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ABSTRACT

The effects of academic self-concept and the learning environment on science and mathematics achievement were studied in remote and rural Western Australia. The Western Australian School Effectiveness Study explored achievement in 28 urban and rural high schools. In the first phase, survey instruments were developed and piloted in two schools, and in the second phase, a 3-year longitudinal study of government, Catholic, and independent secondary schools was implemented. The proposed third phase will use a case study approach to examine some exceptionally effective schools. All results tended to be lower for students from remote areas, but it was suspected that these variations may be related to socioeconomic status. Teachers perceived that students were more supportive in metropolitan schools, and students in rural schools thought that their teachers and peers were more supportive. Students in country schools appeared to be more satisfied with their schools. Achievement scores were not readily comparable because of a lack of prior achievement data. Background and context effects explained a large amount of variance in the classroom, but little was found to explain student achievement at the school or classroom level of analysis. Most variation in science and mathematics achievement was at the student level. (Contains 4 figures, 15 tables, and 106 references.) (SLD)

Amultilevel Analysis of Science and Mathematics Achievement

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A MULTILEVEL ANALYSIS OF SCIENCE AND MATHEMATICS ACHIEVEMENT

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INTRODUCTION

The purpose of this study was to investigate the effect of academic self-concept and the learning environment on science and mathematics achievement among students in rural and remote parts of Western Australia. This study was prompted by some of the findings from the Tomlinson Review of Rural Schools (Tomlinson, 1994). Further comparisons of rural, remote and urban schools revealed the significant effect which socioeconomic status has upon student outcomes (Young, 1991a, 1991b, 1994a, 1994b, 1994c, 1994d, 1994e, 1995; Young & Fraser, 1992a, 1992b, 1993a, 1993b, 1994).

This paper reports findings from a study undertaken in 28 urban and rural schools in Western Australia, called the Western Australian School Effectiveness Study (WASES). While these schools were from entirely different locations, they provided interesting information about how students and teachers perceived their schools.

REVIEW OF RURAL EDUCATION RESEARCH

Recent educational research has examined rural/urban differences in achievement, appropriateness of rural/urban achievement measures, effects of parents and the community on the attainment of rural students, and how well rural students succeed in higher education. However, in order to assess the rural school's impact on student outcomes, rural/urban comparisons must be made on students who are matched by background and school characteristics. Findings that there are little differences in the academic achievement of rural and urban students or in their desire to attend higher education and that rural students aspire to higher education contrast with evidence that rural high school students have less total access to educational information. It could be argued that rural high school students are therefore, in terms of their overall progress, achieving more, not less, in spite of greater obstacles (Edington & Koehler, 1987).

Many educators, researchers, legislators, and the general public believe that students from smaller and rural schools receive an education that is inferior to that of students from larger urban or suburban schools. Until recently, there has been little empirical evidence to challenge that view. Now, however, a growing body of work has begun to examine how well students perform in and after graduation from rural schools. Some of these studies are presented below, and, although the results are far from conclusive, they do suggest that some generally held beliefs about rural student achievement are open to question.

A comparison of the performance on standardised achievement tests of students from small, usually rural, schools with those from larger, often urban, institutions has not produced definitive results. Several studies have not found any significant differences between the two groups. In research completed in the state of New York, Monk and Haller (1986) found that students from smaller (often rural) schools achieved as well as students from larger schools. Kleinfeld and others (1985), in their Alaska study, did not find that high school size determined the quality of a student's education, experience, or achievement on standardised tests. Moreover, in one New Mexico study, which looked at factors affecting performance of selected high school students, those attending schools in rural areas performed as well as those in urban locales (Ward & Murray, 1985).

There is some indication that what is being measured in studies of rural-urban differences is socioeconomic status and/or ethnicity. Easton and Ellerbruch (1985) found that the poorer rural students scored considerably lower on citizenship and social studies tests than did students from upper socioeconomic urban communities. Another study which held socioeconomic level and ethnicity constant revealed no urban-rural achievement gap (Edington & Martellaro, 1984). This has been reaffirmed by an Australian study of students in Years 3, 7 and 10. In this study, the socioeconomic status of the school accounted for most of the variation in student achievement in mathematics, reading and writing (Young, 1994b, 1994d). However, this research was limited in that the variables were collated on a post hoc basis.

Kleinfeld and colleagues (1985) suggested that schools that achieve the best results do exhibit strong teacher/administration/community partnership and school/community agreement on educational programs. They also have reported that there is a direct relationship between quality education programs and the ability of the staff to work toward an educational partnership with the community. Smaller communities tend to generate more community support for the school, with the school becoming a centre for community activity. This, in turn, theoretically provides the students with a greater feeling of belonging to something in which they can participate, and thus enables them to develop a better self-concept.

Rural education research has been conducted in Louisiana by Stringfield and Teddlie (1991, 1993) for ten years and these researchers have produced some fine and valuable findings. These researchers have found significant variations in what makes a school effective in the rural parts of the USA. Further research by Bobbett and colleagues (1990) in the rural Appalachian regions of Kentucky and Tennessee identified effective schools were characterised by school climate factors including:

- orderly and pleasant
- characterised by purposeful activity
- caring
- concerned about student and community involvement
- celebrating achievements of students and faculty
- staffed with highly committed individuals

More importantly, researchers have now begun to question the generalisability of the effective school model for urban, suburban and rural schools, given substantial differences in their social and organisational environments (Hannaway & Talbert, 1993). Rural educational research must therefore not continue to ignore contextual effects and this study presents findings which have accounted not only for the rural sector, but also school context and student background.

REVIEW OF SCHOOL EFFECTIVENESS RESEARCH

In early research on school effectiveness, there was considerable emphasis on the ability and family background of the student in determining academic performance. The Coleman Report (Coleman et al., 1966, p. 296) estimated that the school influence on student achievement was about 10 to 20 percent of the total variance, yet the methodology used by Coleman had not accounted for the hierarchical nature of students nested within schools. Coleman's findings were repeated in further large-scale studies (Jencks et al., 1972, 1979; Hauser, Sewell & Alwin, 1976), which suggested that (1) school level variables, such as physical resources, account for small amounts of variability in student achievement and (2) student characteristics, such as socioeconomic status and home background, should be used to adjust student achievement in statistical analysis of large-scale studies.

In Britain, research into schools became prominent during the 1980s with Fogelman's findings that the amount of schooling received by students was directly related to their academic achievement (1978, 1983). While early British researchers analysed the effects of academic and social backgrounds of students, there was some doubt about whether control for differences in student intake was adequate (Reynolds, 1976; Reynolds & Sullivan, 1979; Rutter et al., 1979). Reynolds reported large school level differences in attendance rates, even when students came from similar social and economic backgrounds. More recent studies, which included student information prior to school entry and better analytic techniques, reported substantial variations between schools (Mortimore et al., 1988; Smith & Tomlinson, 1989; Nuttall et al., 1989). The improvement of analytical techniques more adequately addressed the hierarchical nature of the data, that is, the variability between schools and within schools was separated (Bryk & Raudenbush, 1986; Goldstein, 1984, 1987).

While early British research by Reynolds (1982) and Rutter and colleagues (1979) indicated that schools affected students equally, later studies by Aitkin and Longford (1986) found significant differences in school effects for students from different socioeconomic backgrounds. Further, Cuttance (1992, pp. 78-79) reported that