies were summarised by Edmonds (1979b) into five factors:

1. purposeful educational leadership;
2. challenging teaching and high expectations of students;
3. involvement of and consistency among teachers;
4. a positive and orderly climate; and
5. frequent evaluation of student progress.

The debate about what constitutes school effectiveness continues to be lively and in addition is liable to disagreement, as is any other area of human endeavor. This however doesn't prevent a clear message in much of the literature that says school effectiveness is still measured by indicators that characterise schools into good or bad schools (Slee & Weiner, 1998). A review of school effectiveness research commission in 1994 by the Office for Standards in Education (OFSTED) appeared to have been a genuine attempt to review school effectiveness research that turned sour. The reviewers were based at the International School Effectiveness and Improvement Centre of the London University Institute of Education *and Key Characteristics of effective Schools* (Sammons, Hillman & Mortimore, 1995), an outcome of that review demonstrates many of the problems associated with presenting findings on school effectiveness. The authors of this particular review admit that in school effectiveness research reviews outnumber empirical studies and the search for better understanding is repeatedly overridden by the external demand for marketable prescriptions (Sammons, Hillman & Mortimore, 1995). Such imbalance arises because, as the reviewers also acknowledge, school effectiveness research suffers from a 'weak theoretical base' (p.1). Further to this, Hamilton (1998) in commenting on this particular review states the problematic issues include; key factors being packaged in accessible tabular format, the aggregation of data from different studies conducted at different times, simplification in the interest of packaging and marketing, persistence to conflate clarification with simplification and a criminal acceptance that causal factors are independent, universal and additive; that is they do not interfere with each other and are uninfluenced by their context.

Initially in school effectiveness research, no distinction was made between the different levels between or within schools. There was no accounting for the inherent hierarchical structure in educational data where students are nested within classrooms, which are nested within schools. In early research on school effectiveness, there was considerable emphasis on the students' ability to learn and family background characteristics in determining academic performance. School effectiveness is concerned with how well the school achieves its educational goals of delivering the curriculum to students and providing opportunities for successful learning. This may be for comparative purposes within an educational system, or the focus may be from within the local school community.

Goldstein (1997, p. 375) described the problem of school effectiveness research as one of trying to:

> 'establish which factors are relevant in the sense that they differed between schools and also that they may be causally associated with the outcomes being measured. In this respect most academic research is limited, contenting itself with one or two measures of academic achievement and a small number of measures of social and other background variables, with little attempt to measure dynamically evolving factors during schooling.'

Carefully designed research with respect to teacher behaviour in classrooms and the structure and organisation of schools could not avoid the disappointing conclusion that student characteristics accounted for major proportions of variance in student outcomes, even though research into the relationship between teacher behaviour and student outcomes showed that teacher behaviour could account for a small proportion of the variance in student outcomes (Gibbons, Kimmel & O'Shea, 1997; Mok & Flynn, 1997; Bosker, 1999). With current more sophisticated statistical techniques, it is possible to partition variance in students' outcomes between the different levels and attribute only that variance which is unique to either the student, the classroom or the school.

The more frequent use of multilevel analytic techniques has highlighted the marked impact that teachers can have on student's measured achievement outcomes For example Cuttance (1998, pp. 1158-1159) concluded:

> 'Recent research on the impact of schools on student learning leads to the conclusion that 8-15% of the variation in student learning outcomes lies between schools with a further amount of up to 55% of the variation in individual learning outcomes between classrooms within schools. In total, approximately 60% of the variation in the performance of students lies either between schools or between classrooms, with the remaining 40% being due to either variation associated with students themselves or to random influences.'

Other British research involving Muijs and Reynolds (2001, p. vii) it is reported:

> 'All the evidence that has been generated in the school effectiveness research community shows that classrooms are far more important than schools in determining how children perform at school.'

Teachers play a pivotal role and can be positively or negatively influencial in meeting the needs of students in the classroom and this includes not only cognitive but affective and behavioural needs of these students The teacher also has a role to play in providing normative classroom environment conditions that are conducive to learning. Professor Linda Darling-Hammond (2000) states in her summary of the evidence-based finding for the effects of teacher quality on student outcomes:

'The effect of poor quality teaching on student outcomes is debilitating and cumulative. The effects of quality teaching on educational outcomes are greater than those that arise from students' backgrounds. A reliance on curriculum standards and statewide assessment strategies without paying due attention to teacher quality appears to be insufficient to gain the improvements in student outcomes sought. The quality of teacher education and teaching appear to be more strongly related to student achievement than class sizes, overall spending levels or teacher salaries.'

Further evidence for the influence of class and/or teacher-effects on students' achievements are reported from the VCE Data Project (Rowe, 2000b; Rowe, Turner & Lane, 1999). This was a population study of 270,000 Year 12 students' achievements on 53 subjects over a 6-year period (1994-1999). It has been contended that previous research studies which indicate the majority of variation in student outcomes is due to between-school effects, is in fact due to classroom variation (Rowe, 2001). Furthermore, the emphasis is that research needs to be multilevel in its design, so that the variation within schools of different classes, different pupils and different combinations of groups can be handled with the use of more sophisticated and appropriate statistical techniques (Reynolds & Cuttance, 1992).

2.3 BACKGROUND EFFECTS

In most countries, educational outcomes are related to the social background of the students (Keeves & Saha, 1992). This includes, among other factors, the gender of the student, the socio economic status (SES) of the family (and hence the student) and the ethnicity and language characteristics of the student.

A multilevel investigation by Mok and Flynn in 1997 designed to examine the achievement of students in Catholic schools in New South Wales showed parents' levels of education made a significant contribution to achievement. High SES schools also scored better in the Higher School Certificate than medium or low SES schools (Mok & Flynn, 1997).

In a meta analysis including of approximately 200 studies by White (1982), a high correlation between SES and achievement was found (r = 0.875), while Keeves and Saha (1992) demonstrated that SES indirectly influences student achievement while the direct effects on student achievement are associated with other variables. A multilevel analysis of over 3,000 students in 30 schools in Victoria indicated a direct effect of SES on achievement in English in secondary schools (Hill, Holmes-Smith, & Rowe, 1993). Due to the reported importance of the relationship and effects of student background variables on achievement outcomes, socio-economic status of the student is included in this present study.

In the TIMSS study early reports indicate a positive relationship observed between mathematics achievement and home factors for every country that participated (Beaton et al, 1996). The more educational resources in the home the higher the student achievement than those who reported little access to such resources. Strong positive relationships were found between mathematics achievement and having study aids in the home. In most TIMSS countries, the more books the student reported in the home, the higher their mathematics achievement.

2.3.1 Student Attitudes and Attribution

Research has demonstrated positive correlations between attitudes to mathematics and achievement in mathematics. In a comparative study of factors influencing mathematics achievement, a direct link was found between students' attitudes toward mathematics and student outcomes among the students who participated in that particular study (Burstein, 1992). Further to these findings, in this same research study, 25 per cent (in England) and 26 per cent (in Norway) of the variation in students' attitude toward mathematics was explained by student gender, maternal expectation, expectations of the students friends, and success attribution (belief about success in mathematics).

In an early international study of mathematics and science reported by Lapointe, Mead and Phillips in 1989, data were collected on both instructional practices and attitudes towards mathematics and science however only descriptive statistics were reported. It was also raised that inconsistencies in the results point to cultural differences in the way students answered some of the questions. For example, about two-thirds of United States 13-year olds responded that they were good at mathematics despite their poor overall performance, while only 23 percent of the Korean students, the best performers in that survey, had that same attitude. Although not causal and with no consideration of any confounding effects, it was reported from that study that students in all groups who gave a positive response to the statement about whether they are good at mathematics, were also higher mathematics performers than those students who gave a negative response (Lapointe et al, 1989).

In the recent TIMSS data a clear positive relationship was observed between a stronger liking of mathematics and higher achievement (Beaton et al, 1996). In nearly all countries who participated in this study, there was also a clear relationship between perception and performance, with those students reporting higher self-perceptions of doing well in mathematics also having higher average achievement.

It was suggested in this study that the design of international comparative studies like TIMSS should be appropriate for multi-level data analysis and further research into the effects of attitude toward mathematics on mathematics outcomes should be conducted with this in mind. The disaggregation of scores on teacher variables to the student level should be avoided as this results in lower variance estimates, and therefore correlations with achievement are under reported (Burnstein, 1992).

Student beliefs and attitudes have the potential to either facilitate or inhibit learning. Students' attitudes about the value of learning science may be considered as both an input and outcome variable, because their attitudes towards the subject can be related to educational achievement in ways that reinforce higher or lower performance (Gibbons, Kimmel & O'Shea, 1997). That is, students who do well in a subject generally have more positive attitudes towards that subject, and those who have more positive attitudes towards a subject tend to perform better in that subject. Attribution theory is concerned with how a student perceives causality and the consequences of those perceptions (Trusted, 1989; Railton, 1993; Brandt, 1998). In relation to learning, attribution theory illuminates how a student understands and reacts to their achievement, whether it is judged to be the result of internal factors (ability and effort), or external factors (good or bad luck). In measuring student success attribution, we are measuring the degree of perceived personal responsibility for success or failure. When students are asked about their success orientation they are responding to the particular orientation of their perceived success and are also indicating whether it was internal or external in origin.

2.4 SCHOOLING EFFECTS

Many empirical studies from the early days of research on the stability or consistency of school effects have been considered methodologically inadequate because of their inability to take into account the within-school variation in academic achievement (Cuttance, 1992). To resolve this problem, for over a decade now, many researchers have adapted the multilevel approach of data analysis to accommodate the hierarchical structure of educational data (for example, students nested within schools) (Bryk & Raudenbush, 1987, 1989; Rowe, 1990; Burnstein, 1992; Hill & Rowe, 1996; Goldstein, 1997).

Another reported limitation in previous research on school effects was the lack of adequate statistical control over school characteristics (Raundenbush & Willms, 1991). They contended that many previous analyses on school effects were conducted without any understanding of schooling processes at the school level. The term " schooling processes" refers to the many variables associated with schooling that either directly or indirectly affect schooling outcomes (Cuttance, 1992). Schooling processes can often be classified into two sets of variables. One set of variables describes the context of a school and the other set of variables is associated with the environment or climate of the school. Three of the most important climate variables, which can be directly controlled through the actions of teachers, parents, and principals are the disciplinary climate of the school, the expectations of peers and teachers (referred to as "academic press"), and the extent of parental involvement in children's schooling. Research has shown that these variables are strongly related to student schooling outcomes, particularly academic outcomes (Cuttance, 1992).

So much research on student achievement outcomes has been focussed at the school level (Cuttance, 1998; Hughes et al., 2000, Nash & Harker, 1997), the findings that class effects and teacher effects are so substantial is a more recent phenomenon in an empirical sense. Muijs ad Reynolds (2000, p.*vii*) from British research comment as follows:

> 'All the evidence that has been generated in the school effectiveness research community shows that classrooms are far more important than schools in determining how children perform at school'.

In the US, Biddle, Good and Goodson (1997) emphasize the gains in knowledge about effective teaching arising out of the past 30 years and point out that since 1975 we do know a lot more about the differences in the quality of instruction provided by teachers to students and that the differences in classroom practices do have an impact on students' academic learning.

2.4.1 Opportunity to Learn

Results from the International Organisation for Educational Achievement Classroom Environment Study indicated that quality of instruction directly influenced academic gain in both mathematics and science (Lapointe, mead & Phillips, 1989). Opportinuty to learn in this study was a measure of the students' exposure to curriculum material. The results of this study also showed that students' opportunity to learn varied greatly, between countries, between schools, and between classrooms. Within-country opportunity to learn variance of over 300 per cent was common, regardless of country. Students who spent more time engaged in learning activities showed more academic gain. (Burstein, 1992). In the Classroom Environment Study of the Second International Mathematics Study (SIMS), it was found that the one variable on which the study was able to produce an unequivocal finding was 'Opportunity to Learn'. The more exposure to mathematics content the students had, the higher their mathematics achievement. Burstein stated that while students will not learn all they have been taught, they have to be incredibly resourceful to learn mathematics to which they have not been exposed to (Burstein, 1992, p. 339).

2.4.2 Teacher Characteristics and Instructional Practices

It is reasonable to assume that the characteristics of the teachers, and their experiences and behaviours in the classrooms, contribute to the learning environment of their students, which in turn will have an effect on student outcomes. Although we don't undermine the role of the parent in affecting student learning the data most often collected and used in research is that of the student, teacher and school and in this present study no parent data is included. Also acknowledged is the difficulty in establishing causal links between such factors and student outcomes however this study goes a considerable way to illustrate important influences on student outcomes by way of sophisticated statistical methods employed on well collected data.

A common hypothesis with respect to the relationship between teacher experience and student achievement is that students taught by more experienced teachers achieve at a higher level, because their teachers have mastered the content and acquired classroom management skills to deal with different types of classroom problems (Slavin, 1987; Evans, 1992; Gibbons et al, 1997). In addition, more experienced teachers are considered to be more able to concentrate on the most appropriate way to teach particular topics to students who differ in their abilities, prior knowledge and backgrounds (Raudenbush & Williams, 1991; Stringfield & Teddlie, 1991).

Not all authors agree that there is clear evidence that different types of instructional practices influence achievement and in addition to running regression analysis of the cross sectional data from 20 countries, the Second International Mathematics Survey (SIMS) (Burnstein, 1992) had devoted considerable effort to a longitudinal study of value-added in eight countries with extensive analysis of different teaching methods. The results of this particular analysis indicated that students do experience different types of instructional arrangements however the influence of these arrangements generically was weak relative to such matters as prior learning and the contents of learning opportunities during the course of study (Burnstein, 1992).

In the early days of school effectiveness research, Carroll in his Model of School Learning proposed the following five elements contributing to the effectiveness of instruction:

- aptitude;
- ability;
- perseverance;
- opportunity; and
- quality of instruction.

Carroll's model of school learning mixed two kinds of instructional elements; those elements that are directly under the control of the teacher and those elements that are characteristics under the control of students with the latter of these elements being recognised as difficult to change. Quality of instruction and opportunity to learn (time) are directly under the control of the teacher or the school. Aptitude to learn is mostly an individual characteristic of students over which teachers can have little control in the short term. Ability to understand instruction and perseverance are partly under the control of the teacher, but also partly under the control of the student. Perseverance is a function of both the motivation to learn that a student brings to school and the specific strategies a teacher or school might use to motivate their students to do their best. The Carroll model was the basis for Bloom's concept of Mastery Learning (Bloom, 1976) and is related to 'direct instruction', as described by Rosenshine (1983). Characteristics of this approach to mastery learning are:

- clearly defined educational objectives;
- small discrete units of study;
- demonstrated competence before progress to later hierarchically related units;
- remedial activities keyed to student deficiencies; and
- criterion-referenced rather than non-referenced tests.

Direct instruction also emphasises structuring the learning task, frequent monitoring and feedback, and high levels of mastery, in order to boost the self-confidence of the students. These characteristics of effective instruction support Carroll's 25-year retrospective of his original model where high-quality instruction prescribes that learners must be clearly told what they are to learn, that they must be put into adequate contact with learning materials, and that steps in learning must be carefully planned and ordered (Carroll, 1989).

Slavin (1987) proposed a model of effective instruction that focused on the alterable elements of Carroll's model: those that teachers and schools could have the opportunity to directly change. The elements of this model are:

- quality of instruction;
- appropriate levels of instruction;
- incentive; and
- time.

Slavin (1987) believed that quality of instruction, appropriate levels of instruction, incentive, and time must all be adequate for instruction to be effective. In a report of the Tennessee Value-Added Assessment system (TVAAS), which uses scaled scores to indicate students' levels of achievement, the single largest factor affecting academic growth of student populations is differences in effectiveness of individual classroom teachers. The effects of class size and degrees of heterogeneity of prior achievement within the classroom are but two factors whose impact pales in comparison with the differences in teacher effectiveness.

During the last decade a blending of approaches to instructional effectiveness has taken place. Brophy (1996) suggested a way of integrating the principles of structured classroom management and the principles of self-regulated learning strategies. Elements of effective classroom management such as preparation of the classroom as a physical environment suited to the nature of the planned academic activities, development and implementation of a work-able set of housekeeping procedures and conduct rules, maintenance of student attention, participation in assignments, and noting the progress students are making toward intended outcomes, are equally relevant when instruction is seen as helping students to become more autonomous and self-regulated learners (Brophy, 1996). When it comes to implementing new instructional principles, Brophy suggested a guided, gradual approach where learning goals and expectations are clearly articulated, and students are helped by means of modelling and the provision of cues. Brophy also stressed the fact that, initially, students may need a great deal of explanatory assistance, the opportunity for modelling, and cueing of self regulated learning strategies.

Teaching and learning in the classroom has been described from three general perspectives: instruction, participation and investigation (Keeves & Dryden, 1992). Firstly, there is the perspective of teaching involving imparting information. That which is predominantly teacher-directed instruction or the transmission of knowledge by the teacher (instruction). Secondly, there is the perspective of teaching as meeting the needs of the students, involving student participation (participation). Thirdly, there is the more scientific perspective in which the learning is seen as a process of investigation of practical work and open-ended inquiry learning by the student (investigation).

2.5 RESEARCH ON EDUCATIONAL ENVIRONMENTS

Much attention has been focused on research into factors that influence student learning outcomes in schools. Walberg (1991) wrote about these factors and grouped them into three main areas; Student Aptitude, Instruction, and Psychological Environments. He believed that it was possible that optimized learning environments could lead to enormous increases in academic learning and real-world achievements. The study described in this thesis concentrates on the psychosocial environments of schools.

For school effectiveness studies to give a clear and accurate picture of what is happening in classrooms and schools, researchers and teachers should include classroom environment scales as part of the battery of measures traditionally used in such studies (Fisher & Fraser, 1990). Supporting this it is believed that the environmental setting must first be conceptualised or understood before its impact on student behaviour could be evaluated (Moos, 1979). Anderson and Walberg (1974) stated there is a strong case for environmental research on growth rates in learning and learning effects and pointed to the development of measures of environment as crucial for accurate prediction and effective manipulation of learning.

2.6 HISTORICAL BACKGROUND OF THE STUDY OF LEARNING ENVIRONMENTS

Two factors that affect any person's behaviour are the genetic background they have and the environment in which they grow up. There has been much interest in the degree of influence of each of these factors. This is the so-called "nature-nurture debate". Some of those studying child development have believed that the heredity factor is the more important because it determines the basic material from which a person develops. Studies of identical twins have obtained similar results for both twins on various tests after many years of separation. In some cases, the twins have pursued similar careers and even had similar mannerisms. Others studying in this particular area of psychology have been more impressed by the influence that the environment has on a child's upbringing. Researchers known as "environmentalists" or "empiricists" point to differences that are observed in children brought up in different environments. Assessing the relative influence of genetic background and environment is extremely difficult, however, since there is a constant interaction between these two and other factors during a child's development.

The nature-nurture debate has been expressed as a formula which is founded on the belief that a person's behaviour (B) is a function of the relationship between the person (P) and the environment (E), i.e. $B=f(P,E)$. In these early days of the study of human environments, Murray (1938) introduced the term *alpha press* to describe the environment as assessed by a detached observer and *beta press* to describe the environment as observed by those within that environment. These ideas were extended further to include perceptions of the environment unique to the individual (called *private beta press*) and perceptions of the environment shared among the group (called *consensual beta press*) (Stein, Linn, & Stein, 1986).

It has been argued that, since teachers have no control over their students' genetic backgrounds, they must be environmentalists and attempt to bring about a climate that maximises a student's learning (Walberg, 1979). It was recognised however, that the child's home environment was also important because it has a significant influence on the development of a child's cognitive ability and affective characteristics (Marjoribanks, 1979). This thesis concentrates on the role of the school rather than the family in investigating student outcomes but does include several student background variables of interest.

2.7 STUDYING HUMAN ENVIRONMENTS

Three approaches to studying human environments were described by: organisational structure approach, personal characteristics approach and psychosocial and social approach (Moos, 1973). The first approach describes the dimensions of the organisational structure. With this approach the quality of a school's environment is measured in terms of such factors as size, staffing ratios, salaries and qualifications of the staff. Organisational factors such as these are believed to influence the behaviour of the individuals in that environment. A second approach to studying human environments involves describing the personal characteristics of the people in that environment. The assumption underlying this approach is that the character of any environment depends on the nature of its members. Third, Moos referred to the description of the psychosocial and social dimensions of the environment as perceived in a framework of person-milieu interaction. These perceptions are made by either those inside the environment or by observers from outside the environment. This third approach is the framework used to describe the school-level environment in this present research study.

In order to conceptualise the individual dimensions characterising diverse psychosocial environments, Moos (1973) found that the same three general categories can be used. This finding emerged from Moos' work in a variety of environments including hospital wards, school classrooms, prisons, military companies and university residences. The three basic types of dimensions are: Relationship Dimensions (for example, peer support, cooperation) which identify the nature and intensity of personal relationships within the environment and the extent to which people support and help each other; Personal Development Dimensions (for example, autonomy, independence) which assess the basic directions along which personal growth and self-enhancement tend to occur; and System Maintenance and System Change Dimensions (for example, order and organization, innovation) which involve the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change.

Based on these dimensions, a series of environment measures(which are developed in the form of questionnaires) including the *Classroom Environment Scale* (CES) was developed (Moos, 1973). Students were asked for their perceptions of the learning environment of the class they were in. Also developed was the *Work Environment Scale* (WES), which asked people in factories and other work places for their perceptions of their work environments. At about the same time, during an evaluation of Harvard Project Physics the development of an instrument was deemed necessary to assess learning environments in physics classrooms. This instrument, the *Learning Environment Inventory* (LEI) (Walberg, 1968) asked students for their perceptions of the whole-class environment. These three questionnaires provided considerable impetus for the study of classroom learning environments and provided models for the development of a range of instruments over the next three decades or so (Fraser, 1998). For example, recent classroom environment research has focused on constructivist classroom environments (Taylor, Fraser, & Fisher, 1997) computer-based tertiary classrooms (Newby & Fisher, 2000) science laboratory classroom environments (Fraser, Giddings, & McRobbie, 1995) and teacher interpersonal behaviour in the classroom (Wubbels & Levy, 1993).

Following the development of these questionnaires, assessment of the qualities of the classroom learning environment from the perspective of the student (Fraser, 1991, 1994, 1998; Fraser & Walberg, 1991) and the association between learning environment variables and student outcomes has provided a particular focus for the use of learning environment instruments. In a meta-analysis which examined 823 classes in eight subject areas and represented the perceptions of 17,805 students in four nations, enhanced student achievement was reported in classes which students felt had greater cohesiveness, satisfaction, and goal direction, and less disorganization and friction (Haertel, Walberg, & Haertel, 1981). Subsequent reviews have supported the existence of associations between classroom environment variables and student outcomes (Fraser, 1998).

2.8 SCHOOL ENVIRONMENT

The focus in this thesis is on the school-level environment therefore it is useful to distinguish between school-level and classroom-level environment. Whereas classroom environment might involve relationships between teachers and their students or among students, school environment might involve a teacher's relationships with other teachers, senior staff, and the school Principal. Student perceptions are used frequently to measure classroom environment, but rarely in measuring school environment because it is felt that students could be unaware of many aspects of the school-level environment. The school environment can be considered more global than the classroom environment (Fraser & Rentoul, 1982; Genn, 1984).

For many years there has been an inference in educational literature that a good school environment is linked with student achievement (eg. Fraser, 1998). The suggestion is that, if teachers have a good working environment, then better student achievement will be one positive result. Supporting this Hughes (1991) asserted that every school has a pervasive environment, and what this environment is like influences the behaviour of staff and students to succeed in teaching and learning. In addition, the quality of school environment may influence the behaviour of all participants and especially students' academic performance (Brookover et al., 1979). Research is persuasive in suggesting that student academic performance is strongly affected by school environment and whilst support can also be found for the hypothesis that schools with favourable environments, climates or cultures are academically more successful with students, some researchers have argued that conclusions about these relationships are premature because the data on school environments and student outcomes have been confounded by several issues at class and school levels (Walberg, 1983). The link between school environment and student achievement continues to be of interest and is addressed in this study.

That teachers create an effective school is a view supported strongly by Australian school communities, however, effective schools are more than simply a collection of effective classrooms. The more appropriate way to conceptualise the link between schools and students is to see it as mediated by teachers. Teachers' perceptions of teaching, learning and the curriculum and the teaching practices employed in the classrooms can affect student learning and in addition it is important to consider in educational research the way in which the school organisation influences teachers' efficacy and satisfaction with their teaching roles.

2.8.1 School Level Environment Questionnaire

There have been fewer examples of instruments that have been used to assess the school-level environment than have been developed to assess classroom-level environment. Some of these are: the *College Characteristics Index* (CCI) (Pace & Stern, 1958) which measures student or staff perceptions of 30 environment characteristics; the *High School Characteristics Index* (HSCI) (Stern, 1970) which is an adaptation of the CCI; the *Organizational Climate Description Questionnaire* (OCDQ) (Halpin & Croft, 1963) and the *Work Environment Scale* (WES) (Fisher & Fraser, 1990; Fisher, Fraser, & Wubbels, 1993; Moos, 1991).

Using Moos' conceptualisation, Fisher and Fraser (1990) developed the School Level Environment Questionnaire (SLEQ), which measures teachers' perceptions of psychosocial dimensions of the environment of a school. Work with the SLEQ grew out of previous work with the WES. A careful review of the potential strengths and problems associated with existing school environment instruments, including the WES, suggested that the SLEQ should satisfy the following six criteria (Fisher & Fraser, 1990; Fisher et al., 1993; Rentoul & Fraser, 1983).

1. Relevant literature was consulted and dimensions included in the SLEQ were chosen to characterise important aspects in the school environment, such as relationships among teachers and between teachers and students and the organisational structure (for example, decision making).
2. Dimensions chosen for the SLEQ provided coverage of Moos' three general categories of dimensions – Relationship, Personal Development and System Maintenance and System Change.
3. Extensive interviewing ensured that the SLEQ's dimensions and individual items covered aspects of the school environment, which were perceived to be salient by teachers.
4. Only material which was specifically relevant to the school was included.
5. As a number of good measures of classroom environments already existed, the SLEQ was designed to provide a measure of school-level environment which had minimal overlap with these existing measures of classroom-level environment.
6. In developing the SLEQ, an attempt was made to achieve economy by developing an instrument with a relatively small number of reliable scales, each containing a fairly small number of items.

It was found that the above criteria for an instrument to measure school environment could be satisfied with an instrument consisting of eight scales altogether, with two measuring Relationship Dimensions (Student Support and Affiliation) one measuring the Personal Development Dimension (Professional Interest) and five measuring System Maintenance and System Change Dimensions (Staff Freedom, Participatory Decision Making, Innovation, Resource Adequacy and Work Pressure). The original SLEQ consisted of 56 items, with each of the eight scales being assessed by seven individual items.

2.8.2 Reliability and Validity of the School Level Environment Questionnaire

Fraser (1994) reported on three samples where the SLEQ had been used with teachers (see Table 2.1) and the internal consistency for each of the scales ranged from 0.64 to 0.87, indicating for those three samples satisfactory internal consistency for the scales composed of seven items. The discriminant validity, which is reported as being a mean correlation of a scale with each of the other scales, ranged from 0.19 to 0.38 for the first sample, 0.05 to 0.29 for the second sample and 0.10 to 0.38 for the third sample (see Table 2.2). This was considered a satisfactory level of discriminant validity to demonstrate that the instrument measures distinct although somewhat overlapping aspects of the school environment (Fraser, 1994).

To determine if the SLEQ could differentiate between different schools an analysis of variance was carried out. Fisher and Fraser (1990) reported that a one-way ANOVA was performed for each scale, with school membership as the main effect. They reported that each scale of the SLEQ differentiated significantly between schools with the eta^2 statistic (reported as an estimate of the proportion of variance in SLEQ scores attributable to school membership) ranging from 0.16 to 0.40.

Table 2.1

Alpha Reliabilities for SLEQ Scales for Three Samples

Scale Name		Alpha Reliability		
		Sample 1	**Sample 2**	**Sample 3**
Student Support		0.70	0.79	0.85
Affiliation		0.87	0.85	0.84
Professional Interest		0.86	0.81	0.81
Staff Freedom		0.73	0.68	0.64
Participatory Decision Making		0.80	0.69	0.82
Innovation		0.84	0.78	0.81
Resource Adequacy		0.81	0.80	0.65
Work Pressure		-	-	0.85
Sample	Teachers	83	43	109
Size	Schools	19	34	10

Note. From "Research on Classroom and School climate" by B. Fraser, 1994, in *Handbook of Research on Science Teaching and Learning*, D. Gabel (Ed), New York: Macmillan, p.505.

*Work Pressure was not included in the original form of the SLEQ

Table 2.2

Discriminant Validity for Each SLEQ Scale

Scale Name		Mean Correlations with Other Scales		
		Sample 1	**Sample 2**	**Sample 3**
Student Support		0.19	0.19	0.10
Affiliation		0.34	0.18	0.38
Professional Interest		0.29	0.29	0.36
Staff Freedom		0.31	0.05	0.30
Participatory Decision Making		0.34	0.22	0.34
Innovation		0.38	0.22	0.42
Resource Adequacy		0.22	0.19	0.35
Work Pressure		-	-	0.30
Sample	Teachers	83	43	109
Size	Schools	19	34	10

Note. From "Research on Classroom and School climate" by B. Fraser, 1994, in *Handbook of Research on Science Teaching and Learning*, D. Gabel (Ed), New York: Macmillan, p.505.

*Work Pressure was not included in the original form of the SLEQ

The SLEQ has been modified recently (Fisher & Cresswell, 1999) but still contains eight scales each being measured with seven individual items (see Table 2.3). Recognising the recent trend of schools to be involved in strategic planning processes, a scale titled Mission Consensus was added and two other scales (Staff Freedom and Particpatory Decision Making) were combined into one and the new scale is called Empowerment. The SLEQ is now composed of the scales of Student Support and Affiliation (Relationship Dimension), Professional Interest (Personal Development Dimension), Empowerment, Innovation, Resource Adequacy, Mission Consensus and Work Pressure (System Maintenance and System Change Dimension). A Cronbach alpha value of 0.84 for Mission Consensus, the added scale, was reported in a research study of school environments and science classroom environments in Australia (Fisher & Cresswell, 1999).

Each item in the SLEQ is scored on a five-point scale with the responses of 5=Strongly Agree, 4=Agree, 3=Not Sure, 2=Disagree and 1=Strongly Disagree. Table 2.3 clarifies further the nature of the SLEQ by providing a scale description and sample item for each scale and shows each scale's classification according to Moos' scheme. As well, Table 2.3 provides information about the method and direction of scoring of SLEQ items. This particular version of the SLEQ was used in this study.

Fisher and Cresswell (1999) provided a detailed analysis of the data obtained from the use of the modified version of the SLEQ with 850 teachers and 50 principals throughout Australia. The data showed that the SLEQ is a reliable and valid instrument to measure perceptions of school environment. Analysis of responses to the SLEQ revealed that each scale had acceptable internal consistency, with all scales having a Cronbach alpha reading of greater that 0.72. By conducting a one-way ANOVA for each scale with school membership as the main effect, it was found that each SLEQ scale differentiated significantly ($p < 0.001$) between schools, attesting to its reliability and ability to differentiate between schools.

2.8.3 Associations Between School-Level Environments and Student Outcomes

The link between school environment and students outcomes is not as explicit as the link between classroom environment and student outcomes. Considering studies that linked school environment to student outcomes, Fraser (1986) referred to a study by Perkins (1978) involving a large number of students (3,700) and the 958 teachers of these students and which reported significant simple correlations between the basic skills of these students and the school environment scales which were measured in this study. Using multiple regression analysis, Perkins found that the amount of variance accounted for by the set of 14 school environments scales ranged from 64 percent to 76 percent for the basic skills test. It was also found in this study that the teachers' perceptions of their school's educational effectiveness was particularly important in determining student outcomes. In another study involving over 800 students (Brookover et al, 1979), reported significant simple correlations between student achievement and environment scales measured at the school-level.

Table 2.3

Description of the Scales in the SLEQ

Scale Name	Description of Scale	Sample Item	Moos Category
Student Support	There is good rapport between teachers and students, and students behave in a responsible self-disciplined manner	There are many disruptive, difficult students in the school (-)	Relationship
Affiliation	Teachers can obtain assistance, advice and encouragement, and are made to feel accepted by their colleagues	I feel that I could rely on my colleagues for assistance if I should need it (+)	Relationship
Professional Interest	Teachers discuss professional matters, show interest in their work and seek further professional development	Teachers frequently discuss teaching methods and strategies with each other (+)	Personal Development
Mission Consensus	Consensus exists within the staff about the goals of the school	Teachers agree on the school's overall goals (+)	System Maintenance and System Change
Empowerment	Teachers are empowered and encouraged to be involved in decision making processes	Decisions about the running of this school are usually made by the principal or a small group of teachers (-)	System Maintenance and System Change
Innovation	The school is in favour of planned change and experimentation, and fosters classroom openness and individualisation	Teachers are encouraged to be innovative in this school (+)	System Maintenance and System Change
Resource Adequacy	Support personnel, facilities, finance, equipment and resources are suitable and adequate	The supply of equipment and resources is inadequate (-)	System Maintenance and System Change
Work Pressure	The extent to which work pressure dominate school environment	Teachers have to work long hours to keep up with the work load (+)	System Maintenance and System Change

Note. Items designated (-) are negatively worded items and require recoding. From "Research on Classroom and School climate" by B. Fraser, 1994, in *Handbook of Research on Science Teaching and Learning*, D. Gabel (Ed), New York: Macmillan, p.505.

Chapman, Angus, Burke & Wilkinson (1991), suggested from their research into school environments and students outcomes that schools that emphasise supportiveness, open communication, collaboration and intellectuality, and schools that reward achievement and success, outperform those schools that emphasise competition, constraint and restrictiveness, and rules and standard operating procedures, and that reward conformity.

2.9 SUMMARY

It is apparent from this review of relevant literature that previous studies have concentrated on factors influencing achievement at the student level and the school level. Few studies have included in the analysis factors at the class level and no previous studies have been concerned with or taken account of those influences at the school level which impact at both the class level and the student level. In our education systems it is difficult to make changes at the student level due to class size restrictions, factors outside the school which are beyond our influence and the diversity of student within classes. Therefore, it is essential that changes within classes and schools are based on evidence that demonstrate where the greatest effects are going to be in promoting better student achievement outcomes. This chapter clearly demonstrates that the majority of research into school effectiveness is handled at a policy or collective school level and although it is well known that student learning outcomes are most likely to be challenged at the classroom level and by teachers who are operating in an environment that has an influence on how they operate, there is still the need for empirical evidence to support this.

This present study enabled a detailed investigation into school level environment factors and the direct and indirect effects these factors had on student achievement. An investigation of the relationships with both cognitive and affective student outcomes revealed interesting and new results. Chapter Three presents the unique methodology used in this study and discusses the issues relating to measurement models, structural equation models and multilevel models.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

Chapter Two presented an explanatory model of student performance in mathematics which incorporated the student home background, student attitudes, teaching practices, student opportunity to learn mathematics and school-level contextual and environment factors. The Third International Mathematics and Science Study (TIMSS) provided this research with a large database, from which a sample of 57 Australian schools was surveyed further and data collected using the School Level Environment Questionnaire (SLEQ) in each of these schools. These data were combined and used to investigate within a single model, the influence of classroom level and school level factors on student cognitive and affective outcomes and the relationships that existed between the variables in this model.

This chapter describes the methodology used in this study. Section 3.2 describes the techniques of secondary analysis including the limitations associated with data previously collected for another purpose and the manner in which the TIMSS data were collected. The Third International Mathematics Science Study is then described in section 3.3 in the context of the 45 participating countries and the facilitating organisation, the International Association for the Evaluation of Educational Achievement. The sample design, with its stratification and two-stage cluster nature, is then reviewed in section 3.4. The next section, 3.5, summarises the tests and instruments used in this study and discusses the additional scales that were developed from observed items in these instruments. A full description of the construction of the latent variables used in both the Structural Equation Modelling and the Multilevel Analysis is given in section 3.6.

3.2 SECONDARY ANALYSIS

The basic procedure used in this study was secondary analysis which involves the analysis of data collected previously by other researchers. It is a very general label covering a wide range of analyses. The TIMSS data-base was extraordinarily large in terms of numbers of students and numbers of variables. The range of problems associated with this type of research and the skills required differ from those involved in smaller scale studies and those where different methodologies are used to conduct the research. In this reported research, adequate measures have been taken and procedures followed to allow an accurate and detailed interpretation of all the results presented from the measurement models and the structural equation models to the multilevel modelling. Details of these procedures are to follow and difficulties associated with international achievement studies are discussed in Chapter one and two as well as the benefits and purposes of international achievement studies

A recognised advantage of secondary analysis is the availability of very large data sets that are often not easily obtained by individual researchers, the low cost of these databases when used for secondary analysis and the reduced student response burden on schools by using data collected on one occasion to answer research questions on subsequent occasions without collecting further data from schools and students. The problems associated with secondary analysis can be that the statistical expertise necessary for this type of analysis is not available, the data are not in a useable form due to poor documentation and are often difficult to understand, it takes time to understand the data in terms of what information is present, and the data may not contain the precise variables of interest and be of limited quality. For example, in this present study, a significant limitation was the lack of a measure of students' prior mathematical ability, not allowing the concept of value added or distance traveled, which are terms used to describe improvement in student outcomes, to be explored. The data used in this study involved that collected for the Third International Mathematics and Science Study which is described in detail in the section below.

3.3 THE THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

The TIMSS database came with excellent and comprehensive documentation and explanation of variables. Additional information was available from the Australian Council for Educational Research (ACER) or from the TIMSS web site (http://wwwcsteep.bc.edu/timss). Several official reports arising from the Boston offices of the IEA are available, have been accessed and referred to in chapter one and two in the discussions surrounding international achievement studies. These include Mathematics Achievement in the Middle School Years by Beaton, Mullis, Martin, Gonzalez, Kelly and Smith (1996); Technical reports by Martin and Kelly (1996) and Maths & Science on the Line by Lokan, Ford and Greenwood (1996). Several other publications produced by the Boston offices of the IEA authored by Mullis *et al.* (1997, 1998) specifically report on the mathematics achievement results from the TIMSS.

Some major advantages of the TIMSS database that have been reported are:

- the dependability and reliability of the database and documentation;
- the random sampling of students on national bases;
- the availability of student variables all on one record so that databases do not need to be merged for analysis;
- the provision of a code book to facilitate interpretation of the raw data;
- the provision of common core questions to enable the entire samples to be used for analyses; and
- the comparability of the tests in 30 languages enabling international comparisons to be made.

Limitations of the TIMSS data base to this study included restrictions in using variables chosen previously which did not adequately address the issues of social and environmental influences on mathematics achievement. In addition, cross-sectional studies do not allow for the measurement of growth and change as discussed in section 3.2. (Holmes-Smith & Rowe, 1993). As a result, this study reports estimates of differences in mathematics achievement based on average achievement levels statistically adjusted for relevant intake characteristics, for example, the socioecomonicstatus of the student. Further detail of the mathematics score used in the analysis is provided in section3.7.1.

3.4 SAMPLE DESIGN OF THE THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

3.4.1 Target Populations

TIMSS is a cross-national survey of student achievement in mathematics and science that was conducted at three levels of the educational system:

- two adjacent grades with the largest proportion of 9-year olds at the time of testing (third and fourth grades in many countries)
- two adjacent grades with the largest proportion of 13-year olds at the time of testing (seventh and eighth grades in many countries)
- final year of secondary education

Forty-five countries eventually agreed to participate in the survey. The students, their teachers, and the principals of their schools were asked to respond to questionnaires about their backgrounds, their attitudes towards mathematics, experiences, and practices in the teaching and learning of mathematics and science.

3.4.2 General Sample Design

The basic sample design used in the TIMSS was a two-stage stratified cluster design of three different populations (Rosier & Ross, 1992). The first stage consisted of a sample of schools; the second stage consisted of samples of intact mathematics classrooms from each eligible target grade in the sampled schools. The design required schools to be sampled using a probability proportional to size systematic method (PPS), as described by Foy, Rust, and Schleicher (1996) and class rooms to be sampled with equal probabilities (Schleicher & Siniscalo, 1996).

The TIMSS sampling approach allowed countries to stratify the school sampling frame explicitly or implicitly, or both. Explicit stratification consisted of categorising schools according to some criterion (for example, region of the country) ensuring that a predetermined number of schools were selected from each explicit stratum. Implicit stratification consisted of sorting the school sampling frame according to a set of criteria prior to sampling. This produced an allocation of the school sample proportional to the implicit strata when schools were selected using a systematic PPS sampling method.

While a multi-stage stratified cluster design greatly enhances the feasibility of data collection it results in differential probabilities of selection; consequently, each student in the assessment does not necessarily represent the same number of students in the population, as would be the case if a simple random sampling approach were employed. To account for differential probabilities of selection due to the nature of the design, TIMSS computed a sampling weight for each student that participated in the assessment and these weights were included in all analyses involving student data.

3.4.3 Participation Rates

Weighted school, student, and overall participation rates were computed for each participating country for each grade. The procedures for computing participation (response) rates are documented by Foy, Rust, and Schleicher (1996). The level of participation of schools and students was one aspect of the national samples used to evaluate the quality of the samples and potential biases. The numbers of schools, students and teachers who participated in the TIMSS study is reported in Table 3.1.

Table 3.1

Number of Schools, Students and Teachers participating in TIMSS

	Total numbers
Schools	161
Teachers	1447
Students	12852

3.4.4 Sampling Weights

Complex survey samples, such as those in TIMSS, typically have sampling errors much larger than a simple random sample of the same size. This is because the elements of the clusters that are the building blocks of complex samples (in TIMSS the elements are students grouped in classes within schools) usually resemble each other more than they do members of the population in general. Consequently, a sample of size *n* drawn using simple random sampling from a population will usually be more efficient (i.e., have smaller sampling errors) than a sample of the same size drawn by sampling of pre-existing clusters in the population.

The general weighting procedure for TIMSS required three steps. The first step for all target populations consisted of calculating a school weight. The second step consisted of calculating a classroom weight, which was calculated independently for each school and grade. The final step consisted of calculating a student weight independently for each sampled classroom. The overall sampling weight attached to each student record is the product of the three intermediate weights: school, classroom, and student.

3.5 SAMPLE DESIGN OF THE AUSTRALIAN SCHOOLS

All of the Australian schools that participated in the TIMSS study were invited to also participate in the school level environment study which forms the basis of this thesis. This time, school selection was on a voluntary basis. Requests to principals were in the form of a letter (see Appendix C) explaining the aims of the research and seeking their cooperation. There were initially 161 letters posted to schools in all states and territories, (all the schools which participated in the TIMSS study), asking them if they would allow their staff members to participate in the study. A total of 57 schools agreed to participate and from these schools 620 teachers returned completed questionnaires.

3.6 DESCRIPTION OF THE AUSTRALIAN SAMPLE

To ensure that the study was representative of a wide variety of situations and types of schools, requests to participate were sent to all TIMSS participating schools, with the aim of collecting data from a large, diverse sample of schools. The sample description resulted by TIMSS and the subsequent schools participating in this study were similar (see Table 3.2).

Therefore, it was considered that an adequate balance in the final participating schools was obtained that would be regarded as representative of Australian schools. Being cross sectional in nature, however, regardless of sample size, the generalisability of findings is often questionable.

Table 3.2

Number of Schools from Each State/Territory

State/Territory	Schools	Teachers	Classes	Students
Australian Capital Territory	3	28	9	265
New South Wales	8	65	25	510
Northern Territory	2	14	8	152
Queensland	11	147	43	1024
South Australia	7	68	29	627
Tasmania	3	23	9	218
Victoria	14	142	43	970
Western Australia	9	133	37	879
Total	**57**	**620**	**203**	**4645**

3.7 TESTS AND INSTRUMENTS

During the TIMSS data collected included the mathematics and science achievement of students, success attribution and attitudes towards mathematics and background characteristics of students. In additon, information from the teachers, and information about the schools was collected. To obtain information about the contexts of learning mathematics and science, TIMSS included questionnaires for the participating students, their mathematics and science teachers, and the principals of their schools. In this study additional data measuring the school level environment were collected from 57 of the Australian schools, which had participated in TIMSS. A description of the tests and questionnaires used in TIMSS and the SLEQ is provided in this section.

3.7.1 Mathematics Achievement Tests

The TIMSS achievement tests yielded estimates of student proficiency in 11 content areas as well as overall mathematics and science scores. The TIMSS test design used a variant of matrix sampling to create a mathematics and science item pool of eight student booklets. The item pools were divided in 26 sets, or clusters, of items. These were then arranged in various ways to make up eight test booklets, each containing seven item clusters. One cluster, the core cluster, appeared in each booklet. Seven 'focus' clusters appeared in three of the eight booklets. The items in these eight clusters were considered sufficient to permit accurate reporting of their statistics. There were also 12 'breadth' clusters, each of which appeared in just one test booklet. These helped ensure wide coverage. Finally, there were eight 'free-response clusters,' each of which appeared in two booklets. A criticism of the achievement tests has been that multiple choice items can produce bias favouring those types of students who do well on questions which require a selection, rather than production of a response from the student without prompting as does a multiple choice question with a selection of possible answers. Some studies suggest that multiple-choice items are biased in favour of male students, when compared with female students. Drawing inferences about outcomes using these type of test items may not be valid if achievement is usually assessed using open-ended or other types of questions. The use of these achievement data in this study is defended because although many of the items were in fact multiple choice, free response open-ended questions were also included and the students' scores on these questions were combined with the scores on the multiple choice items to calculate the total student mathematics achievement scores as reported by TIMSS.

3.7.2 The School Questionnaire

The school questionnaire was designed to provide information about the overall organisation and resources of each participating school. Information about staffing, facilities, staff development, enrolment, course offerings, and the amount of school time allocated to students for mathematics and science instruction was collected.

3.7.3 Student Questionnaire

The student questionnaire explored students' attitudes towards mathematics and science, career aspirations and success attribution regarding science and mathematics, perceived parental expectations of the students, and out-of-school activities. Students were also asked to respond to questions about their classroom activities in mathematics and science and in particular the various ways in which their teachers delivered the mathematics and science curriculum. The items relating to student attitude, teaching practices and success attribution are discussed in more detail in the following sections. The students were asked to indicate how many hours they spend on homework each night and they also provided general home and demographic information.

3.7.4 Teaching Practices

This construct can be defined using several items from the student questionnaire. Five of these variables reflect a more student-oriented teaching style and five other variables reflect a more teacher-centred teaching style. Students were asked to respond to these items on a four point Likert scale from a response of 1 being 'never' to a response of 4 being 'almost always'. The teaching practices scale was constructed by using weighted factor score loadings and creating a composite score for each student with the highest score reflecting a more teacher-centred approach to instruction.

Variables reflecting a 'student-oriented teaching style' include the following statements.

- We begin a new topic by discussing a problem related to everyday life.
- We begin a new topic by having the teacher ask us what we know that is related to the new topic.
- We begin a new topic by working together in pairs or small groups on a problem or project.
- We use things from every day life in solving mathematics problems.
- We begin a new topic by trying to solve a real life example related to that new topic.

Variables reflecting a 'teacher-centred teaching style' include the following statements.

- The teacher shows us how to do mathematics problems.
- We copy notes from the board.
- We begin a new topic by having the teacher explain the rules and definitions.
- We work from worksheets or textbooks.
- We begin a new topic by looking at the textbook while the teacher talks about it.

3.7.5 Student Attitudes Toward Mathematics

The attitude towards mathematics can be regarded not only as a predictor for mathematics achievement but also as an independent variable. The TIMSS student questionnaire contained 10 questions that potentially referred to attitude. Five items referred to liking mathematics, the other five referred to 'the perceived importance of mathematics by the student'. The students were asked to respond on a Likert scale from 1 being 'strongly disagree' to 4 being 'strongly agree'. The items used to create the Attitude Toward Mathematics scale are:

- I would like a job that involved using mathematics.
- Mathematics is important to everyone's life.
- Mathematics is boring.
- I enjoy learning mathematics.
- I like mathematics.

3.7.6 Opportunity to Learn

This variable is a measure of the total number of minutes the students are exposed to mathematics in his or her class per week. Certainly it is not the best indicator for effective learning time but it is the best available in the TIMSS data set and was used in the analysis in this study.

3.7.7 School Level Environment Questionnaire

One of the main purposes of this study was to investigate the relationship between students' cognitive and affective outcomes and the environment of the school. The instrument selected to measure the school environment in the study described in this thesis, was the School Level Environment Questionnaire (SLEQ). As described earlier the version of the SLEQ used included 56 items that produced eight scales (Student Support, Affiliation, Professional Interest, Mission Consensus, Empowerment, Innovation, Resource Adequacy, Work Pressure) and each scale consisted of 7 individual items as described in Chapter Two. Each of the 56 items was scored on a five-point scale with responses of Strongly Disagree (1) to Strongly Agree (5). The development of the SLEQ has also been described in Chapter Two and issues of validity and reliability also discussed in full detail.

3.8 TWO-STEP APPROACH TO MODELLING: THE MEASUREMENT MODEL PRIOR TO STRUCTURAL MODEL

A two-step model-building approach, which consisted of the analysis of two conceptually distinct models, measurement and structural, was adopted in this study and was followed by a subsequent multilevel analysis. The two-step model building approach is recommended by Anderson and Gerbing (1988) and Jöreskog and Sörbom (1996) and the multilevel analysis is recommended for educational research by Goldstein (1996). The first part of this stage of the study involved is an analysis of the measurement model, which specifies the relationships between the observed variables (items) and latent variables or hypothetical constructs (factors). The results of this analysis identify the measurement properties (reliabilities and validities) of the observed and latent variables (Jöreskog & Sörbom, 1996). This is done separately before fitting a structural equation model to investigate the relationships and the direct and indirect influences evident between the latent variables. Measurement models were defined for all the independent latent variables. The dependent variable, Mathematics Achievement, was developed by TIMSS and is used as it is in this analysis.

The second part of this stage of the study is the structural equation model, which specifies the relationships among the hypothetical constructs (latent variables) as posited by theory or previous research and describes the links between school-level environment, student background characteristics and student cognitive and affective outcomes.

This two-step approach allows the researcher to determine whether any source of poor fit of a full structural model is due to the measurement or structural model. Jöreskog and Sörbom (1996) also noted that the testing of the structural model might be meaningless unless it is first established that the measurement model holds. They further noted that if the chosen observed variables (items) for a construct do not measure that construct, the specified theory must be modified before it can be tested. Therefore, the measurement model should be tested prior to the structural relationships being tested. Both the measurement models and the structural models are explained and discussed in the following sections.

3.8.1 Measurement Model (Confirmatory Factor Analysis)

The measurement model specifies the relationships between the observed variables and hypothetical constructs or latent variables and describes the measurement properties of the observed variables in terms of reliabilities and validates. The term 'confirmatory factor analysis (CFA)' is also used to refer to the analysis of measurement models. CFA approaches attempt to test the viability of *a priori* structures, which have been identified based on theory or previous experience or research, and to examine whether or not existing data are consistent with a highly constrained *a priori* structure that meets conditions of model identification (Maruyama, 1998).

In this study, two types of measurement models were assessed, namely one-factor congeneric models and multi-factor models. One-factor congeneric measurement model analysis was used to assess item reliability, determine scale reliability, and to generate factor score regression values for computing composite variables to be used in the structural model. The one-factor congeneric measurement models are discussed below. To be consistent with the program used in this study, LISREL notations are used here.

3.8.2 One-factor Congeneric Measurement Model

A one-factor congeneric measurement model is one type of measurement model within which a single latent variable (factor) is measured by several observed variables (items). Latent (unobserved) variables, which represent abstract concepts or theoretical constructs, are not directly observable or measured but must be assessed indirectly or inferred (Schumacker & Lomax, 1996). This is often accomplished by collecting responses for a number of items and then computing the latent (unobserved) variable. Such variables are often referred to as factors or constructs. For example, student attitude toward mathematics cannot be directly observed (for example, through visual inspection of an individual) and thus there is no single, agreed-upon definition or measure of attitude, however, it can be indirectly measured or inferred through observable or indicator variables (for example, question items from the TIMSS student questionnaire).

Observed (indicator) variables are variables that are directly observable or measured (Schumacker & Lomax, 1996) such as items in a survey instrument. Schumacker and Lomax (1996) suggest a minimum of three items is required for fitting a congeneric model and computing a latent construct (factor). Four to five items per factor are recommended.

Figure 3.1 presents an example of a one-factor congeneric measurement model that defines an independent latent variable (ξ). This approach can also be used to define a dependent latent variable (η) and is appropriate for analysing the latent variables related to factors affecting student outcomes. The processes of fitting both independent and dependent one-factor congeneric models are exactly the same, the only difference being the LISREL notation used in the pictorial representations.

Such a model was tested for each latent variable separately for student, class, and school components. LISREL 8.30 was used to test each hypothesised measurement model, such as the eight school level environment scales.

Composite Variable	Factor Loading	Indicator Variable	Measurement Error

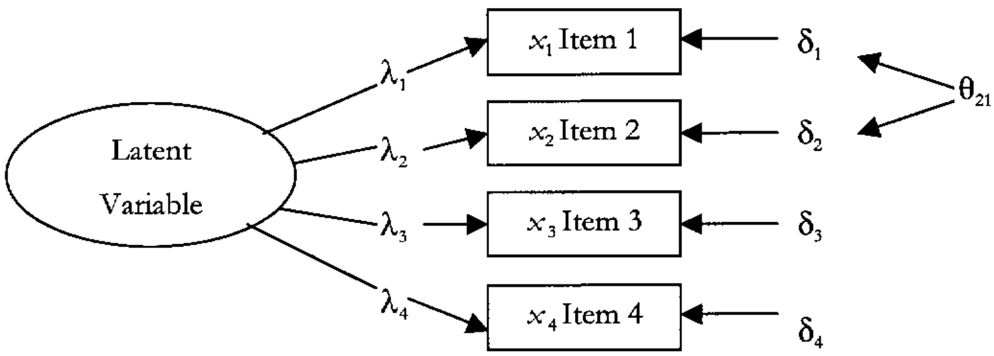


Figure 3.1. **A Generic One Factor Congeneric Model.**

A one-factor congeneric model represents the regression of a set of observed variables on a single latent variable. In Figure 3.1 the following apply:

1. ξ is the single latent independent variable (factor) in the model depicted by an ellipse
2. x_i indicates the observed indicator variables (items) and are depicted by rectangles
3. δ_i are the errors associated with the measurement of x_i
4. λ_i are the regression coefficients (factor loadings) of the ξ in the regression against x_1
5. θi indicates the error variances that are allowed to covary indicating that something in common is being measured, other than that measured by the items being estimated.

In matrix format, Equation 3.1 shows the regression of x_i on ξ_1 where the elements of λ_{xi} are the partial regression coefficients of ξ_1 in the regression of x_i on ξ_1, namely:

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} = \begin{bmatrix} \lambda_{11} \\ \lambda_{21} \\ \lambda_{31} \\ \lambda_{41} \\ \lambda_{51} \end{bmatrix} \begin{bmatrix} \xi_1 \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \end{bmatrix}$$

or

$$x_i = \lambda_{xi}\xi_1 + \delta_I \qquad \text{Equation 3.1}$$

For example, in a study designed to measure and test a theoretical construct, 'student attitudes towards mathematics' which can only be measured indirectly, such as responses to a survey, the construct will always be measured with error. As a further example, the statement 'Thinking about your school now, how would you rate the agreement on the overall school policy by the staff?' is an example of a measurable (observed) variable and 'mission consensus' is an example of an unobservable, latent variable.

For the observed variable, researchers are particularly interested in the extent to which they actually measure the hypothesised latent variable – i.e., how good is the SLEQ as a measure of school level environment? Which observed variable is the best measure of a particular latent variable – i.e., is item 5 a better measure of 'student support' than item 3? Or, to what extent are the observed variables actually measuring something other than the hypothesised latent variable, that is, is the SLEQ measuring something other than school level environment?

The measurement model reflects the extent to which the observed variables are assessing the latent variables in terms of reliability and validity. The relationships between the observed variables and the latent variables are described by factor loadings λ_1, and convergent validity is reflected in the magnitude of the factor loadings. In other words, the factor loadings provide us with information about the extent to which a given observed variable is able to measure the latent construct (Schumacker & Lomax, 1996). If observed variables specified to measure a common underlying factor all have relatively high loadings on that factor, then this is evidence of convergent validity (Kline, 1998).

Measurement error (δ_1) is the portion of an observed variable that is measuring something other than what the latent variable is intended to measure. It serves as a measure of reliability (Schumacker & Lomax, 1996). A correlated measurement error (θ_{21}) reflects the assumption that items 1 and 2 measure something in common that is not represented in the model (Kline, 1998).

3.8.3 Advantages of Using One-Factor Congeneric Measurement Models

Use of congeneric measurement models provides a number of benefits in structural equation modelling, for example, reducing the number of observed variables to a single latent variable, assessing item and composite reliability, improving the reliability and validity of composite variables, etc. (Holmes-Smith, 2000; Rowe & Rowe, 1999). Unlike traditional unit-weighted methods for computing composites, the use of factor score regression weights that are obtained from estimates in confirmatory factor analysis one factor congeneric measurement models minimizes measurement error in the items contributing to each scale, this increasing the reliability (and validity) of the computed scale scores (Rowe & Hill, 1995a). Chapter Four describes in detail the one-factor congeneric models that were fitted for all student scales and school-level environment scales that were then used in both the structural equation modelling and the multilevel modelling analysis.

3.9 MULTI-FACTOR ANALYSIS

In previous school environment studies, the constructs have been aggregated to give overall environment scores for participating schools, however, by doing this environment is represented as a unidimensional concept. Yet it is believed that both classroom level and school level environments are multidimensional constructs. Teachers may be happy with some aspects of the environment and yet not be happy with other aspects of the environment, which in an aggregated arrangement for constructing factors negates the ability to distinguish between these possibilities. A multi-factor model analysis allows researchers to test the multidimensionality of a theoretical construct. Moreover, a multi-factor analysis allows researchers to address the issues of convergent and discriminant validity. Discriminant validity refers to the distinctiveness of the factors measured by different sets of observed variables and can be supported if the estimated correlations between the factors are not excessively high.

3.10 STRUCTURAL EQUATION MODELS

The structural models which specify and simultaneously estimate the relationships among the latent dependent (endogenous: such as student outcome measures) and dependent (exogenous: such as school level environment measures) variables describe their links (Jöreskog & Sörbom, 1996). As discussed in the previous section, measurement models must first be specified and fitted to test that the latent variables (factors) are measured well (valid and reliable) by selected observed variables (items). In this study, in building structural equation models, both the independent and dependent latent-variable measurement models were used.

Based on the measurement model, the values of factor loadings and measurement error variances were then fixed when examining the latent-variable relationships in subsequent structural equation models (Holmes-Smith, 2000). Since the factor loadings and the measurement error variances were fixed in the measurement part of the model, the parameters to be estimated are structural regression coefficients in the structural part of the model. The structural regression coefficients indicate the strength (i.e. weak or strong) and direction (i.e. positive or negative) of the relationships among the latent variables. Each structural equation also contains an error term that indicates the portion of the latent dependent variable that is not explained or predicted by the latent independent variables in that equation (Jöreskog & Sörbom, 1996).

Are student outcomes and school level environments components related? How strong, exactly, is the influence of the school level environment on student outcomes? Could there be other latent variables that we need to consider in order to gain a better understanding of the influences on student outcomes? These are the types of questions in this study to which structural equation modelling is able to provide insights.

In summary, this research adopted Anderson and Gerbing's (1988) two-step approach, where the measurement parameters for the latent variables were estimated and then fixed in the structural model. In this way, the reliability and validity of the measurement model are established before structural models are estimated.

3.11 MODEL ASSESSMENT AND MODIFICATION

The main purpose of conducting structural equation modelling analysis is to assess the extent to which an hypothesised model adequately describes the sample data. The steps discussed by Burne (1998) were used in this study to assess the adequacy of a hypothesised model and to detect any sources of mis-estimation in the model. This process includes the following three steps:

1. adequacy of the parameter estimates. A non-significant parameter can be considered unimportant to the model and should be deleted (Byrne, 1998)
2. adequacy of the measurement model. This can be determined from the squared multiple correlation (R^2) reported for each observed variable (which is an indication of item reliability with respect to its underlying latent construct) and the coefficient of determination reported for all the observed variables jointly (which is an indication of composite reliability for the individual measurement model) (Byrne, 1998). These values range from 0 to 1.00; values close to 1.00 represent good models. The scale coefficient of determination is equivalent to the maximised composite scale reliability coefficient (Holmes-Smith, 2000) used in this study; and
3. adequacy of the model as a whole. It is recommended that assessment of model adequacy must be based on various goodness of fit criteria that take into account theoretical, statistical and practical considerations (Byrne, 1998; Kline, 1998; Schumacker & Lomax, 1996). The following criteria were used to evaluate the adequacy of the model fit: Normed Chi square (χ^2/df) < 3 (Kline, 1998) the Root Mean Square Error of Approximation (RMSEA) < .05, Non-Normed Fit Index (NNFI) > .090, the Comparative Fit Index (CFI) > 0.90 and the Adjusted Goodness of Fit Index (AGFI) > 0.90 (Byrne, 1998; Holmes-Smith, 2000). All of these criteria were adopted in constructing the measurement and structural models in this study. Each of the indices is an assessment of fit between the hypothesised model and sample data.

If an hypothesised model did not fit the given data, the model could be modified to fit the data better through post hoc model testing. Post hoc analysis focuses on the detection and identification of the source of poor model fit in the originally hypothesised model, based on improvement information from LISREL (i.e. residual and modification index) (Byrne, 1989). ***Residual*** is the discrepancy between the sample covariance matrix and the fitted covariance matrix. A well-fitted model should have standardised residuals that are less than 2.58 and symmetrically clustered around the zero point (Byrne, 1989). The value of a ***Modification index*** represents the expected drop in overall χ^2 value if the parameter were to be freely estimated. This information provides a guideline about how a hypothesised model can be refined. However, parameters were only free to be estimated if there was substantive support from previous research or theory to indicate that there is justification for so doing.

3.12 MULTILEVEL ANALYSIS

Most educational research revolves around students who receive schooling in classrooms located within schools, within school districts, within states and within countries. The grouping of students, classes and schools occurs in a hierarchical order with each group influencing the members of the group in thought and behaviour. The nature of these hierarchical structures produces multilevel data. Therefore, in addition to the use of measurement and structural modelling, this research involved the use of multilevel modelling which takes into account this hierarchical structure of the data.

Theories about the effects of the multilevel structure of education (the different levels of the educational hierarchy) should lead to attempts to specify models which involve the analysis of multilevel educational data. Serious educational researchers cannot ignore the amount of variation in estimates of variables affecting academic achievement across different levels of analysis. Traditional linear models on which most researchers rely require the assumption that subjects respond independently, yet most subjects are 'nested' within classrooms, schools districts, states and countries so that responses within groups are group dependent. To ignore the nested structure of this type of data ultimately will give rise to problems of aggregation bias (within-group homogeneity) and ultimately imprecision (Raudenbush & Bryk, 1998).

The importance of educational effects operating within each level of the social organisation of schooling has stimulated researchers to develop statistical modelling approaches appropriate for hierarchical, multi-level data. These methods enable researchers to: formulate and test explicit statistical models for processes occurring within and between educational units; solve the problem of aggregation bias; enrich the class of research questions about educational effects which are accessible to empirical investigations; and provide specification of appropriate error structures, including random intercepts and random coefficients.

3.13 SUMMARY

The aims of this present study were to present and explain a student outcome model based on preliminary hypothesised model presented in Chapter One. This model is described in further detail in Chapter Five where the results of the estimation of the model are presented. This current chapter has described the research design, study procedure and data collection and analysis techniques. It was considered necessary to give a brief introduction to the use of measurement modelling, structural equation modelling and multilevel modelling to give the reader some background and justification for the decision to use these more sophisticated methods of data analysis and modelling.

CHAPTER FOUR

RESULTS OF THE MEASUREMENT MODELS

4.1 INTRODUCTION

This Chapter presents the results of the measurement models for the eight SLEQ scales and the student scales of socio-economic status, attitude toward mathematics, success attribution and instructional practices. In section 4.1 the goodness of fit summary and composite reliability estimates for each of the eight SLEQ scales and the four student scales is described in detail. A discussion of the use of confirmatory factor analysis given in this section was considered necessary to give the reader an understanding of this choice. For each SLEQ and student scale, a pictorial representation of the congeneric measurement model is presented in section 4.2 complete with regression estimates, error estimates, and reliability details. The necessity to make some model specification adjustments to improve the fit in some of these models is explained in section 4.3. Two multi-factor measurement models of the eight SLEQ scales are described in section 4.4 and their convergent and discriminant validity discussed. In section 4.4 the hypothesised and revised structural equation models of factors that influence mathematics achievement are presented and the results discussed.

4.2 EXAMINING STUDENT LEVEL CONSTRUCTS AND SCHOOL-LEVEL ENVIRONMENT CONSTRUCTS

In this section, confirmatory factor analyses, both one and multifactor measurement models, were used to examine the theoretical constructs included in the analysis which are as follows:

1. eight school-level environment constructs (Student Support, Affiliation, Mission Consensus, Professional Interest, Empowerment, Innovation, Resource Adequacy and Work Pressure);
2. student socio-economic status;
3. student attitudes towards mathematics;
4. instructional practices; and
5. success attribution

The reason for selecting confirmatory factor analysis and not exploratory analysis lies with the philosophical position of the researcher which is that theory drives analysis and not analysis drives theory. All the constructs were estimated using LISREL 8.30 (Jöreskog & Sörbom, 1999) with polychoric correlation and asymptotic covariance matrices and using a weighted least square (WLS) estimation procedure . The adequacy of each measurement (Byrne, 1998; Jöreskog & Sörbom, 1996) model was assessed using this process and the criteria for making judgements are discussed in Chapter Three. The goodness of fit statistics, the maximised composite reliabilities (r_c), the estimated composite variable regression coefficients ($\lambda\hat{}_c$), the measurement error variances ($\theta\hat{}_c$), and the unit weight reliability coefficients (α^b) for each of the composite variables estimated are summarised in Table 4.1 (SLEQ) and Table 4.2 (student-level scales).

Each of the factors has adequate fit on one-factor congeneric measurement models. The goodness of fit statistics and what they measure are discussed in detail in Chapter Three and the results for the eight SLEQ scales and the four student composite variables are reported in Tables 4.1 and 4.2 respectively. All fit statistics met acceptable levels of fit for all of the composite scales in this analysis. The maximised reliabilities for all composite variables, both the composite reliability (r_c) and the Cronbach's Alpha (α^b) in the SLEQ were high (r_c = 0.892 to 0.931 and α^b = 0.706 to 0.885). For all four of the student composite variables these reliability measure were also high (r_c = 0.873 to 0.965 and α^b = 0.706 to 0.891) suggesting that all observed variables, both SLEQ and student observed variables were reliable measures of each of the proposed latent constructs.

A fitted congeneric model allows large numbers of observed variables to be reduced to a single composite scale and subsequently reduces the number of variables to be included in the structural equation models and other subsequent analysis (Holmes-Smith & Rowe, 1994). The overall results of the analysis of one-factor congeneric measurement models were used to compute composite scores for each latent construct using factor score regression (FSR) as a proportional weight (see Figures 4.1 to 4.12) to determine the composite scale (maximised) reliability (Holmes-Smith, 2000; Rowe & Rowe, 1999). The Statistical Package for the Social Sciences (SPSS) was used and a command file was created to compute composite factor scores and maximised reliability for each latent variable using a weighted factor loading which attributes only that proportion of each item to a latent variable that should be attributed to the variable. Some items load more heavily on a latent variable than other factors and using estimates obtained from LISREL output, correctly weighted estimates are able to be calculated.

In LISREL notation, the character η (eta) represents a latent dependent variable that is influenced by some other latent variable in the model (for example,. student outcomes), and the character ξ (ksi) represents a latent independent variable which is not influenced by any other latent variable (for example, student attitudes towards mathematics). In a congeneric measurement model arrows pointing from the latent constructs (ellipses) to the observed variables (rectangles) are equivalent to factor loadings in factors analyses. All loadings for the eight SLEQ constructs were above 0.42 and all loadings for the student constructs were above 0.52. With the school-level environment factors, after fitting all eight one-factor measurement models an eight-factor school level environment model was then constructed to assess the discriminant validity of the whole construct of School Level Environment (see Figure 4.13). The discriminant validity is discussed further in this chapter

Table 4.1 FITTED ONE-FACTOR CONGENERIC MODELS FOR SCHOOL-LEVEL ENVIRONMENT SCALES: GOODNESS OF FIT SUMMARY AND COMPOSITE RELIABILITIES

Composite Variable	Student Support	Affiliation	Professional Interest	Mission Concensus	Empower-ment	Innovation	Resource Adequacy	Work Pressure
N[a]	563	501	553	528	564	523	564	563
χ^2	3.186	2.903	3.266	6.201	3.600	3.412	9.801	7.310
Df	3	3	4	3	4	4	4	3
P	0.036	0.147	0.089	0.066	0.172	0.283	0.063	0.049
RMSEA	0.043	0.019	0.040	0.006	0.042	0.053	0.009	0.043
NNFI	0.962	0.991	0.903	1.000	0.953	0.901	1.000	0.950
CFI	0.971	0.999	0.923	1.000	0.972	0.950	1.000	9.998
GFI	0.979	1.000	0.945	1.000	0.982	0.969	1.000	1.000
AGFI	0.963	0.998	0.932	0.989	0.973	0.951	0.999	0.998
Composite Reliability r_c	0.931	0.902	0.925	0.899	0.892	0.901	0.929	0.918
Factor Loading $\lambda^{\wedge}$	0.571	0.480	0.539	0.483	0.532	0.510	0.489	0.501
Measurement Error $\theta^{\wedge}$	0.031	0.042	0.020	0.025	0.040	0.024	0.041	0.030
Cronbach's Alpha α^b	0.885	0.823	0.873	0.718	0.706	0.781	0.750	0.736

RMSEA Root Mean Square Error of Approximation

NNFI Non-normed Fit Index

GFI Goodness of Fit Index

CFI Comparative Fit Index

AGFI Adjusted Goodness of Fit Index

N[a] The number of teachers with complete data

α^b Cronbach's standardised item alpha – unit weight reliability which assumes every item has an equal contribution to the latent construct

Table 4.2 FITTED ONE-FACTOR CONGENERIC MODELS FOR STUDENT SCALES: GOODNESS OF FIT SUMMARY AND COMPOSITE RELIABILITIES

Composite Variable	Socio-economic Status	Attitudes Towards Mathematics	Success Attribution	Instructional Practices
N[a]	4631	4628	4637	4623
χ^2	8.960	9.103	3.240	6.802
Df	3	3	2	7
P	0.111	0.098	0.211	0.141
RMSEA	0.029	0.041	0.001	0.019
NNFI	0.997	0.990	1.000	0.936
CFI	0.998	0.992	1.000	0.981
GFI	1.000	0.998	1.000	0.998
AGFI	0.999	0.995	0.999	0.996
Composite Reliability r_c	0.895	0.965	0.873	0.925
Factor Loading $\hat{\lambda}$	0.895	0.905	0.876	0.978
Measurement Error $\hat{\theta}$	0.031	0.025	0.010	0.032
Cronbach's Alpha α^b	0.712	0.891	0.706	0.801

RMSEA Root Mean Square Error of Approximation

NNFI Non-normed Fit Index

GFI Goodness of Fit Index

CFI Comparative Fit Index

AGFI Adjusted Goodness of Fit Index

N[a] The number of students with complete data

α^b Cronbach's standardised item alpha – unit weight reliability which assumes every item has an equal contribution to the latent construct

4.3 SCHOOL LEVEL ENVIRONMENT MEASUREMENT MODELS AND IMPROVING FIT

The initial fit statistics for some of the SLEQ models were poor and an investigation of the correlation matrix indicated a very high correlation between some of the items within each scale. The highest of these correlations was r=0.91 and was the bivariate correlation between item six and seven in the Student Support scale. High correlations indicate that one variable can almost be predicted from the other. One solution can be to include only one of the items in the model however this may not improve the fit statistics and conceptually may not be appropriate. Another solution is to examine the modification indices for each model, which often suggest allowing a correlated measurement error between two items to improve the model fit. A measurement error correlation indicates that two observed variables measure 'something in common that is not represented in the model (Kline, 1998). Considering the items where this was suggested it was deemed appropriate to allow the errors to be correlated and on each occasion the model fit was improved significantly. Table 4.3 indicates those items from the SLEQ scales where it was necessary to allow some of the errors to correlate in order to improve the fit of the models.

Further investigation of the congeneric measurement models for each of the eight SLEQ scales, show that all loadings were not only strong as mentioned previously, but also significant ($p < 0.05$). For each scale, all seven items were used to compute the composite scale. It was not statistically necessary to drop any of the items. The reliabilities for each item in each of the eight scales were above 0.40 and most of these reliabilities were above 0.60. The weighted factor score regressions are given in each table and these were used to compute each of the eight composite scales.

Figure 4.1 STUDENT SUPPORT CONGENERIC MEASUREMENT MODEL

Composite Variable	Factor Loading	Indicator Variable	Measurement Error	Item Reliability	Factor Score Regression
Student Support ξ_1	λ_1 0.681	Studsup1	0.360	0.529	0.214
	λ_2 0.763	Studsup2	0.360	0.501	0.256
	λ_3 0.761	Studsup3	0.368	0.532	0.236
	λ_4 0.598	Studsup4	0.401	0.487	0.104
	λ_5 0.502	Studsup5	0.418	0.470	0.103
	λ_6 0.621	Studsup6	0.371	0.521	0.166
	λ_7 0.500	Studsup7	0.462	0.453	0.031

Figure 4.2 AFFILIATION CONGENERIC MEASUREMENT MODEL

Composite Variable	Factor Loading	Indicator Variable	Measurement Error	Item Reliability	Factor Score Regression
Affiliation ξ_2	λ_1 0.501	Affil1	0.249	0.596	0.161
	λ_2 0.603	Affil2	0.192	0.685	0.253
	λ_3 0.486	Affil3	0.378	0.463	0.136
	λ_4 0.598	Affil4	0.201	0.653	0.221
	λ_5 0.487	Affil5	0.361	0.493	0.154
	λ_6 0.542	Affil6	0.247	0.598	0.171
	λ_7 0.423	Affil7	0.401	0.401	0.130

Figure 4.3 PROFESSIONAL INTEREST CONGENERIC MEASUREMENT MODEL

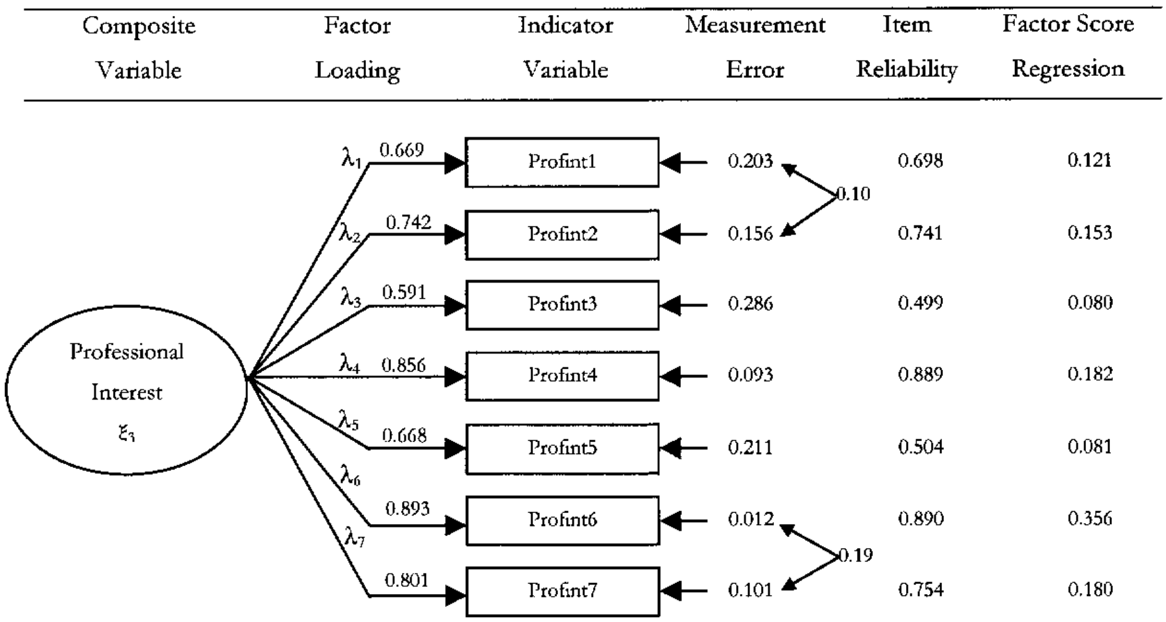


Figure 4.4 MISSION CONCENSUS CONGENERIC MEASUREMENT MODEL

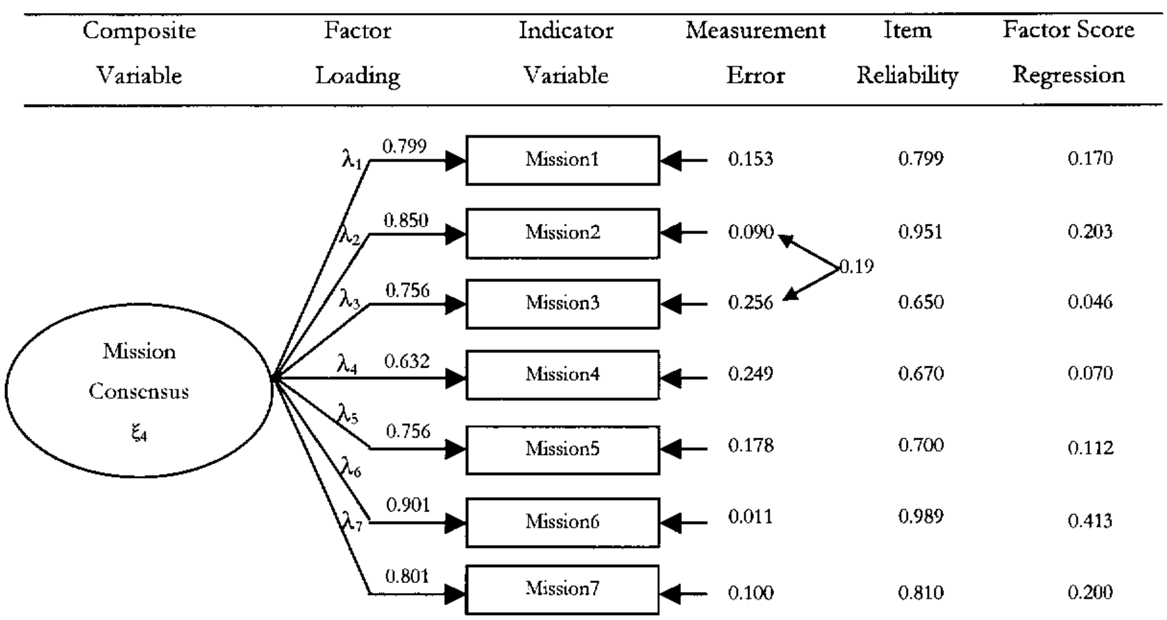


Figure 4.5 EMPOWERMENT CONGENERIC MEASUREMENT MODEL

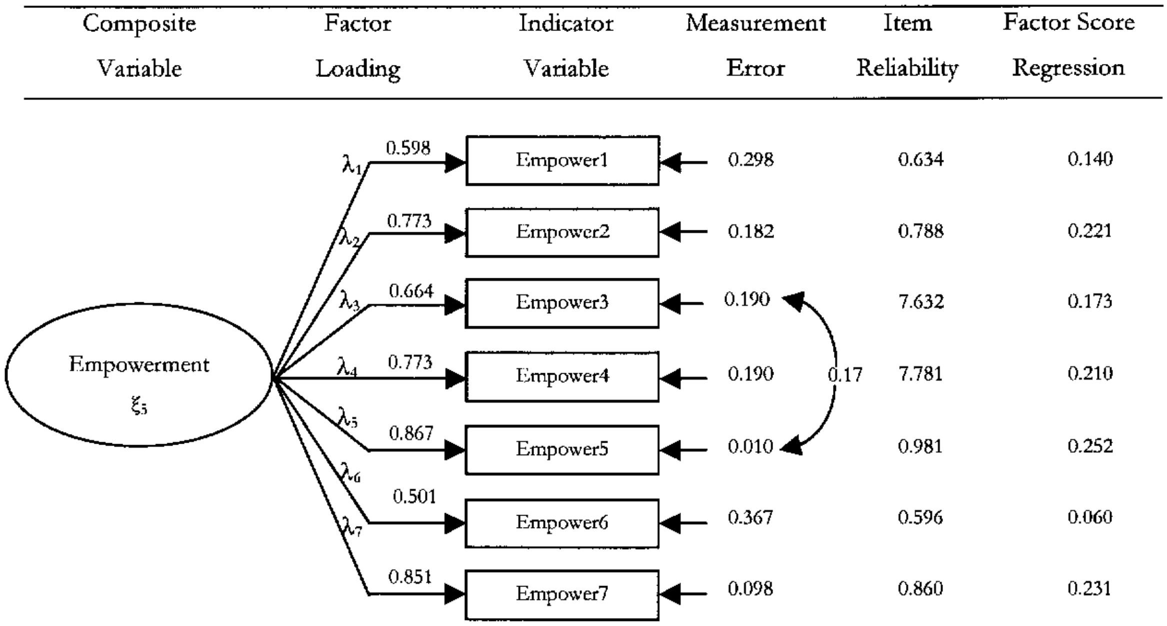


Figure 4.6 INNOVATION CONGENERIC MEASUREMENT MODEL

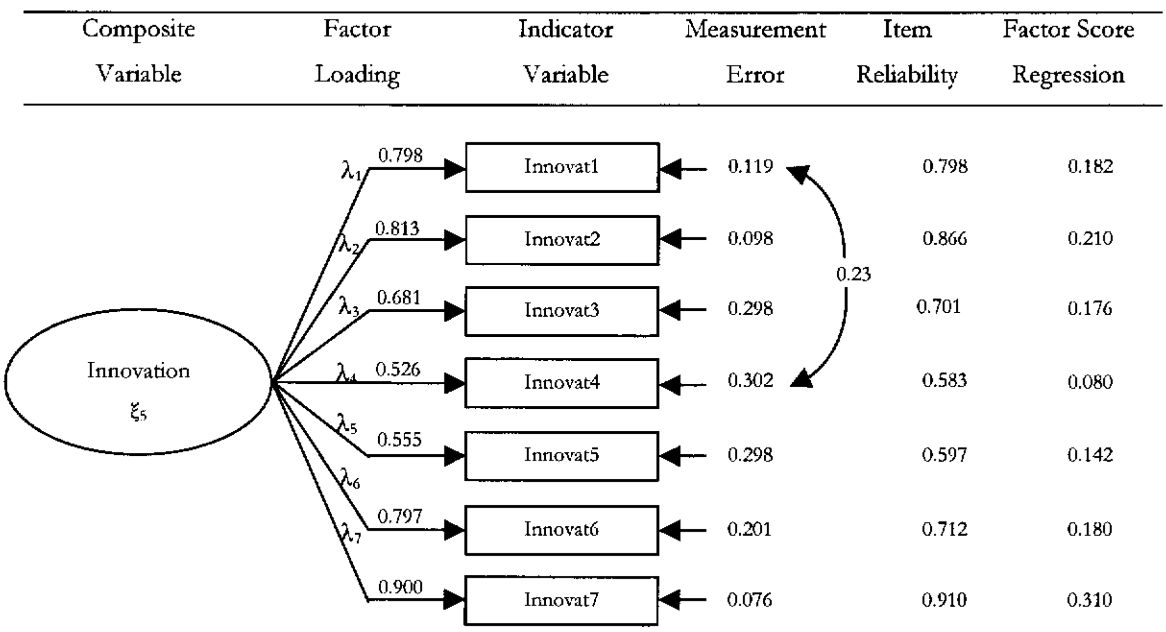


Figure 4.7 RESOURCE ADEQUACY CONGENERIC MEASUREMENT MODEL

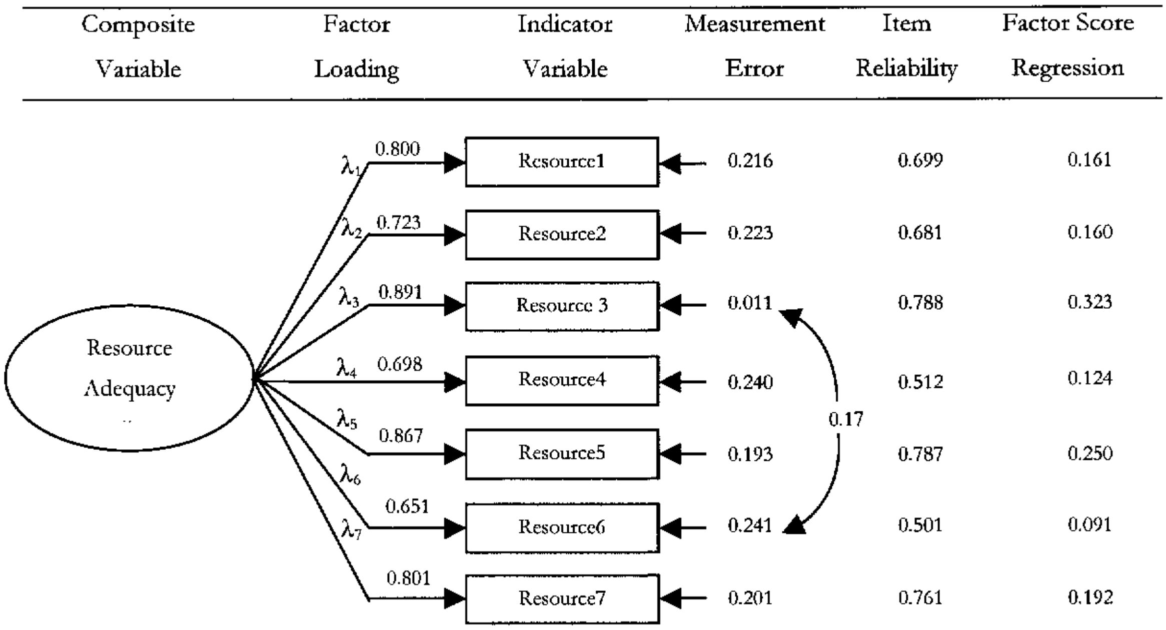


Figure 4.8 WORK PRESSURE CONGENERIC MEASUREMENT MODEL

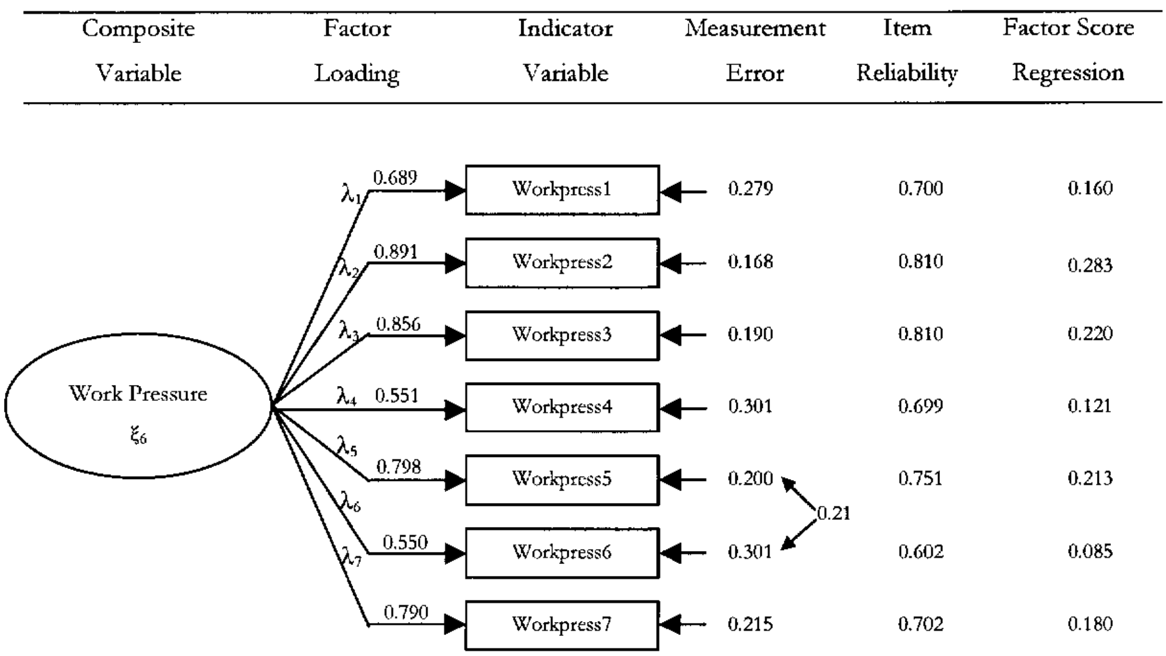


Table 4.3 SLEQ ITEMS WHERE ERRORS ARE ALLOWED TO CORRELATE

Latent Construct	Items	θ
Student Support	Most students are well mannered and respectful to the school staff	0.26
	Strict discipline is needed to control many of the students	
Professional Interest	Teachers discuss teaching methods and strategies with each other	0.10
	Teachers avoid talking with each other about teaching and learning	
	Teachers are keen to learn from their colleagues	0.19
	Teachers show considerable interest in the professional activities of their colleagues	
Mission Consensus	The organisation of this school reflects its goals	0.19
	Teachers regularly refer to the mission of the school when addressing school issues	
Empowerment	Action can be taken without gaining the approval of a senior member of staff	0.17
	I am encouraged to make decisions without reference to a senior member of staff	
Innovation	It is difficult to change anything in this school	0.23
	Most teachers like the idea of change	
Resource Adequacy	Video equipment, tapes and films are readily available and accessible	0.17
	Facilities are adequate for catering for a variety of classroom activities and learning groups of different sizes	
Work Pressure	You can take it easy and still get the work done	0.21
	Seldom are there deadlines to meet	

4.4 STUDENT LEVEL MEASUREMENT MODELS AND IMPROVING FIT

4.4.1 Socio-economic Status Model

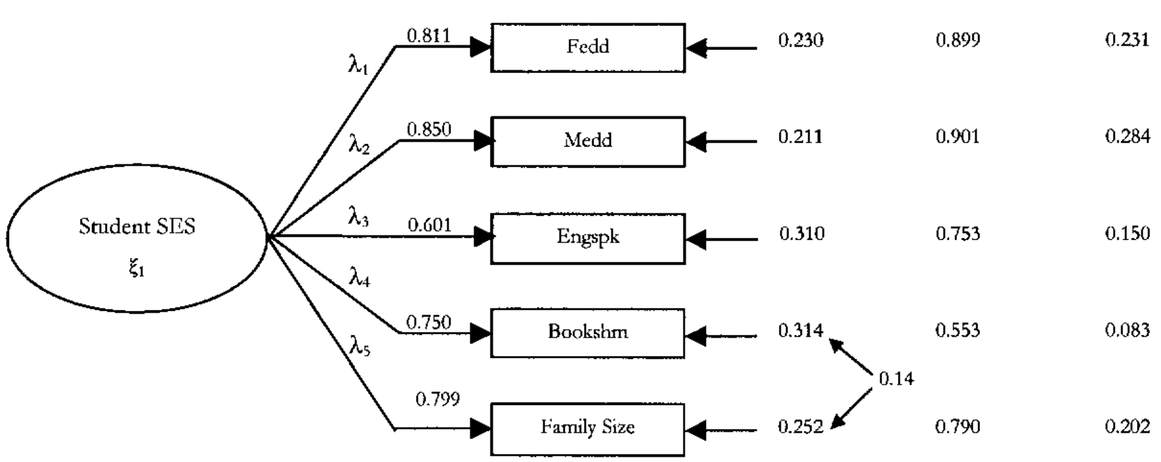
In this study, the socio-economic status (SES) of the family is measured by the five items listed below.

1. Mother's highest level of education.
2. Father's highest level of education.
3. What language does your family mostly speak at home.
4. About how many books are there altogether in your home.
5. Family size.

It has been suggested that the occupation of the father and the mother can be used with other variables to measure SES, however, in this analysis, these two items, although asked of the students, did not contribute to the construct and so have been omitted.

Figure 4.9 STUDENT SOCIO-ECONOMIC STATUS CONGENERIC MEASUREMENT MODEL

Composite Variable	Factor Loading	Indicator Variable	Measurement Error	Item Reliability	Factor Score Regression



The parameter estimates, item reliabilities and factor score regressions are presented in Figure 4.9. All items in the scale have good item reliability (0.553 to 0.901) with the exception of number of books in the home. Although this item also contributes least to the scale, this estimate was significant so it was included when computing the composite scale SES. Two items in this scale (number of books in the home and size of family) were highly correlated (r=0.82) and an investigation of the modification indices suggested an improvement to the fit of the model if the errors (δ) for these two items were allowed to correlate. The phi (θ) estimate for these two items was 0.14 and the result was a good fitting overall model for this scale and improvement in the individual item reliabilities.

4.4.2 Instructional Practices Model

The students were asked to respond to items regarding the various methods that their teachers used to deliver the curriculum and the instructional practices they employed in the mathematics classroom. The ten items used to compute this scale are listed as following.

How often does this happen in your mathematics class?

1. We copy notes from the board
2. We work from worksheets or textbooks
3. The teacher shows us how to do mathematics problems
4. We use things from every day life in solving mathematics problems

When we begin a new topic in mathematics, we begin by:

5. Working together in pairs or small groups on a problem or project
6. Having the teacher explain the rules and definitions
7. Discussing a problem related to everyday life
8. Having the teacher ask us what we know that is related to the new topic
9. Looking at the textbook while the teacher talks about it
10. Trying to solve an example related to the new topic

The composite reliability of this scale was 0.925 and all the fit statistics indicated a good model. The factor loadings (λ) were all significant and this justified leaving the scale with all ten items. Due to weighted factor score regressions being used to compute the composite variable 'Instructional Practices' having large numbers of items does not detract from the essence of the scale as only that proportion of the scale that should be attributed to each individual item is used. The parameter estimates, item reliabilities and factor score regressions are presented in Figure 4.10 and show that each item reliability is strong, ranging from 0.442 to 0.721.

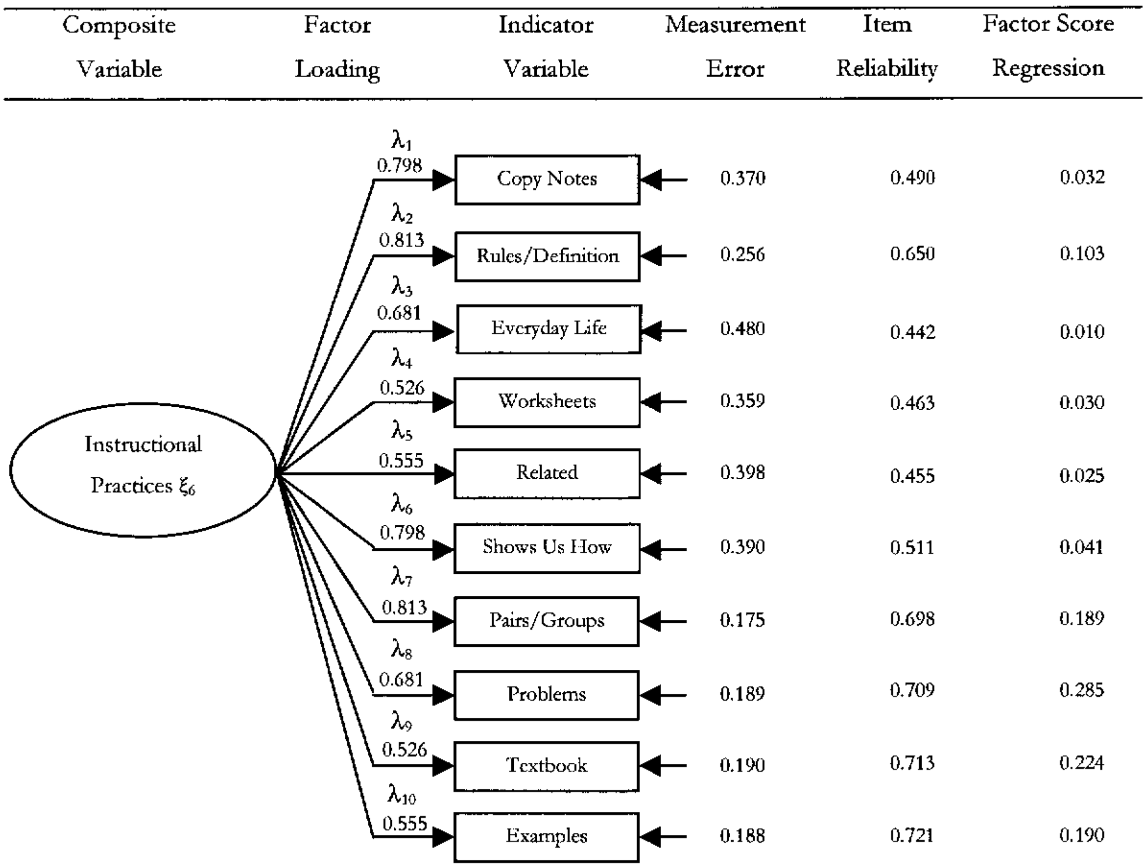
4.4.3 Student Success Attribution Model

From the student questionnaire, four items were used to measure success attribution and these items are listed below.
To do well in mathematics you need:

1. Lots of natural ability
2. Good luck
3. Lots of hard work studying at home
4. To memorise the textbook or notes

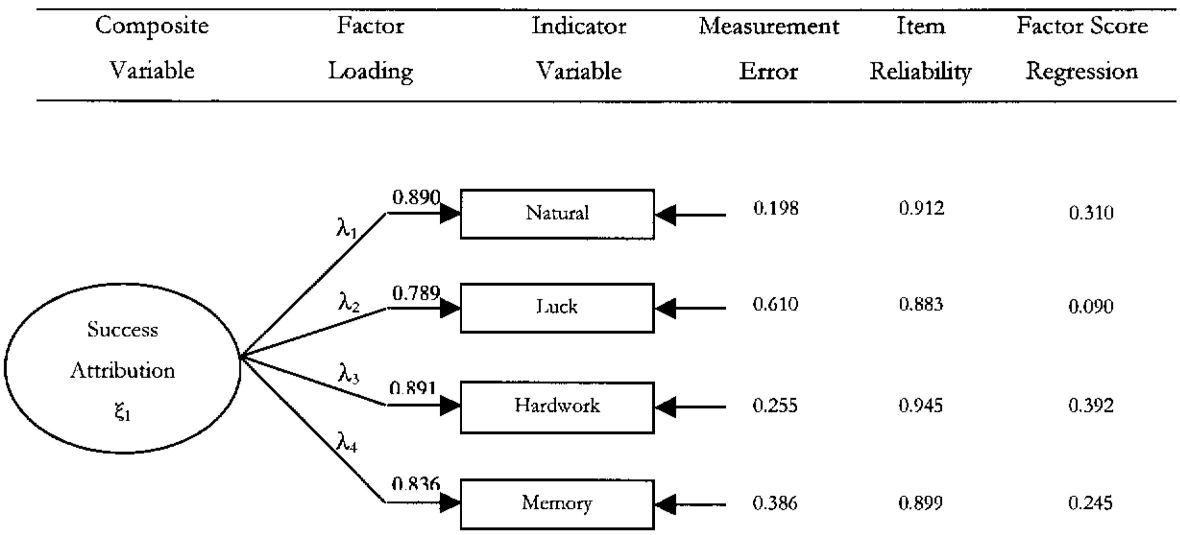
5.

Figure 4.10 INSTRUCTIONAL PRACTICES CONGENERIC MEASUREMENT MODEL



The parameter estimates, item reliabilities and factor score regressions for this model are presented in Figure 4.11. All items have good item reliability (above 0.8). The composite reliability for this scale was 0.873 and the model has good fit indicated by the various fit indices as reported in Table 4.4.

FIGURE 4.11 SUCCESS ATTRIBUTION CONGENERIC MEASUREMENT MODEL



4.4.5 Student Attitude Toward Mathematics Model

Five items were used to measure student attitude toward mathematics. The parameter estimates, item reliability and factor score regressions are presented in Figure 4.12. The overall composite reliability (r_c) for this scale was 0.965 and all the goodness of fit statistics were acceptable. The items included in this model were:

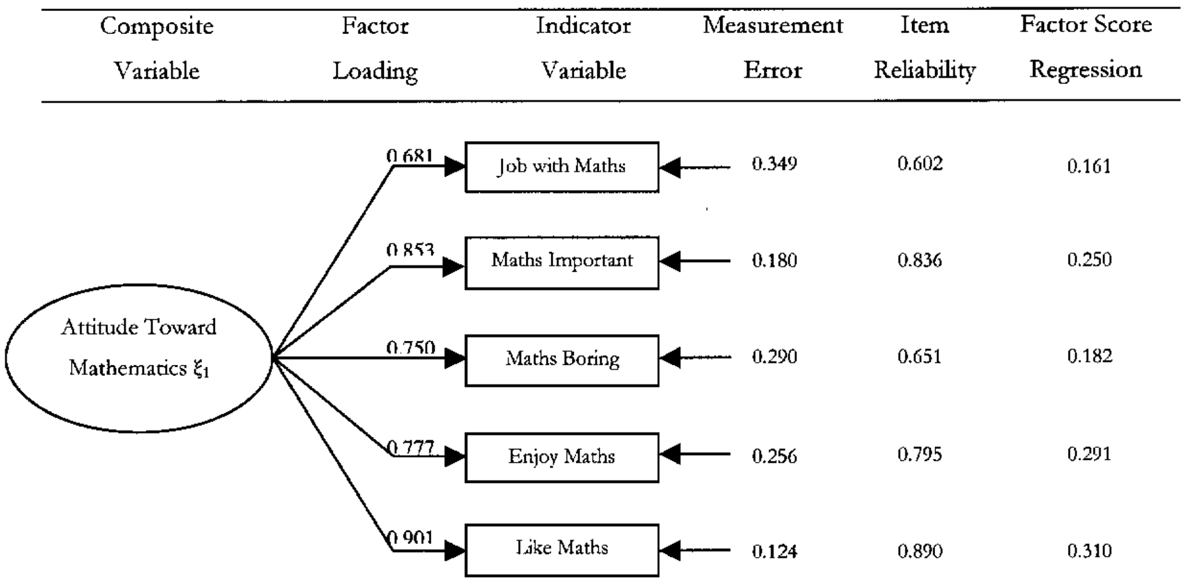
What do you think about mathematics?

1. I would like a job that involved using mathematics
2. Mathematics is important to everyone's life
3. Mathematics is boring
4. I enjoy learning mathematics
5. I like mathematics

Wanting a job involving mathematics had the lowest item reliability (0.602) and contributed less to the composite scale (FSR=0.161) for attitude toward mathematics that the other items.

The item that contributed most to the scale was whether or not the students liked mathematics, Factor Score Regression (FSR) =0.310.

Figure 4.12 ATTITUDE TOWARD MATHEMATICS CONGENERIC MEASUREMENT MODEL



4.5 MULTIFACTOR SCHOOL ENVIRONMENT MODEL

It seems intuitively obvious that school environment structure is best represented by a multidimensional model; however, many researchers have chosen to aggregate all scores on environment items to obtain an overall mean environment score. By doing so, they imply that school environment is a unidimensional concept (the one factor model). This section examines the appropriateness of such assumption and practice. The eight sets of school environment items (56 items) are linked together to further test if the eight-factor environment structure can be simplified to a one single factor model, i.e. general school-level environment. To achieve this goal, the following two hypotheses were tested.

1. Hypothesis A: School-level environment is a one-factor structure

2. Hypothesis B: School-level environment is an eight-factor structure

Values of selected fit statistics for the two hypothesised models are reported in Table 4.4.

4.5.1 Hypothesis A: School-level Environment is a One-factor Structure

The one-factor model, whereby all 56 items were loaded onto a single factor 'general school-level environment', was tested first. Table 4.4 shows that the χ^2 was 2579 (398) and was significant at the 0.001 level, however, this is not surprising considering the large sample size (620 teachers). More informative is the $\chi^2/$ *df* ratio, which for this model is greater than 3. In addition, the value of the Non-Normed Fit Index (NNFI) is less than 0.90. Also, the value of the RMSEA is greater than 0.05. Overall, these results indicate that a one-factor 'general school-level environment' model does not adequately fit these data.

Table 4.4 GOODNESS OF FIT SUMMARY – SCHOOL LEVEL ENVIRONMENT MODELS

Model	χ^2	df	χ^2/df	p	RMSEA	NNFI	DFI	GFI	AGFI
One-factor model	2579	398	6.479	0.000	.068	.895	.944	.956	.949
Eight-factor model	780	301	2.591	0.000	.039	.959	.944	.982	.979
Fit change between two models			χ^2=1799		*p*=0.000				

4.5.2 Hypothesis B: School-level Environment is an Eight-factor Model

The second model to be tested postulates *a priori* that school-level environment is an eight factor structure, composed of Student Support (stusup), Affiliation (affil), Professional

Interest (profint), Mission Consensus (mission), Empowerment (empower), Innovation (innovat), Resource Adequacy (resource) and Work Pressure (workpress).

The results in Table 4.4 indicate a better fit than the one-factor model of school-level environment. The χ^2 change (1799) is significant at the 0.001 level, suggesting that the fit of the eight-factor model is significantly better than that of the one-factor model. As was expected, all other indices of fit suggests that school-level environment structure is best represented by the hypothesised eight-factor model, which is illustrated in Figure 4.13.

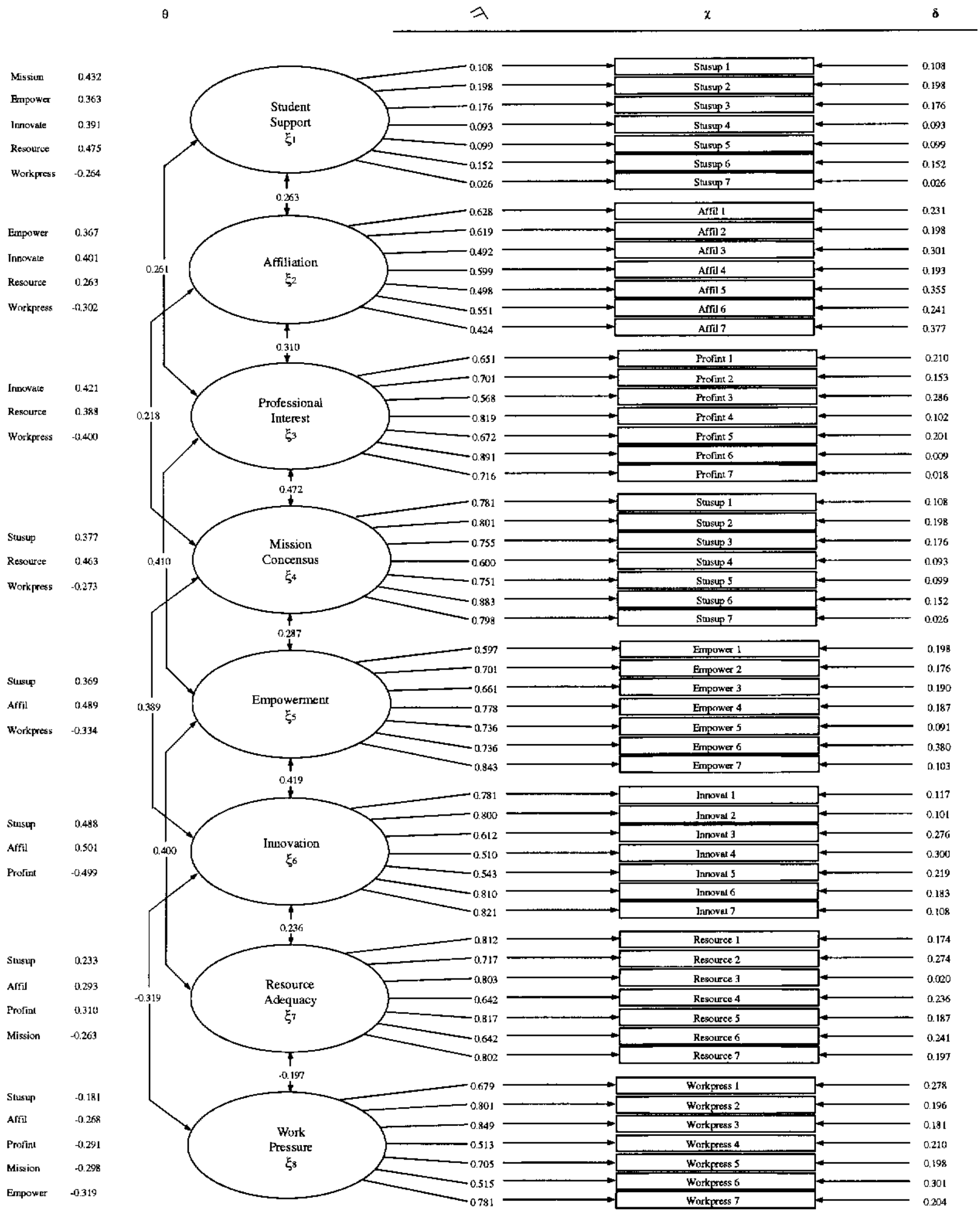
4.6 CONVERGENT AND DISCRIMINANT VALIDITY

In this section, convergent and discriminant validity are also assessed and reported. Convergent validity refers to 'indicators specified to measure a common underlying factor all have relatively high loading on that factor' (Kline, 1998). As shown in Figure 4.13, all standardised parameter estimates (factor loadings) are greater than 0.05 and these were all significant at the 0.01 level of significance. These results suggest that convergent validity was supported by the data in this study.

Discriminant validity refers to the distinctiveness of the factors measured by different sets of indicators – estimated correlations between the factors are not excessively high (Kline, 1998). As shown in Figure 6.8, the estimated correlations among the eight factors are moderate from that between Innovation and Affiliation (0.501) to that between Student Support and Work Pressure (-0.181). These correlations are all low enough to indicate that the dimensions measure quite different aspects of the school-level environment and suggest that discriminant validity was supported by the data in this study.

In summary, it is evident from these analyses that school-level environment is a multidimensional construct, which in this study comprised the eight factors detailed above. Based on the results, it is concluded that the eight-factor model schematically portrayed in Figure 4.13 represents an adequate description of school-level environment and can be included in further analysis investigating the factors affecting and associated with mathematics achievement.

Figure 4.13 EIGHT FACTOR MODEL OF SCHOOL ENVIRONMENT



4.7 SUMMARY

This chapter has presented the outcomes of the modelling process that is more appropriate, giving the most accurate estimates when constructing scales from a number of observed items. This process has been used in previous research but what is new in this analysis is the addition of the two-step approach to modelling school level environment. The modelling in this study clearly demonstrated that school level environment is not unidimensional but multidimensional and should remain a set of eight scales for further any analysis in studies of school environment. The next chapter describes the results from the structural equation modelling, an analytical procedure that investigates the relationship between student outcomes and school-level, class-level and student background variables. The hypothesised *a priori* model is tested first and on the basis of the estimates a post hoc approach is adopted to fit the best model of student achievement with the variables of interest in the study.

CHAPTER FIVE

RESULTS OF THE STRUCTURAL EQUATION MODELLING

In this chapter the magnitude and direction of the effects among student outcomes and school, class, and student variables is investigated using structural equation modelling. The chapter reports the exploration of the relative importance of the factors influencing student achievement. The analysis involves those student, class and school-level variables, which were developed and discussed in Chapter Four. This technique of structural equation modelling demonstrates the strength of effects, the direction of effects, and also gives an opportunity to test the recursive nature of relationships. Based on previous research a hypothesised model of interaction between school, class and student variables, and student achievement was developed. Based on the hypothesised model described in Figure 5.1, a post hoc approach was adopted to identify the best fitting and most meaningful model for student achievement.

5.1 FITTING AND EXPLORING 'FULL' STUDENT ACHIEVEMENT MODELS

A major purpose of this study was to fit a student achievement model and to identify the relationships among student, class, and school factors. Prior to considering a full structural model, the distribution properties of the continuous variables were assessed. Many of these variables were minimally negative skewed with little to no kurtosis. Because the data are marginally non-normally distributed and the sample size meets the minimal requirement of weighted least square (WLS) estimation, this estimation procedure was used to investigate relationships (Byrne, 1998).

All variables to be included in the full model were continuous variables except sex of the student, which was used as a dummy variable. Therefore, polyserial correlation matrices and asymptotic covariance matrices were used in the structural equation analysis. Two models, the first hypothesised model (see Figure 5.1) and the revised hypothesised model (see Figure 5.3) were examined and explored in the structural equation analysis, each of which has been theorised to explain the influences on student achievement.

When fitting the full models, the estimated composite variable regression coefficients and measurement errors (see Tables 4.1 and 4.2 from Chapter Four) were used as fixed parameters, as recommended by other researchers (Holmes-Smith, 1999, 2000; Rowe & Rowe, 1999), in the measurement part of the structural equation models. These estimates are not shown in the path diagrams in this thesis in order to reduce complexity. The only parameters to be estimated here were the structural part of the model which includes the regression coefficients betas (βs) and gammas (γs). The adequacy of the models was evaluated using the goodness of fit statistics which are presented with the structural models in Figure 5.2 and 5.4.

The models were tested first including only the hypothesised pathways (both gammas and betas). If the hypothesised model did not fit adequately, a post hoc data analysis was then adopted to explore the possible relationships revealed in these data. Re-specification of the model was guided as much as possible by substantive considerations (Byrne, 1998; Kline, 1998) which means that paths were included only if they are supported by theory.

5.2 HYPOTHESISED MODEL OF STUDENT ACHIEVEMENT

The hypothesised model below has been described in Chapter One. In addition to those effects on achievement previously reported this hypothesised model includes the school learning environment factors. It is hypothesised that:

H_1 Student attitudes have a positive effect on student.

H_2 SES (ξ_2) of the student has a positive effect on student achievement (η_1). The higher the SES of the student the better the student will achieve.

H_3 Sex (ξ_1) has an effect on student achievement. Males will achieve better than females.

H_4 School level environment (ξ_3) has a positive effect on instructional practices (η_5) and an indirect effect on student achievement.

H_5 Instructional practices (η_4) have an effect on student achievement (the more student centred approaches promote higher achievement).

H_6 Success attribution (η_3) has an effect on student achievement (students with an internal orientation toward success achieved higher).

H_7 There is a relationship between success attribution and student attitudes and this has an effect on student achievement.

Figure 5.1 HYPOTHESISED MODEL OF STUDENT ACHIEVEMENT

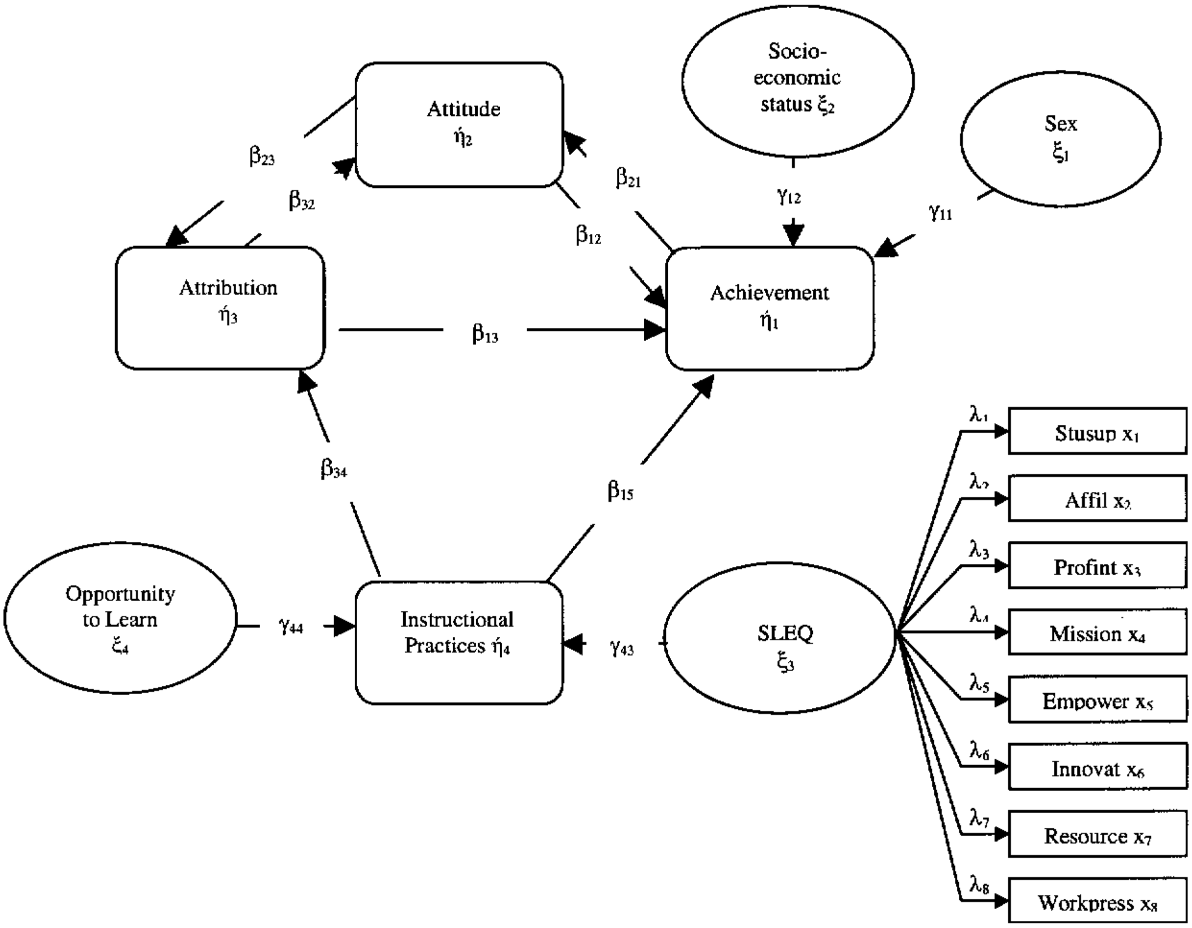
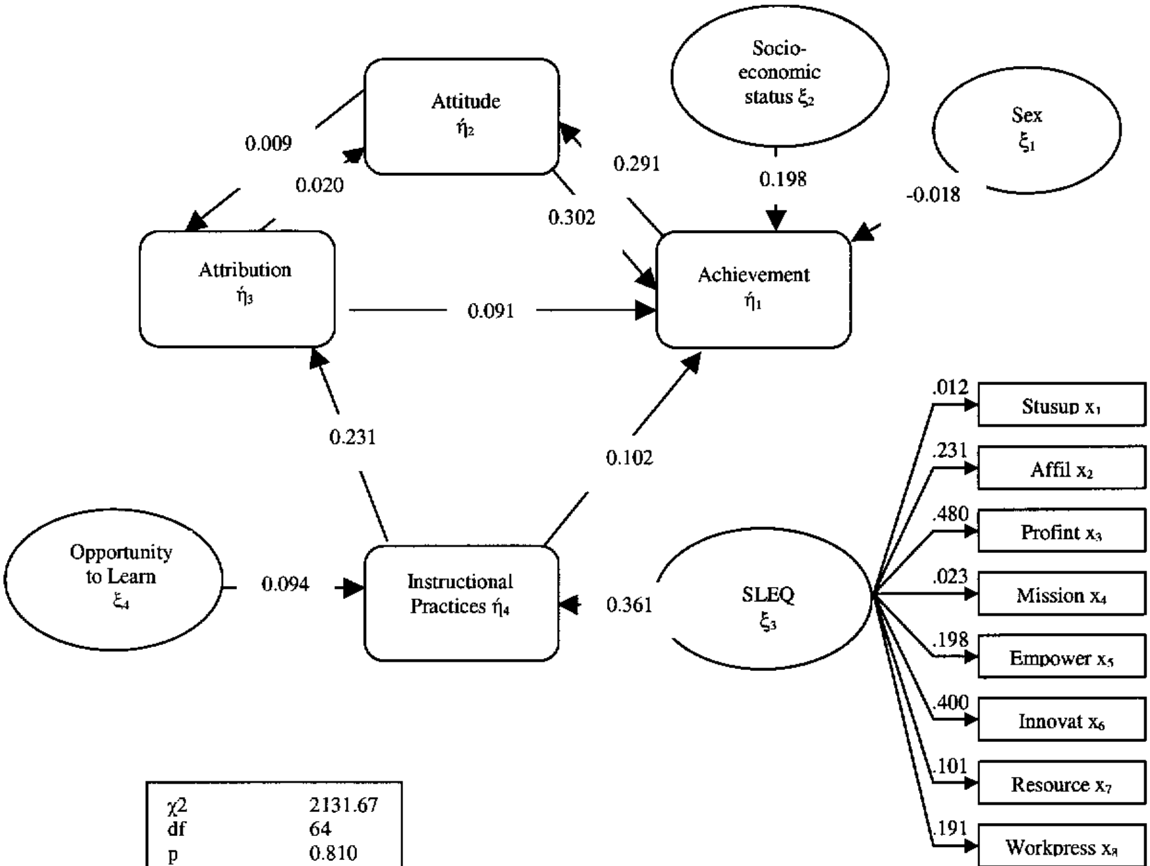


Table 5.1 VARIABLES USED IN THE FULL STRUCTURAL MODEL

Dependent Variables (Endogenos variables - η)	Independent Variables (Exogenous variables - ξ)
η_1 Mathematics achievement	ξ_1 Sex of student
η_2 Attitude toward mathematics	ξ_2 Socio economic status
η_3 Success attribution	ξ_3 School level environment
η_4 Instructional practices	ξ_4 Opportunity to learn

Tests of the initially hypothesised model for student achievement generated poor goodness of fit statistics and an examination of the structural results revealed several non-significant paths (see Figure 5.2).

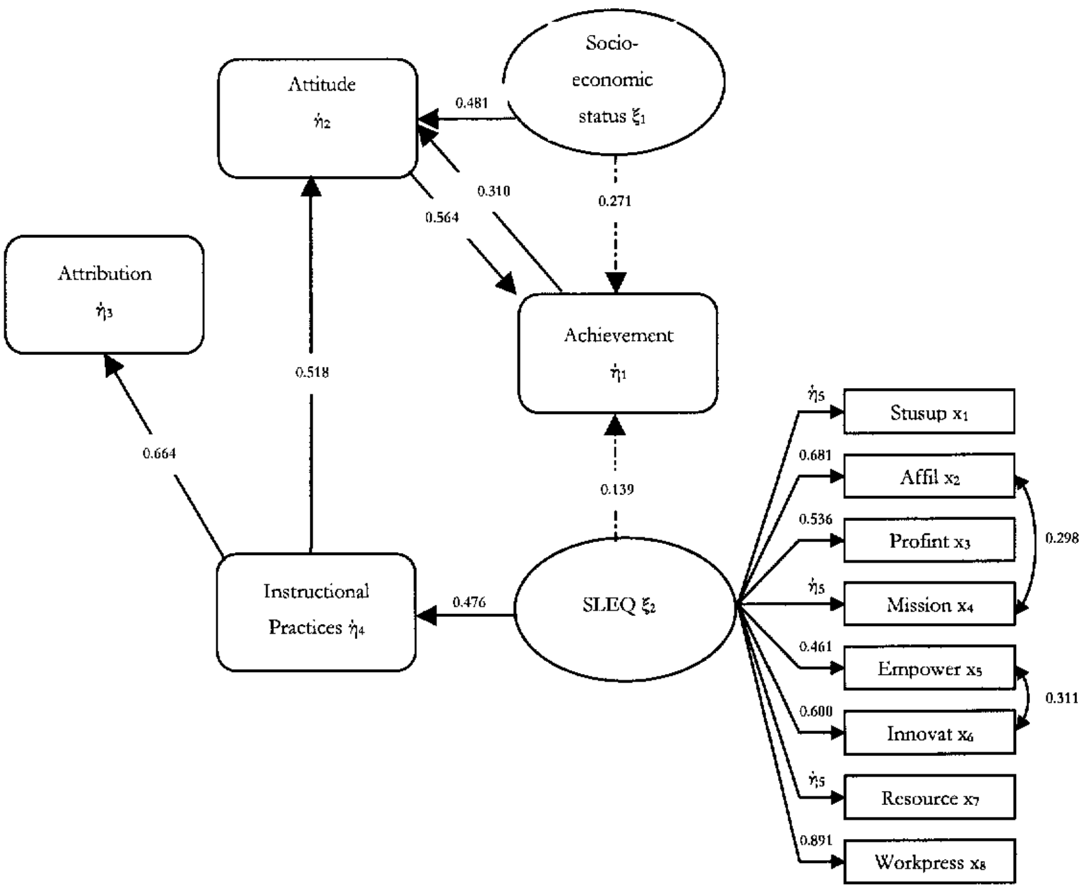
Figure 5.2 RESULTS OF HYPOTHESISED MODEL OF STUDENT ACHIEVEMENT



$\chi 2$	2131.67
df	64
p	0.810
RMSEA	0.210
GFI	0.675
AGFI	0.719

The analysis identified that four of the relationships (depicted as paths on the models) between the dependent variables were not significant. The regression of attribution on achievement was positive but not significant (0.091), the regression of instructional practices on achievement was also positive but not significant (0.102), and the regression of both attitude on attribution (0.020) and attribution on attitude (0.009) were positive and not significant. The regression of the independent variable opportunity to learn on instructional practices was also not significant (0.094). Surprisingly, these data did not support the hypothesis that sex of the student had an effect on student achievement demonstrated by a non-significant regression (-0.018). As a result of the overall bad fit of the model a second hypothesised model was developed on the basis of these results (see Figure 5.3).

Figure 5.3 REVISED HYPOTHESISED MODEL OF STUDENT ACHIEVEMENT



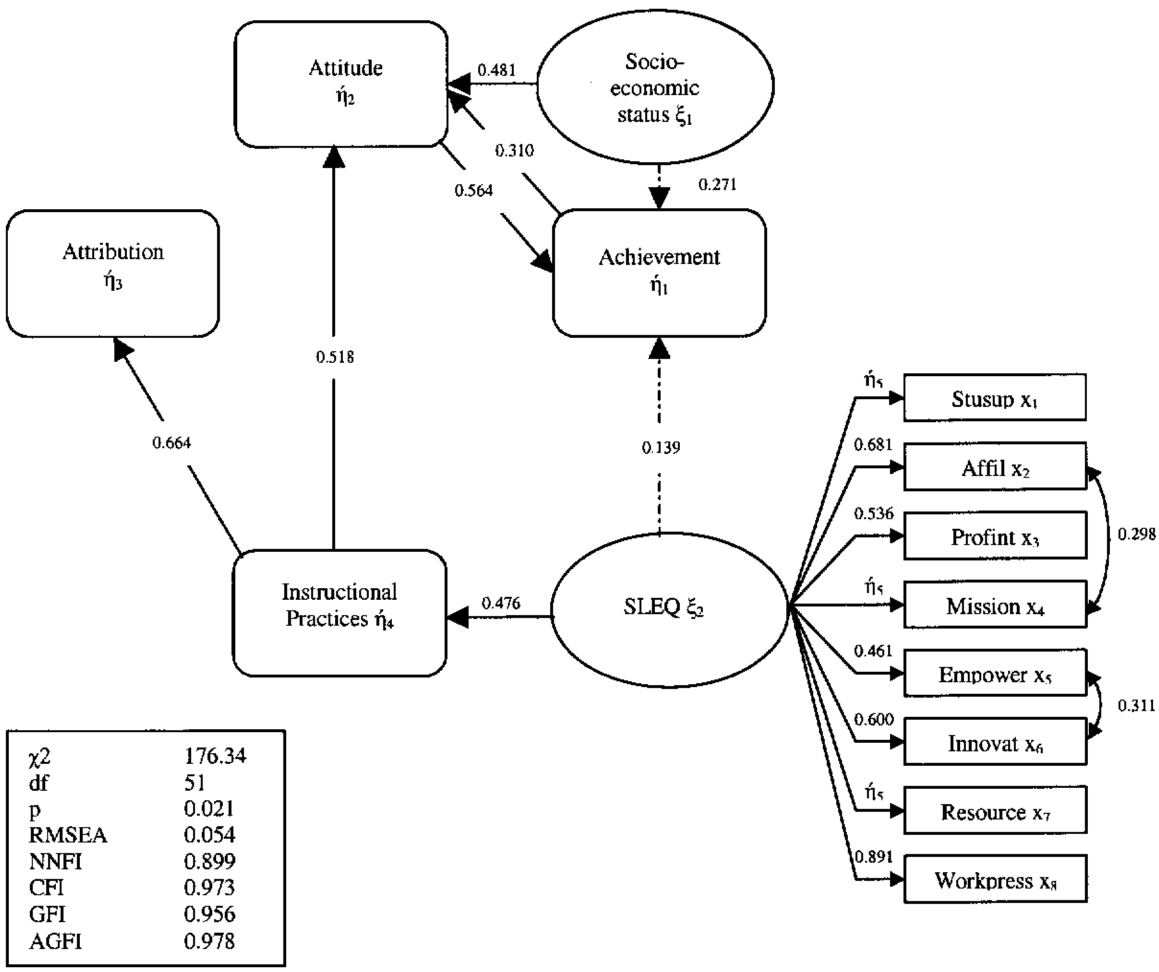
χ^2	176.34
df	51
p	0.021
RMSEA	0.054
NNFI	0.899
CFI	0.973

5.3 REVISED HYPOTHESISED MODEL OF STUDENT ACHIEVEMENT

The results of the modified model are presented in Figure 5.4 along with the goodness of fit statistics. This model is a good fit to the data indicated by the chi-square (χ^{2} = 176.34, *df* 51; *p*= 0.021) and supporting fit statistics (RMSEA = 0.54; GFI = 0.956). Although the model results in Figure 5.3 show that Student Support (stusup), Mission Consensus (mission) and Resource Adequacy (resource) are not significant, these scales of the school-level environment were kept in the model on the basis of the results of the eight-factor measurement model described in Chapter Four. School-level environment was validated as an eight-factor model and the modified structural model has good model fit indicating that all relationships are contributing to the overall relationship with student achievement.

The structural part of the model indicates several significant relationships some of which support previous research and those that add to the evidence of factors influencing student achievement. In this model, the relationship between attitude and achievement is recursive. Both effects are significant with the effect of student attitude towards mathematics strongly affecting student achievement (β = 0.564). The socio-economic status of students has a positive effect on student attitude (β = 0.481) resulting in an indirect effect on achievement (β = 0.271). Of particular interest in this study is the school-level environment and the effects on student achievement. These results show that there is an indirect effect of the school environment as perceived by teachers and student achievement (β = 0.139). This effect is a result of the school environment having a direct effect on the way teachers deliver the curriculum (β = 0.476). The better the environment for the teachers the more the instruction in classrooms is teacher-centred. The way teachers deliver the curriculum in their classrooms has a strong and positive effect on student attitudes (β = 0.518), which has already been reported as having a significant effect on student achievement. The more teacher-centred the instruction the more positive the attitudes of students and the better the achievement is. These results support previous research that has indicated students' respond to structured, directed, and clear instruction in classrooms. In this model, instructional practices positively affect success attribution (β = 0.664). There were no significant relationships between success attribution and other variables in the model. The model fit with these data did not allow for any paths showing the influence of success attribution.

Figure 5.4 FINAL MODEL OF STUDENT ACHIEVEMENT



5.4 SUMMARY

CHAPTER SIX

RESULTS OF THE MULTILEVEL MODELLING

This chapter presents the results of the multilevel analysis conducted with both the TIMSS data and the SLEQ data collected from the 57 participating schools. Section Firstly, an overview of the use of multilevel analysis in educational research and the software chosen to conduct the analysis is discussed. Secondly, the fully unconditional model is presented and an explanation of the three levels of analysis, (student, class, and school) are described in detail. The first conditional model, presented in the next section, is the student background model and this includes the socio-economic status and the sex of the student. An additional model of student attitudes towards mathematics and student beliefs about success in mathematics is also presented in this section. The classroom-level variables are then introduced and a model which includes instructional practices in the classroom, is described in this section. Descriptive information regarding how teachers deliver the curriculum has been used to create a composite score of instructional practices in which the higher the score the more teacher-directed is the instruction. This model of instructional practices also includes students' opportunities to learn which is a measure of the exposure students in classrooms have to mathematics instruction. To investigate the interaction of instructional practices and student characteristics, an additional model including SES and gender is also presented in this section. The following section involves school-level variables including the school environment and the average SES of the school. Also included in this final section is an investigation of the interaction of the school environment and the instructional practices used to deliver the curriculum.

6.1 INTRODUCTION

Traditional linear models, on which most educational researchers have previously relied, require the assumption that errors are independent, yet most subjects are 'nested' within classrooms, schools, districts, states, and countries so that responses within groups are group dependent. To ignore the nested structure of this type of data ultimately gives rise to problems of aggregation bias (within-group homogeneity) and imprecision (Raudenbush & Bryk, 1998). The Multilevel Linear Model provides an integrated strategy for handling problems such as aggregation bias in standard error estimates and erroneous probability values in hypothesis testing of school effects. For this study, the multilevel software selected for this stage of the analysis was MLn (Goldstein, 1996), chosen as the software program most appropriate for studying school and student effects related to the student outcomes of particular interest in this study.

Usually research on school effects has previously been conducted with a set of data analysed at the individual student level with the assumption that classrooms and schools affect students equally. However, when the effects vary among individuals and their contexts, this type of statistical analysis can be misleading (Bryk & Raudenbush, 1987). Ordinary least squares analysis provides information about the total variance, but can only break this total variance into the between- and within-school effects. The between-school effect may be influenced by school-level variables, such as the affluence of the school and the school-level environment. This study aimed to explain variations in student outcomes by first decomposing observed relationships into between-school and within-school components and taking into account the inherent multilevel structure of the data collected from the participating schools.

6.2 THE FULLY UNCONDITIONAL MODEL

In this study, the use of the multilevel linear model involved the single cross-section of data with a three-level structure consisting of students (Level 1) nested within classes (Level 2) nested within schools (Level 3). The fully unconditional model with no predictor variables specified was the first model to be estimated. The outcome measure, mathematics achievement, was free to vary across three different levels of analysis: student, class, and school. This model is described below in Equations 1, 2 and 3 and the results are presented in Table 6.1.

6.2.1 Student-Level Model

Mathematics achievement for each student is estimated as a function of the class average plus random error:

$$\mathrm{Ach}_{ijk} = \pi_{0jk} + e_{ijk} \qquad \text{Equation 1}$$

where:

Ach_{ijk} represents the mathematics achievement of each student *i* in class *j* and school *k*.

π_{0jk} represents the class mean Mathematics achievement of class *j* in school *k*.

e_{ijk} represents the random error of student *i* in class *j* and school *k*

$i = 1, 2, 3, \ldots, n_{jk}$ students in class *j* and school *k*.

$j = 1,2, \ldots j_k$ classes within school *k*,

$k = 1, \ldots, k$ schools.

6.2.2 Class-Level Model

Mathematics achievement classroom mean varies as a function of the school mean plus random error:

$$\pi_{0jk} = \beta_{00k} + r_{0jk} \qquad \text{Equation 2}$$

where:

β_{00k} represents the mean Mathematics achievement in school *k*.

r_{0jk} represents the random error of class *j* within school *k*

6.2.3 School-Level Model

Mathematics school mean achievement varies randomly around a grand mean for all schools.

$$\beta_{00k} = \gamma_{000} + \mu_{00k} \qquad \text{Equation 3}$$

where:

γ_{000} represents the grand mean Mathematics achievement for all schools.

μ_{00k} represents the random school effect, the deviation of school *k's* mean from the grand mean.

This three-level model partitions the total variability in the outcome measure, mathematics achievement, into its three components: students within classes (σ^2), classes within schools (τ_π) and between schools (τ_β).

Table 6.1 VARIANCE COMPONENTS FOR THREE-LEVEL MULTILEVEL MODEL FOR MATHEMATICS ACHIEVEMENT

Level of Analysis	Parameter	Estimate (s.e.)	
Fixed Model	Constant	4.976 (0.189)	
Random Model	Parameter	Variance Estimate (s.e.)	Percentage of Total Variance
School	Constant	0.139 (0.072)	7.5%
Class	Constant	0.642 (0.085)	34.3%
Student	Constant	1.089 (0.075)	58.2%
Total		**1.870**	**100.0%**

The results of this analysis revealed that a large proportion of the residual variance in students' achievements in mathematics was located at the class level 34.3 per cent. As expected, 58.2 per cent of the variance in mathematics achievement was located at the individual student level and only 7.5 per cent at the school level. All of these estimates are statistically significant, meaning that the parameter estimates are more than twice the variance estimates (s.e.) at all levels (see Table 6.1).

6.3 STUDENT BACKGROUND MODEL

To investigate the effect of those student background factors demonstrated in previous research to be mediating factors when accounting for variance in student outcomes, this model was estimated first using socio-economic status (SES) of student and sex of student. The intercept in this model was allowed to vary across classes and schools. That is, mean achievement varied between classes due to classroom effects and schools due to school effects. This model is described in Equation 4 and the results are presented in Table 6.2. In the student-level equation presented below, Ach_{ijk} is the mathematic achievement of student i in class j and in school k. The classroom level equation includes one random equation and two fixed effects equations, with the mean achievement π_{0jk} allowed to vary between classes. Finally, there is one random equation at the school level, where the grand mean achievement β_{00k} is allowed to vary across schools.

$$\text{Ach}_{ijk} = \pi_{0jk} + \pi_{1jk}(\text{SES}_{ijk}) + \pi_{2jk}(\text{Sex}_{ijk})$$
$$\pi_{0jk} = \beta_{00k} + r_{0jk}$$
$$\pi_{1jk} = \beta_{100}$$
$$\pi_{2jk} = \beta_{200}$$
$$\beta_{00k} = \gamma_{000} + \mu_{00k} \quad \text{Equation 4}$$

Table 6.2 **THREE-LEVEL MULTILEVEL ANALYSIS OF STUDENT SOCIO-ECONOMIC STATUS AND GENDER AND MATHEMATICS ACHIEVEMENT**

Level of Analysis	Parameter	Mathematics Achievement Estimate (s.e.)	Percentage Variance Explained by the predictor variables
Fixed Model	Constant	2.799 (0.180)	
	SES	0.301 (0.078)	
	Sex (1=M/2=F)	-1.278 (0.073)	
Random Model		Variance Estimate	
School	Constant	0.290 (0.013)	7.9%
Class	Constant	0.489 (0.049)	6.0%
Student	Constant	0.875 (0.068)	8.5%
Total		**1.654**	**22.4%**

The predictor variables, SES and sex of student, together account for 22.4 per cent of the total variance in mathematics achievement with 7.9 per cent of this being at the school level. This is an indication that the affluence of the school, measured by aggregated student SES affects achievement at the student level. The class-level influence of 6 per cent is also significant. An investigation of the estimates for each variable shows that males significantly perform better than females in mathematics (β = -1.278) and students from higher socio-economic backgrounds perform better than other students.

6.4 STUDENT ATTITUDES AND BELIEFS MODEL

Upon estimation of the student background model, a further conditional model was estimated in order to investigate the effects of student attitudes towards mathematics (StudAtt) and student beliefs about success in mathematics (StudBel). For this model, the student background variables (SES and sex) were also included in the fixed part of the model. The generic statistical equation is described in Equation 5 and the results are presented in Table 6.3.

$$
\begin{aligned}
Ach_{ijk} &= \pi_{0jk} + \pi_{1jk}(SES_{ijk}) + \pi_{2jk}(Sex_{ijk}) + \pi_{3jk}(StudAtt_{ijk}) + \pi_{4jk}(StudBel_{ijk}) + e_{ijk} \\
\pi_{0jk} &= \beta_{00k} + r_{0jk} \\
\pi_{1jk} &= \beta_{100} \\
\pi_{2jk} &= \beta_{200} \\
\pi_{3jk} &= \beta_{300} \\
\pi_{4jk} &= \beta_{400} \\
\beta_{00k} &= \gamma_{000} + \mu_{00k}
\end{aligned}
$$

Equation 5

Table 6.3 THREE-LEVEL MULTILEVEL ANALYSIS OF STUDENT ATTITUDES AND STUDENT BELIEFS AND MATHEMATICS ACHIEVEMENT

		Mathematics Achievement	
Level of Analysis	Parameter	Estimate (s.e.)	Further Percentage Variance Explained
Fixed Model	Constant	2.299 (0.098)	
	SES	0.298 (0.087)	
	Sex	-1.003 (0.002)	
	StudAtt	0.499 (0.082)	
	StudBel	1.008 (0.043)	
Random Model		Variance Estimate	
School	Constant	0.004 (0.000)	0
Class	Constant	0.203 (0.071)	5.6%
Student	Constant	0.698 (0.100)	12.7%
Total			**18.3%**

A further 18.3 per cent of the variance in student achievement is accounted for by the inclusion of student attitude towards mathematics and students beliefs about success. The majority of this is accounted for at the individual student level, however, 5.6 per cent at the class level is strong and significant. The estimates for student attitudes (β=0.499) reveal no surprises. Students with positive attitudes towards mathematics perform better than students with more negative attitudes. What is not revealed by this analysis is the recursive nature of attitudes and achievement, that is, do students achieve better as a result of having more positive attitudes or do students have more positive attitudes because they are achieving better? The estimate for student beliefs about mathematics is also positive and significant (β=1.008) and indicates that students with a more internal orientation towards success performed better in mathematics than those students who believed success was more attributed to external factors. At the school level, students' attitudes and beliefs did not account for any further variance in achievement.

6.5 INSTRUCTIONAL PRACTICES MODEL

The student questionnaire in the TIMSS provided descriptive information about the classroom and how the teacher delivered the mathematics curriculum and a composite score for instructional practices for each student was developed as described in Chapter Three. The scoring of this scale is such that the higher the score the more teacher directed is the instruction. This model also included the opportunity to learn that students have in their classroom which is the number of hours that students are exposed to mathematics in the week.

$$\text{Ach}_{ijk} = \pi_{0jk} + \pi_{1jk}(\text{SES}_{ijk}) + \pi_{2jk}(\text{Sex}_{ijk}) + \pi_{3jk}(\text{Instruction}_{ijk}) + \pi_{3jk}(\text{Opport}_{ijk})$$

$$e_{ijk}$$

$$\pi_{0jk} = \beta_{00k} + r_{0jk}$$

$$\pi_{1jk} = \beta_{100}$$

$$\pi_{2jk} = \beta_{200}$$

$$\pi_{3jk} = \beta_{300}$$

$$\pi_{4jk} = \beta_{400}$$

$$\beta_{00k} = \gamma_{000}, + \mu_{00k}$$

Equation 6

The results presented in Table 6.4 indicate that student achievement is significantly higher when there is more teacher directed instruction and that a significant proportion of this is explained at the class level (9.2 per cent).

In this model, opportunity to learn was not a significant predictor of student achievement but the instructional practices of the teacher in the classroom did result in a significant estimate ($\beta = 0.621$) indicating that in classrooms where there is a greater degree of teacher-directed instruction the students achieve better. The inclusion of these classroom variables in the model explained a further 13.5 per cent of the variance in student achievement with most of this variance being explained at the class level.

Table 6.4 THREE-LEVEL MULTILEVEL ANALYSIS OF INSTRUCTIONAL PRACTICES AND MATHEMATICS ACHIEVEMENT

Level of Analysis	Parameter	Estimate (s.e.)	Further Percentage Variance Explained
Fixed Model	Constant	1.901(0.078)	
	SES	0.932(0.102)	
	Sex	-1.004(0.319)	
	Opportunity to learn	0.418(0.239)	
	Instructional practices	0.621(0.048)	
Random Model		Variance Estimate	
School	Constant	0.000(0.000)	0%
Class	Constant	0.601(0.127)	9.2%
Student	Constant	0.032(0.018)	4.3%
Total			**13.5%**

6.6 SCHOOL-LEVEL ENVIRONMENT MODEL

This final model includes five of the eight school-level environment scales. An initial investigation showed that student support, mission consensus and resource adequacy did not have a significant effect on student mathematics achievement and so they were omitted from this final model. Also included in this model is the average socio-economic status of the school, which is computed by aggregating the student SES to the school level. This model of school-level variables is described in Equation 7.

$$Ach_{ijk} = \pi_{0jk} + \pi_{1jk}(SES_{ijk}) + \pi_{2jk}(Sex_{ijk}) + \pi_{3jk}(Affil_{ijk}) + \pi_{2jk}(Affil_{ijk}) + \pi_{4jk}(Profint_{ijk}) + \pi_{5jk}(Empower_{ijk}) + \pi_{6jk}(Innovat_{ijk}) + \pi_{7jk}(Workpress_{ijk}) + \pi_{8jk}(AvSES_{ijk}) + e_{ijk}$$

$$\pi_{0jk} = \beta_{00k} + r0_{jk}$$

$$\pi_{1jk} = \beta_{100}$$

$$\pi_{2jk} = \beta_{200}$$

$$\pi_{3jk} = \beta_{300}$$

$$\pi_{4jk} = \beta_{400}$$

$$\pi_{5jk} = \beta_{500}$$

$$\pi_{6jk} = \beta_{600}$$

$$\pi_{7jk} = \beta_{600}$$

$$\pi_{8jk} = \beta_{600}$$

$$\beta_{00k} = \gamma_{000}, + \mu_{00k}$$ Equation 7

Table 6.5 THREE-LEVEL MULTILEVEL ANALYSIS OF SCHOOL-LEVEL VARIABLES

Level of Analysis	Parameter	Mathematics Achievement Estimate (s.e.)	Mathematics Achievement Further Percentage Variance Explained
Fixed Model	Constant	0.646(0.371)	
	SES	0.300(0.080)	
	Sex	-0.910(0.044)	
	Affiliation	0.199(0.070)	
	Professional interest	0.213(0.072)	
	Empowerment	0.111(0.051)	
	Innovation	0.211(0.100)	
	Work pressure	-0.138(0.038)	
	AvSES	0.098(0.551)	
Random Model		Variance Estimate	
School	Constant	0.103(0.008)	1.9%
Class	Constant	0.299(0.051)	5.6%
Student	Constant	0.109(0.076)	3.8%
Total			**11.3%**

The results presented in Table 6.5 indicate that the five school-level environment factors and the average SES of the school explain an additional 11.3 per cent of the variance in student achievement with most of this being at the class level. A further 1.9 per cent is accounted for at the school level and 3.8 per cent at the individual student level. An examination of the fixed model estimates reveals that the average SES of the school is not significant and most likely should be removed from the model. The socio-economic status is being accounted for at the student level and these results indicate that is there is no effect of the combined SES of students in schools. All of the school-environment scales are significant and indicate that the better the teachers perceive their environment in the school the higher the student achievement is. The work pressure estimate is negative because this scale has a reversed scoring, that is the higher the score the more pressure of work the teachers feel.

The final model described in Equation 8 involves an investigation of the interaction of the school environment and the instructional practices. The SLEQ scale used in this model was a composite of the five individual scales Affiliation, Professional Interest, Empowerment, Innovation, and Work Pressure. These five SLEQ scales had strong and significant regressions in modelling school-level environment of schools in this study. These results are presented in the structural equation model described in Chapter Five. An examination of the estimates in Table 6.6 shows that there is merit in including both school-environment scales and instructional practices in the same model and that these together explain a further 17.9 per cent of the variance in mathematics achievement 9.9 per cent of which is at the classroom level. All the estimates in this model are significant.

$$Ach_{ijk} = \pi_{0jk} + \pi_{1jk}(SES_{ijk}) + \pi_{2jk}(Sex_{ijk}) + \pi_{3jk}(SLEQ_{ijk})\ \pi_{4jk}(Instruct_{ijk}) + e_{ijk}$$

$$\pi_{0jk} = \beta_{00k} + r_{0jk}$$

$$\pi_{1jk} = \beta_{100}$$

$$\pi_{2jk} = \beta_{200}$$

$$\pi_{3jk} = \beta_{300}$$

$$\pi_{4jk} = \beta_{400}$$

$$\pi_{5jk} = \beta_{500}$$

$$\pi_{6jk} = \beta_{600}$$

$$\beta_{00k} = \gamma_{000}, + \mu_{00k}$$

Equation 8

Table 6.6 THREE-LEVEL MULTILEVEL ANALYSIS OF SLEQ AND INSTRUCTIONAL PRACTICES

Level of Analysis	Parameter	Mathematics Achievement Estimate (s.e.)	Further Percentage Variance Explained
Fixed Model	Constant	0.336(0.071)	
	SES	0.209(0.120)	
	Sex	-0.690(0.084)	
	SLEQ	0.391(0.037)	
	Instructional practices	0.099(0.010)	
Random Model		Variance Estimate	
School	Constant	0.044(0.007)	1.2%
Class	Constant	0.239(0.061)	9.9%
Student	Constant	0.118(0.077)	6.8%
Total			**17.9%**

The results of the multilevel analysis in this section demonstrate the importance of taking into account the hierarchical nature of the data allowing variance in achievement to be estimated at the levels where most variance is accounted for. These analyses indicate student achievement is affected by factors at all three levels and that the clustering effects of class and of school membership should be considered when explaining differences in student achievement. Also indicative of student achievement is the way the curriculum is delivered in classrooms and how instruction in classrooms influences student attitudes and how particular modes of instruction are preferred by students dependent on their success attribution. Variance in student achievement is enhanced at the class level by the more teacher directed instructional practices. The interaction between both school level environment and instructional practices and student background variables further explains the variance in student achievement at the class level by 9.9 per cent. Students' beliefs about success and students' attitudes toward mathematics accounts for variance mainly at the individual student level and is mediated by SES and sex.

The decision to continue to include student SES and sex in all of the models presented in this chapter is based on the theoretical knowledge outlined in Chapter Two that these variables have strong and significant influences on student achievement at all levels of analysis and by including them and allowing the analysis to account for individual differences in these factors, the variance accounted for by other factors is in spite of these particular differences.

6.7 SUMMARY

This chapter has presented the results of the multilevel modelling which has taken into account the hierarchical nature of the data in this study. It is essential when investigating influences on student achievement to consider both that there are clustering effects, and that influences are not always at an individual level. When making policy and curriculum decisions evidence about where the greatest and most influential variance is in student outcomes such as achievement is useful for teachers and school leadership to implement changes where the most effect is going to be. It is not always practical to cater to individual needs in the classroom. Teachers are unable to change student background variables which we now do influence student outcomes and therefore it is important for teachers and leaders in schools to know where changes can be made and policy can be implemented that will facilitate change leading to improvement in student outcomes. Evidence that indicate changes at a classroom level or a school level will have impact on improving student outcomes can be used to enhance student cognitive and affective outcomes in schools.

CHAPTER SEVEN

DISCUSSION AND CONCLUSION

7.1 INTRODUCTION

This study involved an investigation of factors influencing student achievement and student attitudes towards mathematics and involved an investigation of the magnitude and direction of the relationships between those particular variables and student outcomes both achievement and affective outcomes. The study also involved a multilevel analysis, which enabled the partitioning of the variance in student achievement to the school level, class level and student level. Using the TIMSS data alone would not have enabled this and the additional collection of environment data provided an opportunity to further investigate factors that take consideration of the reality that learning for students occurs in classrooms with teachers and not independently of the interactions that the environment allow and provide. This study is unique and contributes to the existing body of knowledge in that it involves the use of national student achievement data and adds to it school learning environment data to allow the researcher to demonstrate and provide evidence that factors at the school level such as the environment influence both student achievement and also the way in which teachers instruct in the classroom. We know that teachers in classrooms operate within a system that influences the way they teach and that student learning occurs in schools not independent of the teachers, the classroom or what is happening at the school (see Good Biddle & Goodson, 1997, pp. 673) who wrote in the 'International Handbook of Teachers and Teaching':

> 'We have gained a good deal of convincing empirical evidence confirming large difference in the quality of instruction among teachers and classrooms and that these differences have significant impact on students' academic performance'.

Although we know this and the questions about the influence at the classroom level and that teachers have on student learning outcomes are not new ones, there continues to be a consistent focus on research that looks at student outcomes and improvement in these learning outcomes at a system and collective school level. The addition of the school environment data in this present study, although not ideally collected as previously discussed, provides new knowledge about the influences that the teacher has on student outcomes by the way the environment in the school enables the teacher to teach in the classroom.

The way teachers present the curriculum has direct effects on student attitudes and indirect effects on student achievement and this was discussed in detail in Chapter Five. The results presented in Chapter Six support previous research that has demonstrated that variation in student achievement is significant at the class level. This particular data provides further and new support for these previous findings and with the use of national achievement data merged with subsequently collected school environment data. These results explain variation in student achievement by including class-level factors and school-level factors into the model.

In the past 25 years, there has been much research in the area of learning environments. Much of this research was based on the work done by Moos in developing the Social Climate Scales (1976), which assessed aspects of a number of different types of human environments. A number of instruments have been developed to measure and describe various aspects of classroom-level and school-level environments (Fraser, 1994), including the School Level Environment Questionnaire (SLEQ). The study of learning environments is extensive and international however this present study takes what we already know about learning environments to another level in both methodology and context. More appropriate statistical procedure have been used in this study and the addition of student achievement data provided the opportunity to demonstrate the influences on student learning outcomes of the learning environments within the school. In addition the instructional practices which we already know have an impact on student learning in this study are modelled in relation to the learning environment and student learning outcomes.

This research is unique because it has combined the school-level environment and student-level and class-level variables in an exhaustive structural equation modelling and multilevel modelling process to investigate the differences in student mathematics achievement and the factors that affect these student outcomes. Prior to these stages of the study, the measurement scales in the learning environment survey were computed using a confirmatory factor analysis and multivariate measurement modelling procedure which is unique to the learning environment field of study. The specific benefits of this type of measurement modelling is discussed in detail in Chapter Four.

The study involved 620 teachers in 57 schools and 4,645 students in 203 classes. All states and territories in Australia were represented and the study included both independent and public schools. Results from the study indicate that the school-level environment has an influence on the way that teachers instruct students in classrooms and these instructional practices have a direct effect on student attitude toward mathematics and an indirect effect on student achievement.

7.2 OVERVIEW OF THE STUDY

This thesis firstly presented a hypothesised model to explain achievement differences in mathematics education in terms of student-level, class-level and school-level variables and then the model was tested using data collected from the TIMSS (1995) study and the subsequent school learning environment (1997) study. Student data collected included socio-economic status, attitudes towards mathematics and success attribution in addition to the measured achievement data in mathematics. The class-level data collected included opportunity to learn and instructional practices. At the school level the data collected included eight scales of the school level environment being student support affiliation, professional interest, mission consensus, empowerment, innovation, resource adequacy and work pressure.

Chapter Two presented the literature on school effectiveness and the factors reported to influence student learning outcomes in mathematics, the influence of background factors, the success attribution and the instructional practices within classrooms and how these influence student learning outcomes. It is clear that school effectiveness research has travelled a long journey and the results of many good studies provide support for the need to focus our attention at the classroom level where teachers are positioned to make a difference with the learning outcomes of the students. The void of substantive studies that bring together that which is happening in the classroom with the information collected from national achievement studies is apparent making this particular study an important inroad into placing the emphasis for educational effectiveness in the classroom where the teachers and students are interacting within the school environment to maximise the learning outcomes of the students.

Also presented in Chapter Two is the literature available about the school-level environment influences on teaching and learning in schools and the clear message in this literature is that the school environment does have an influence on how the teachers operate in the classrooms which may, but no evidence was provided, influence student learning outcomes. Also evident by the lack of it, was in all the studies reported, appropriate construction of the school level environment scales by use of sophisticated statistical techniques that enable the computation of the composite scales by attributing In addition what had not been previously investigated was the hypothesis that the school-level environment has an influence at the student level as well as the school level and class level.

Chapter Two also presented previous research in which there is support that student attitudes towards mathematics and student success attribution influence student achievement. This present study adds to this current body of knowledge and provided an investigation of the direct and indirect effects of attitude and success attribution and included the measurement of instructional practices used in the classrooms. An extensive review of the effects that instructional practices have on the way students learn and the different models of instruction was presented in Chapter Two.

The study including both the collection of the TIMSS data and the learning environment data was cross-sectional in design and the methodological problems involved in these types of studies and the associated limitation have been discussed in Chapter One and Chapter Three. Other issues of methodology were also described in Chapter Three, including the sampling procedures, instruments used to collect data, and the statistical analysis conducted during the investigation.

The measurement models and their outcomes is detailed in Chapter Four. The construction of the variables used in the analysis is presented and the results of the congeneric measurement models and the eight-factor and the one-factor models were given. The school-level environment was demonstrated to be a multifaceted construct rather than a global environment construct, which makes the hypothesised model of factors affecting student achievement rather complex, but a better reflection of reality. It is the first known attempt to model such a complicated phenomenon as school environment and to account for variance in student outcomes at all levels of the education system within schools. Along with the findings that far more variance in student outcomes is attributable between class differences and teacher instructional differences a collective perspective of what the school can offer the teacher in terms of the environment in which to work is highlighted as an important consideration. This is supported by Darling-Hammond in her synthesis of research (1997) where she concluded that schools which were structured for success organise teachers and students to work together I ways that get beyond bureaucracy to produce a collective perspective across the school. Although not talking about environments per se, the issue is still one of students and teachers not operating independent of the environments in which they teach and learn.

The structural equation modelling and the multilevel modelling results and procedures were presented in Chapter Five and Chapter Six. Part of the discussion in this current chapter includes each of the research questions being addressed and the findings discussed in light of these questions. The research questions are addressed in order however the results presented for each of the questions may at times be a combination of results from several chapters and not in particular numerical order.

7.3 FINDINGS

The first research question posed for this study was:

1. Does mathematics achievement vary systematically among schools?

This question could be asked at system level and unfortunately the answers wanted may be in total disregard to factors other than measured student achievement that may in fact have had an influence. In this analysis nothing is conducted in isolation to factors that have previously been demonstrated to have and influence and no league table type results are in any part presented. We already know that the amount of variance in student measured achievement accounted for at the school level is very little demonstrated in studies such as those by Scheerens (1992, 1997) and Scheerens and Bosker (1997). What was found in studies such as these was that when relevant prior achievement and other intake characteristics of students are considered, differences between schools are important but not particularly large. The results from this analysis provide further knowledge about the direct and indirect effects involving student attitudes towards mathematics.

The first set of estimates given in Chapter Six and presented in Table 6.1 are results of the unconditional model, partitioning variance in student mathematics achievement between the student level, class level, and school level. These results indicate that very little of the variance in student mathematics achievement is at the school level but that the 7.5 per cent that is accounted for is a significant estimate. Previous research has demonstrated that very little of the variance in student achievement outcomes is to be located at the school level but more one of what happens in the classroom (Cuttance, 1998; Muijs & Reynolds, 2001; Rowe, 2000b; Rowe 2001) and so this is not an unusual result. However, when other variables are included in the model, the only additional variance at the school level is explained by the school environment factors of Affiliation, Professional Interest, Empowerment, Innovation, and Work Pressure. An additional 1.9 per cent of the variance in achievement is explained by these factors.

3. The results of the structural equation models show an indirect effect (β=0.139) on student achievement from the school environment. The direct effects are from student attitude towards mathematics (β=0.564). However, there is also a direct effect of student achievement on student attitudes (β=0.310). Both of these estimates are significant and indicate that, the influences between achievement and attitudes are recursive in nature. These findings support the influences on student outcomes both academically and affectively by what is happening in the classroom. Although no significant direct effects from the school-level variables are reported, these indirect effects are significant and important in planning and promoting student achievement.

4.

5. By addressing school-level issues and creating an environment where teachers are empowered, feel a sense of support and affiliation and the work pressure is acceptable, has the potential to result in changes to instructional practices which have direct effects on student attitudes and, in turn, can promote student achievement. Previous research has shown that attitudes and beliefs account for variation in student achievement, but little research has taken into account the relationships between these variables and the differences in achievement attributed to them at the different levels of education.

To investigate this, the second research question posed was:

2. To what extent do sex, socio-economic status, and student attitudes and beliefs account for differences in mathematics achievement?

Student achievement in this study was identified in this analysis as being directly influenced by student attitudes a result that is supported by previous findings (Brandt, 1998; Burnstein, 1992; Gibbons, Kimmel & O'Shea, 1997). However, in this present study two things are noteworthy. Firstly the development of the attitude scale and the methodology used to create the scale is commensurate to the more acceptable rigour involved in collapsing item level data to latent variables. Secondly the recursive phenomenon associated with cognitive and affective outcomes has been investigated.

The more positive the attitudes of the student to mathematics the higher the achievement. This influence was identifies as being recursive and as a point of departure to this present study further research would be in order to investigate the catalyst for improved measured achievement. Is student achievement influenced by positive attitudes or are positive attitudes a result of better achievement? In addition student achievement was significantly influenced by the socio-economic status (SES) of the student (β=0.271). Students from higher SES backgrounds achieved better in mathematics. SES also had a direct influence on student attitudes (β=0.481) and having more positive attitudes has a direct influence on better achievement in mathematics (β=0.546). These results support previous research that demonstrates the direct influence that SES has on student achievement and these results give new evidence showing the direct influence on student achievement as a result of the influence on student attitudes. The attribution beliefs of the students had no significant influence on student achievement in this model, however the instructional practices in the class did have a direct effect on these beliefs about success (β=0.664).

The attitudes and beliefs of students can be influenced by what is happening in their classrooms and the third and fourth research questions posed to investigate classroom instructional influences and opportunity to learn issues were:

3. Does instruction affect the average achievement of students within the same class?
4. How are student outcomes in mathematics influenced by opportunity to learn and different instructional practices?

In addressing these two research questions we are really beginning to provide an addition to the body of knowledge about the influences that teachers in classrooms have on the learning outcomes of the students.

The final model from the structural equation analysis indicated that the average achievement of students within the same class was indirectly influenced by the way the teachers presented the curriculum. We know from previous research that the characteristics, experiences and behaviours of the teacher has an influence on student learning. Carroll as early as 1963 included in his model of school learning the quality of instruction by the teacher. Later Slavin (1987) proposed a model of effective instruction that was built from Carroll's model of school learning and more recently (see Brophy, 1996; Keeves & Dryden, 1992) educational researchers have begun to look at the influence that instruction in the classroom has on student learning. What is new about this present study is again in the methodology of the development of the scales used to measure the different types of instructional practices and the inclusion of the data from class level, that is the students reporting on how the teacher is presenting the material, with that of measured student achievement.

The results from this present study demonstrate that instructional practices have a direct effect (β=0.518), on the attitude students have toward mathematics. A greater level of teacher-directed instruction promotes more positive attitudes which indirectly influences student achievement. These results show that to promote student achievement there are factors at the school level that can be considered which will influence the way teachers present the curriculum. In making such changes at the school level, teachers have an influence on the attitudes of students' which will achieve the outcome of better achievement outcomes.

Although in earlier studies, opportunity to learn was found to have an influence on student learning outcomes (see Keeves, 1992; Lapointe *et al*, 1989) when, in the analysis of the data in this study, other variables such as attitude, attribution, gender and socioeconomic status were included simultaneously in the model, no statistical significant effect was evident. This doesn't mean that a students' opportunity to learn isn't important in terms of student learning outcomes but it demonstrates the need to employ simultaneous methods of analysing data that allow for the consideration of all variables in the contextual models being tested. The inclusion of opportunity to learn in the hypothesised model revealed no statistically significant influence on student mathematics achievement nor was there any contribution to a good model fit, which became clear when this variable was removed from the analysis. In light of these results from this stage of the analysis the variable *opportunity to learn* was removed, a revised hypothesised model was presented and fitted.

The results of the multilevel modelling indicated that if the instructional practices were more teacher directed, and, if in the classroom students were given more opportunity to learn, the variation in student achievement was further explained at the class level by 9.2 per cent. These conclusions have strategic implications for the professional development that is provided for teachers and policy implications for the direction the curriculum should take in terms of the exposure to particular subjects that students should have in order to promote improved student learning. The last research question was posed to investigate the influence of school-level factors on student learning outcomes and this is an important educational question to ask in order to answer what is the better environment for teachers to be working in to promote positive and improved learning outcomes for students.

5. Does instruction interact with school-level factors to influence mathematics achievement?

Because the school-level environment was demonstrated to influence instructional practices, these variables were included in an additional three-level model and the results clearly show that both instructional practices and school-level environment further explained student achievement at the class-level by 9.9 per cent. In terms of what value this it to education and student learning and how does it take us further to what we already know has to do with the conception that a combination of factors that are not just a school level issue influences student outcomes. Educational research should be directed at what it is we can do to promote positive environments that then facilitate effective teaching practices in order to see improved learning outcomes for the students. Without the evidence that the environment that the teachers are working in does have an influence on the way that they teach which all influences student learning outcomes we are no further than those involved in educational research in previous years.

7.4 LIMITATIONS OF THE STUDY

In conducting a study such as this present one, where the authors have collected subsequent data post facto to that already collected for other purposes there are some limitations that need to be explained. The learning environments data was collected 18 months after the TIMSS data was collected. It has been discussed in chapter one that it was not possible to collect the data concurrently yet with the problems acknowledge there is still a considerable contribution to be made in terms of what is happening at the classroom level with teachers in those classrooms who are working and teaching not independently of the environments of the schools. The fact that the data was collected from teachers in those schools at a different time still provides us with a more complete picture of each of the schools who participated in this study which without the learning environment data we would not have.

One other limitation of this study is the lack of a prior knowledge score for students. It is well known that a students prior knowledge has an influence on measured student achievement and that in looking at improvement this should be accounted for. Without a measure of prior knowledge there is no opportunity to measure the value added to student outcomes and the influence that factors at any level had on any measured improvements. The cross sectional nature of the data collected and used in this present study (discussed in detail in Chapter Three) brings the associated limitations of not being able to map trends and also the inability to account for individual differences that a longitudinal study would allow. Although not really a problem with this present study, with the TIMSS data there was no opportunity for the input as to what data were collected and the manner with which it was collected. Other variables of interest, such as, whether the school was coeducational or single sex or students' English speaking ability, could have been added to the analysis and the differences in student outcomes at different sectors investigated as explanatory variables. Although not part of the content of the research questions for this study, an inherent limitation of secondary data analysis is the lack of input into the design and methodology which includes what data is collected.

7.5 SIGNIFICANCE OF THE STUDY

The methodological process and outcomes of the research are both significant. The unique methodology used allowed for the variables included in the analysis and the investigation of influences on student mathematics achievement, to be developed in a manner that attributed only that proportion of the contribution to each variable from individual items. Previous studies have used a method of unit weighting which does not account for individual contribution of items to the composite scale. In addition, the development of the school-level environment scales is unique to this study and clearly demonstrates that the school-level environment is a multi-factor concept and not a unidimensional concept. In allowing the variables that contribute to the school-level environment to remain multi-factor in the analysis, it was possible to separate and distinguish exactly where the influences were and the strength and significance of those influences. The estimates resulting from the measurement models at the student level, the class level and the school level can be used in further research.

Although there have been many years of educational environment research and these studies are well documented in Chapter Two, this study provides evidence about the influences and effects on student achievement that are new and significant. Studies that have been designed to allow the estimation of class level effects on student learning outcomes have shown larger proportions of between class and teacher variance and demonstrated a need for the focus to be more on what the teacher is doing in the classroom and the effectiveness of the instruction provided by the teacher in the classroom (Mortimore *et al.* 1998; Hill *et al*, 1993; Hill & Rowe, 1995, 1996; Rowe & Hill, 1995, 1998). This present study addresses that need and provides evidence that there are significant effects on student learning outcomes that are influenced by the instructional practices of the teacher. For policy and procedures to change in a way that has positive effects on student outcomes, it is essential to have evidence based on solid research conducted with rigour and purpose, and this study provides such evidence to the educational wider community. This study involved high-level research procedures and a sample that enables the results to be applied with confidence to the wider education community.

A knowledge of what it is at the school level that affects how teachers teach, allows schools to concentrate on those aspects of the school environment that are going to make the biggest difference to student outcomes. Why it is important to concentrate on the way teachers deliver the curriculum is demonstrated by this study in both the structural equation modelling and the multilevel modelling. Student attitudes are drivers of positive outcomes and these attitudes are influenced by factors at the class level such as instructional practices. This study gives solid evidence to support this and so policy makers and school governments are able to use these results to determine the most appropriate areas in which to make changes.

This study supports previous research that has shown student SES influences student affective and cognitive outcomes (Keeves & Saha, 1992). However, what is further revealed in this study is that these influences on the variation in achievement are as important at the school and class levels as they are at an individual level. This evidence has implications for policy-making in school districts where average SES can be considered for funding. Whereas we cannot change the SES of students, we can take into account the overall SES of our schools and our classes in making resourcing and teaching arrangements. This is also true for other student background variables such as sex and success attribution which cannot be changed but can be considered when developing programs and implementing policies so that the learning outcomes are optimal for the majority of students and learning processes are targeted for students in a way which facilitates optimal learning for their individual and collective characteristics.

Of particular importance in these results is the evidence that clearly demonstrates the recursive nature of students' affective and cognitive outcomes. If teachers are aware of which instructional practices promote positive attitudes and that these positive attitudes influence better achievement then they can adjust their practices to suit the learning needs of the students in their classes. Studies such as this present one present an argument for teachers, policy makers and school leadership that can be used in strategic directions to promote improved student learning outcomes. It is in addition helpful for teachers to know that mathematics students with a more internal locus of control, that is they attribute success to hard work and lots of extra study, achieve better when the curriculum is delivered with more teacher-directed instruction. If there are students in classes who have a more external locus of control then the curriculum can be delivered in a more student-centred paradigm to promote better achievement. Although it is difficult to cater for individual differences in classrooms, evidence such as that provided here, enables teachers to make adjustments to their teaching based on what is effective for particular groups of students who have specific learning needs.

In a climate of economic rationalism, and during periods of financial restrictions, schools require evidence based on solid research to make policy and procedural decisions, such as that evidence which is provided in this study. Schools can act with more confidence knowing that when teachers are given opportunities to be innovative in their teaching, when there is a strong sense of affiliation among staff, and when they are empowered to make decisions then the learning environments are more positive and this has consequences on the way teachers deliver the curriculum.

7.6 RECOMMENDATIONS FOR FURTHER RESEARCH

There are several areas where the author recommends further research that adds to the design of this study and the findings presented. As has been highlighted the environment data collected in this study was collected after the TIMSS data and ideally the data should be collected at the same time. The results of this study provide strong support for classroom activities and school environments that influence the way the teachers perform their role have an effect on student learning outcomes. There are limitations with what is possible with the data collected post facto that would be possible had the data been collected together with the teachers teaching the children whose measured achievement data were collected from. In designing future studies the author recommends this be taken into consideration.

Further research is recommended to be undertaken to confirm the effects of student background variables, such as success attribution and attitudes, that includes the students' prior knowledge. A study, which does not need to be on such a large scale as the study reported in this thesis, but which includes a measure of prior mathematical ability as a covariate will enable this. A smaller study could involve the use of estimates from the measurement models in this study to construct the composite variables of interest which means that the study need only involve a small sample. The weights and factor loadings obtained by these data can be used with new data from a further study.

To demonstrate the influence that changes at the school level make on student outcomes, a follow up study with selected schools would be of value to the educational community. Those schools where there were significantly low scores on particular school level environment scales, could be selected for the follow up study. Changes based on the outcomes of these analyses could be implemented and the influences measured by the collection of further data and comparisons of the aggregated school data.

7.7 FINAL COMMENTS

Because context is so important to our understanding of what works this present study pulls together the literature about educational effectiveness and develops from that a conceptual framework that includes what is happening in the classroom for the students in terms of their learning experiences. The context of the classroom and the environment that teachers are working in is not able to be ignored in the investigation of how we can provide more conducive learning environments and experiences to facilitate improved measured student learning outcomes.

The purpose of this thesis is to report a more comprehensive study of the influences on student outcomes that has included a methodology that is unique in its application to the variables of interest in this study. The purpose of the study is to provide school leadership, teachers and policy makers with evidence that demonstrates those variables that have positive effects on student outcomes and also to provide evidence about the most effective ways to improve student outcomes at the class level and at the school level.

The results of this study indicate that certain aspects of the school environment do influence what happens at the class level which then influences student outcomes at the individual level. These findings have important practical application because they provide schools with information that could help to promote the development of positive school environments, the development of positive instructional practices and therefore, improve the quality of the educational process.

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APPENDIX A

SCHOOL LEVEL ENVIRONMENT AND TIMSS QUESTIONNAIRE

Master Code Sheet.

curtin
University of Technology
Perth Western Australia

Our Lady of the Sacred Heart
Regional College
School No 231

1-3

Curtin University of Technology

The School Environment and The Third International Mathematics and Science Study

P
2

1996

Teacher Questionnaire

Dr Deidra Young, Research Fellow
Project Coordinator
Science and Mathematics Education Centre
Curtin University of Technology
GPO Box U1987
Perth WA 6001
☎ (09) 351 2988
Fax: (09) 351 2503 or 440 0243

This research project is funded by the Australian Research Council and the Department of Education Employment and Training as a Federal Initiative.

Email:
TYoungDJ@cc.curtin.edu.au

SECTION A

SOME QUESTIONS ABOUT YOU

1. When were you born? 8 (day) 2 (month) 1950 (year) 4-11

2. How old are you? 46 12-13

3. Are you male or female? Male ☐ 1 Female ☑ 2 14

4. Are you an Aboriginal person or Torres Strait Islander person?

   Yes ☐ 1 No ☑ 2 15

5. Do you speak English at home? 16

   Almost never or never ☐ 1

   Sometimes ☐ 2

   Almost always or always ☑ 3

6. How far in educational qualifications did you go? 17

   Primary school only ☐ 1

   Some secondary school ☐ 2

   Finished secondary school (Yr12) ☐ 3

   TAFE (Technical College) ☐ 4

   Some university study ☐ 5

   Finished university degree (Bachelor) ☑ 6

   Finished university degree (DipEd) ☑ 7

   Finished university degree (PostGrad) ☐ 8

   Finished university degree (Masters) ☐ 9

   Finished university degree (PhD) ☐ 10

7. How many years have you been teaching at the end of this school year?

   16 years 18 - 19

SECTION B

YOUR SCHOOL ENVIRONMENT

There are 56 items in this questionnaire. They are statements to be considered in the context of the school in which you work and your actual working environment.

Think about how well the statements describe your school environment.

Indicate your answer by circling:

1 if you *strongly disagree* with the statement;
2 if you *disagree* with the statement;
3 if you neither agree nor disagree with the statement or are not sure;
4 if you *agree* with the statement;
5 if you *strongly agree* with the statement.

If you change your mind about a response, cross out the old answer and circle the new choice.

		Strongly Disagree				Strongly Agree	Column
1	Most students are pleasant and friendly to teachers.	1	2	3	4	5	19
2	I receive encouragement from colleagues.	1	2	3	4	5	20
3	Teachers discuss teaching methods and strategies with each other.	1	2	3	4	5	21
4	The school mission statement and its associated goals are well understood by school staff.	1	2	3	4	5	22
5	Decisions about the running of this school are usually made by the principal or a small group of teachers.	1	2	3	4	5	23
6	It is difficult to change anything in this school.	1	2	3	4	5	24
7	The school or department library includes an adequate selection of books and periodicals.	1	2	3	4	5	25
8	There is constant pressure to keep working.	1	2	3	4	5	26
9	Most students are helpful and cooperative to teachers.	1	2	3	4	5	27
10	I feel accepted by other teachers.	1	2	3	4	5	28
11	Teachers avoid talking with each other about teaching and learning.	1	2	3	4	5	29
12	The organisation of this school reflects its goals.	1	2	3	4	5	30
13	I have to refer even small matters to a senior member of staff for a final answer.	1	2	3	4	5	31
14	Teachers are encouraged to be innovative in this school.	1	2	3	4	5	32
15	The supply of equipment and resources is inadequate.	1	2	3	4	5	33
16	Teachers have to work long hours to complete all their work.	1	2	3	4	5	34
17	There are many disruptive, difficult students in this school.	1	2	3	4	5	35
18	I am ignored by other teachers.	1	2	3	4	5	36
19	Staff meetings are dominated by administrative matters rather than teaching and learning issues.	1	2	3	4	5	37
20	Teachers regularly refer to the mission of the school when addressing school issues.	1	2	3	4	5	38
21	Action can be taken without gaining the approval of a senior member of staff.	1	2	3	4	5	39
22	There is a great deal of resistance to proposals for curriculum change.	1	2	3	4	5	40

23	Video equipment, tapes and films are readily available and accessible.	1	2	3	4	5	41
24	Teachers don't have to work hard in this school.	1	2	3	4	5	42
25	There are many noisy, badly-behaved students.	1	2	3	4	5	43
26	I feel that I could rely on my colleagues for assistance if I needed it.	1	2	3	4	5	44
27	Many teachers attend inservice and other professional development courses.	1	2	3	4	5	45
28	There is a high degree of consensus within the staff with regard to what the school is trying to achieve.	1	2	3	4	5	46
29	Teachers are asked to participate in decisions concerning administrative policies and procedures.	1	2	3	4	5	47
30	Most teachers like the idea of change.	1	2	3	4	5	48
31	Adequate copying facilities and services are available to teachers.	1	2	3	4	5	49
32	There is no time for teachers to relax.	1	2	3	4	5	50
33	Students get along well with teachers.	1	2	3	4	5	51
34	My colleagues take notice of my professional views and opinions.	1	2	3	4	5	52
35	Teachers show little interest in what is happening in other schools.	1	2	3	4	5	53
36	My views of the overall mission of this school are very similar to other staff members.	1	2	3	4	5	54
37	I am encouraged to make decisions without reference to a senior member of staff.	1	2	3	4	5	55
38	New courses or curriculum materials are seldom implemented in the school.	1	2	3	4	5	56
39	Tape recorders and cassettes are available when needed.	1	2	3	4	5	57
40	You can take it easy and still get the work done.	1	2	3	4	5	58
41	Most students are well-mannered and respectful to the school staff.	1	2	3	4	5	59
42	I feel that I have many friends among my colleagues at this school.	1	2	3	4	5	60
43	Teachers are keen to learn from their colleagues.	1	2	3	4	5	61
44	The operation of this school is consistent with its goals.	1	2	3	4	5	62
45	I am allowed to do almost as I please in the classroom.	1	2	3	4	5	63
46	There is much experimentation with different teaching approaches.	1	2	3	4	5	64
47	Facilities are inadequate for catering for a variety of classroom activities and learning groups of different sizes.	1	2	3	4	5	65
48	Seldom are there deadlines to be met.	1	2	3	4	5	66
49	Strict discipline is needed to control many of the students.	1	2	3	4	5	67
50	I feel lonely and left out of things in the staffroom.	1	2	3	4	5	68
51	Teachers show considerable interest in the professional activities of their colleagues.	1	2	3	4	5	69
52	Teachers agree on the school's overall goals.	1	2	3	4	5	70
53	I have little say in the running of this school.	1	2	3	4	5	71
54	New and different ideas are being tried in this school.	1	2	3	4	5	72
55	Class sets of important resource books are available when needed.	1	2	3	4	5	73
56	It is hard to keep up with your workload.	1	2	3	4	5	74

APPENDIX B

STUDENT QUESTIONNAIRE

TIMSS

IEA Third International Mathematics and Science Study

Student Questionnaire 2

In this booklet, you will find questions about yourself. Some questions ask for facts while other questions ask for your opinion. Read the questions carefully and respond as accurately and carefully as possible. You may ask for help if you do not understand something or are not sure how to respond.

Sometimes you have to write in words or numbers in the space provided to answer a question. Please write neatly and clearly. For other questions you need to choose your answer from those provided and colour in a circle to show your choice, like this:

1	Do you go to school?	● Yes		○ No	
		like a lot	*like*	*dislike*	*dislike a lot*
2	How much do you like school?	○	●	○	○

If you make a mistake, rub it out thoroughly and then colour in the circle corresponding to your new answer. You must use a 2B, B or HB pencil.

First of all, on the next page there are some pairs of words. In each pair, the two words have something in common. You need to decide whether the words mean nearly the **same** thing, or nearly the **opposite** thing, about what they have in common.

Here is an example:

		Same	*Opposite*
high	low	○	●

The two words 'high' and 'low' are both about height, but they are nearly **opposite** in meaning. Therefore you should colour in the circle under 'Opposite'.

PRACTICE

		Same	*Opposite*
fast	slow	○	○
huge	enormous	○	○

Doc. Ref.: ICC878/NRC415

02250

For each of these pairs of words, colour in a circle to show if the words mean nearly the same as each other or nearly the opposite.

			Same	*Opposite*
1	informed	unaware	○	○
2	precarious	stable	○	○
3	rapid	sluggish	○	○
4	supple	malleable	○	○
5	associate	partner	○	○
6	decoration	ornamentation	○	○
7	mute	voluble	○	○
8	prosperity	opulence	○	○
9	ordered	confused	○	○
10	prohibited	forbidden	○	○
11	boastfulness	modesty	○	○
12	wealthy	impoverished	○	○
13	adjacent	contiguous	○	○
14	create	originate	○	○
15	rare	habitual	○	○
16	benevolent	intolerant	○	○
17	vague	precise	○	○
18	wise	judicious	○	○
19	acquire	dispel	○	○
20	ancient	antique	○	○
21	obtuse	explicit	○	○
22	loosen	relax	○	○
23	despise	scorn	○	○
24	flagrant	obvious	○	○
25	gauge	measure	○	○
26	paltry	exorbitant	○	○
27	absolute	relative	○	○
28	everlasting	permanent	○	○
29	conformity	dissimilarity	○	○
30	converge	approach	○	○
31	consecrate	dedicate	○	○
32	variable	inconstant	○	○
33	bounty	generosity	○	○
34	delicate	tactful	○	○
35	obvious	indisputable	○	○

Now go straight on with the rest of the questio

1 **Are you a girl or a boy?** ○ Girl ○ Boy
(colour in a circle)

2 **Are you an Aboriginal person or Torres Strait Islander person?**
(colour in a circle)
○ Yes ○ No

3 **How old are you?** ________ years
(write in)

4 **On what date were you born?** ________ ________ ________
(write in) *day* *month* *year*

5 **Were you born in Australia?** ○ Yes ○ No
(colour in a circle)

If you were born in another country, what country was it?
(write in)

I was born in ______________________________

If you were born in another country, how old were you when you came to Australia to live?
(colour in a circle to show your age at that time)

○ under 1 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7
○ 8 ○ 9 ○ 10 ○ 11 ○ 12 ○ 13 or older

DO NOT USE THIS S

0	0	0	0	0	0
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9

6 **How often do you speak English at home?**
(colour in one circle)

① always or almost always

② sometimes

③ never

7 **What language does your family mostly speak at home?**
(write in)

____

Go straight

8 During the week, how much time before or after school do you usually spend ...

(colour in one circle for each line)

	no time	*less than 1 hour*	*1-2 hours*	*3-5 hours*	*more than 5 hours*
a) having extra lessons or coaching in mathematics?	○	○	○	○	○
b) having extra lessons or coaching in science?	○	○	○	○	○
c) participating in science or mathematics clubs?	①	②	③	④	⑤
d) working at a paid job?	○	○	○	○	○

9. On a normal school day, how much time do you spend before or after school doing each of these things?

(colour in one circle for each line)

	no time	*less than 1 hour*	*1-2 hours*	*3-5 hours*	*more than 5 hours*
a) watching television and videos	○	○	○	○	○
b) playing computer games	○	○	○	○	○
c) playing or talking with friends outside of school	○	○	○	○	○
d) doing jobs at home	○	○	○	○	○
e) playing sport	○	○	○	○	○
f) reading a book for enjoyment	○	○	○	○	○
g) studying mathematics or doing mathematics homework after school	○	○	○	○	○
h) studying science or doing science homework after school	○	○	○	○	○
i) studying or doing homework in school subjects other than mathematics and science	○	○	○	○	○

10 Which of these people live at home with you most or all of the time?
(colour in the circle next to each of the people who live with you)

- ○ mother
- ○ father
- ○ stepmother
- ○ stepfather
- ○ one or more brothers
- ○ one or more sisters
- ○ one or more grandparents
- ○ another relative or relatives such as uncles, aunts, cousins, etc.
- ○ another person or persons (not relatives)

---

11 Altogether, how many people live in your home?
(colour in one circle to show the total number of people)

Don't forget to include yourself.

○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 or more

---

12 Which of these things are in your home?
(colour in the circle next to each of the things found in your home)

- ○ calculator
- ○ computer
- ○ dictionary
- ○ study desk/table for yourself
- ○ your own bookshelves and books
- ○ your own wardrobe
- ○ dishwashing machine
- ○ CD or video player in your own room

---

13 About how many books are there altogether in your home?
(Do not count magazines, newspapers, or your school books.)
(colour in one circle to show how many books)

- ○ none or very few (0 - 10 books)
- ○ enough to fill one shelf (11 - 25 books)
- ○ enough to fill one bookcase (26 - 100 books)
- ○ enough to fill two bookcases (101 - 200 books)
- ○ enough to fill 3 or more bookcases (more than 200)

Go straight

14 **a) Was your mother born in Australia?** ○ Yes ○ No

(colour in one circle)

If not, which country was she born in? ____________________

b) Was your father born in Australia? ○ Yes ○ No

(colour in one circle)

If not, which country was he born in? ____________________

DO NOT USE THIS SPACE

0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

---

15 **What are your parents' occupations?** Not admin in VSA

Please describe the occupations of your mother and father as clearly as you can. Write in the **name** of the job and the **type of workplace** where the job is done.

Example 1

Name of job: fitter and turner

Place where job is done: factory that makes caravans

Example 2

Name of job: sales assistant

Place where job is done: supermarket

DO NOT USE THIS SPACE

0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

FATHER: Name of job: ____________________

Place where job is done: ____________________

MOTHER: Name of job: ____________________

Place where job is done: ____________________

If your mother and father are retired or ***unemployed,*** *describe their job before they became retired or unemployed.*

If your mother or father ***no longer lives*** *with the family, write 'other'. However, if you live with a stepmother or stepfather, describe their job instead.*

If your mother or father does not usually have a paid job but ***works at home*** *looking after children etc., write 'home duties'.*

18) Classroom Order
In my mathematics class ...

(colour in one circle for each line)

	strongly agree	agree	disagree	strongly disagree
a) students often neglect their school work. (+)	①	②	③	④
b) students are orderly and quiet during lesson time. (–)	①	②	③	④
c) students do exactly as the teacher says. (–)	①	②	③	④

19 Most of my friends think it is important to ...

(colour in one circle for each line)

	strongly agree	agree	disagree	strongly disagree
a) do well in science at school.	①	②	③	④
b) do well in mathematics at school.	○	○	○	○
c) do well in English at school.	○	○	○	○
d) have time to have fun.	○	○	○	○
e) be good at sport.	○	○	○	○
f) be placed in classes with the high achieving students.	○	○	○	○

20 I think it is important to ...

(colour in one circle for each line)

	strongly agree	agree	disagree	strongly disagree
a) do well in science at school.	○	○	○	○
b) do well in mathematics at school.	○	○	○	○
c) do well in English at school.	○	○	○	○
d) have time to have fun.	○	○	○	○
e) be good at sport.	○	○	○	○
f) be placed in classes with the high achieving students.	○	○	○	○

Perceived Ability

21) **How well do you usually do in mathematics and science at school?**

(colour in one circle for each line)

		strongly agree	agree	disagree	strongly disagree
a)	I usually do well in mathematics. (−)	①	②	③	④
b)	I usually do well in science. (−)	○	○	○	○

22 **How often did any of these things happen last month at school?**

(colour in one circle for each line)

Saftey

		never	once or twice	3-4 times	5 times or more
a)	I skipped a class.	①	②	③	④
b)	Something of mine was stolen. (+)	○	○	○	○
c)	I thought another student might hurt me. (+)	○	○	○	○
d)	Some of my friends skipped classes.	○	○	○	○
e)	Some of my friends had things stolen. (+)	○	○	○	○
f)	Some of my friends were hurt by other students. (+)	○	○	○	○

Locus of Control

23 **To do well in mathematics you need ...**

(colour in one circle for each line)

		strongly agree	agree	disagree	strongly disagree
ext a)	lots of natural ability. (−)	①	②	③	④
b)	good luck. (+)	○	○	○	○
int c)	lots of hard work studying at home. (−)	○	○	○	○
d)	to memorise the textbook or notes. (+)	○	○	○	○

24 **To do well in science you need ...**

(colour in one circle for each line)

		strongly agree	agree	disagree	strongly disagree
ext a)	lots of natural ability. (−)	①	②	③	④
b)	good luck. (−)	○	○	○	○
int c)	lots of hard work studying at home. (−)	○	○	○	○
d)	to memorise the textbook or notes. (−)	○	○	○	○

Go straight o

25 How much do you like ...

(colour in one circle for each line)

	dislike a lot	*dislike*	*like*	*like a lot*
a) mathematics?	○	○	○	○
b) science?	○	○	○	○

26 How much do you like using computers in ...

(colour in one circle for each line)

	don't use computers	*dislike a lot*	*dislike*	*like*	*like a lot*
a) mathematics classes?	○	○	○	○	○
b) science classes?	○	○	○	○	○

27 What do you think about mathematics?

(colour in one circle for each line)

	strongly agree	*agree*	*disagree*	*strongly disagree*
a) I enjoy learning mathematics.	○	○	○	○
b) Mathematics is boring.	○	○	○	○
c) Mathematics is an easy subject.	○	○	○	○
d) Mathematics is important to everyone's life.	○	○	○	○
e) I would like a job that involved using mathematics.	○	○	○	○

28 I need to do well in mathematics ...

(colour in one circle for each line)

Motivation

	strongly agree	*agree*	*disagree*	*strongly disagree*
a) to get the job I want.	○	○	○	○
b) to please my parent(s).	○	○	○	○
c) to get into the university/post-school course I prefer.	○	○	○	○
d) to please myself.	○	○	○	○

29 How often does this happen in mathematics lessons?

(colour in one circle for each line)

		almost always	*pretty often*	*once in a while*	*never*
a)	The teacher shows us how to do mathematics problems. Tea Dir	○	○	○	○
b)	We copy notes from the board. Tea Dir	○	○	○	○
c)	We have a quiz or test. Tea Dir	○	○	○	○
d)	We work from worksheets or textbooks on our own. Practical	○	○	○	○
e)	We work on mathematics projects. Practical	○	○	○	○
f)	We use calculators.	○	○	○	○
g)	We use computers.	○	○	○	○
h)	We work together in pairs or small groups. Practical	○	○	○	○
i)	We use things from every day life in solving mathematics problems. Stud Part	○	○	○	○
j)	The teacher gives us homework.	○	○	○	○
k)	We can begin our homework in class.	○	○	○	○
l)	The teacher marks our homework.	○	○	○	○
m)	We check each other's homework.	○	○	○	○
n)	We discuss our completed homework. Stud part	○	○	○	○

Go straight on

30 26 **When we begin a new topic in mathematics, we begin by ...**

(colour in one circle for each line)

		almost always	pretty often	once in a while	never
a)	having the teacher explain the rules and definitions. Tea Dir	○	○	○	○
b)	discussing a problem related to everyday life. Stud Part	○	○	○	○
c)	working together in pairs or small groups on a problem or project. Practical	○	○	○	○
d)	having the teacher ask us what we know that is related to the new topic. Stud Part	○	○	○	○
e)	looking at the textbook while the teacher talks about it. Tea Dir	○	○	○	○
f)	trying to solve an example related to the new topic. Practical	○	○	○	○

31 a) Listed below are some of the world's environmental problems. How much do you think the application of science can help in addressing these problems?

(colour in one circle for each line)

		not at all	very little	some-what	a great deal
a)	air pollution	○	○	○	○
b)	water pollution	○	○	○	○
c)	destruction of forests	○	○	○	○
d)	endangered species	○	○	○	○
e)	damage to the ozone layer	○	○	○	○
f)	problems from nuclear power plants	○	○	○	○

b) Which one of the above problems concerns you most?

○ a ○ b ○ c ○ d ○ e ○ f

32 What do you think about science?

(colour in one circle for each line)

		strongly agree	agree	disagree	strongly disagree
a)	I enjoy learning science. (-) recode	①	②	③	④
b)	Science is boring. (+)	○	○	○	○
c)	Science is an easy subject.	○	○	○	○
d)	Science is important to everyone's life.	○	○	○	○
e)	I would like a job that involved using science.	○	○	○	○

33 I need to do well in science ...

(colour in one circle for each line)

		strongly agree	agree	disagree	strongly disagree
a)	to get the job I want.	○	○	○	○
b)	to please my parents.	○	○	○	○
c)	to get into the university/post-school course I prefer.	○	○	○	○
d)	to please myself.	○	○	○	○

34 If you were going to choose a career that uses a science, which science would you prefer to use?

(colour in one circle)

- ○ Biology
- ○ Chemistry
- ○ Earth Science
- ○ Physics

Go straight on →

35 **How often does this happen in science lessons?**

(colour in one circle for each line)

		almost always	pretty often	once in a while	never
a)	The teacher shows us how to do science problems.	○	○	○	○
b)	We copy notes from the board.	○	○	○	○
c)	We have a quiz or test.	○	○	○	○
d)	We work on science projects.	○	○	○	○
e)	We work from worksheets or textbooks on our own.	○	○	○	○
f)	We use calculators.	○	○	○	○
g)	We use computers.	○	○	○	○
h)	We use things from every day life in solving science problems.	○	○	○	○
i)	We work together in pairs or small groups.	○	○	○	○
j)	The teacher gives us homework.	○	○	○	○
k)	We can begin our homework in class.	○	○	○	○
l)	The teacher marks our homework.	○	○	○	○
m)	We check each other's homework.	○	○	○	○
n)	We discuss our completed homework.	○	○	○	○
o)	The teacher gives a demonstration of an experiment.	○	○	○	○
p)	We ourselves do an experiment or practical investigation in class.	○	○	○	○

36 When we begin a new topic in science, we begin by ...

(colour in one circle for each line)

		almost always	*pretty often*	*once in a while*	*never*
a)	having the teacher explain the rules and definitions.	○	○	○	○
b)	discussing a problem related to everyday life.	○	○	○	○
c)	working together in small groups on a problem or project.	○	○	○	○
d)	having the teacher ask us what we know that is related to the new topic.	○	○	○	○
e)	looking at the textbook while the teacher talks about it.	○	○	○	○
f)	trying to solve an example related to the new topic.	○	○	○	○

THANK YOU for answering these questions. You are one of 500 000 students from about 50 countries who are taking part in this important study.

TIMSS Study Center
Boston College
Chestnut Hill, MA, USA 02167

Australian Council for for
Educational Research Ltd.,
Private Bag 55
Camberwell, VIC, Australia 3124

APPENDIX C

CONSENT FORM

curtin
University of Technology
Perth Western Australia

Third International Mathematics and Science Study and the School Level Environment Questionnaire

Please return this form to Dr Deidra Young, Science and Mathematics Education Centre, Curtin University of Technology, GPO Box U1987, Perth WA 6001, as soon as possible to confirm that you agreed to participate in this study and agree to allow the Australian Council for Educational Research (ACER) to release to us your TIMSS School Identification Code for the purposes of merging the TIMSS and SLEQ data.

We promise not to divulge this information nor to use it for any other purpose other than the conduct of this study. No individual teacher data, names or SLEQ information will be used in this study or for any purposes. Your confidentiality is important to us and to ACER.

A reply paid envelope has been enclosed for your convenience, although you are welcome to fax your information to: (08) 9266 2503 or (08) 9440 0243.

Thank you very much for your assistance and participation!

☐ Yes, I wish to allow the Australian Council for Educational Research to release the TIMSS school identification codes to Dr Deidra Young for the purposes of her combined TIMSS and SLEQ study

☐ No, I do not wish to allow the Australian Council for Educational Research to release the TIMSS school identification codes to Dr Deidra Young for the purposes of her combined TIMSS and SLEQ study

Signature of Principal: ______________________ Date: __________

Principal Name: ______________________

School Name: ______________________

Fax No: ______________ Telephone No: ______________

School Address: ______________________

____

____

For further information, please contact: Dr Deidra Young, Telephone: (08) 9266 2988, Fax: (08) 9440 0243 or (08) 9266 2503, Email: tyoungdj@cc.curtin.edu.au

DEADLINE: 16th May 1997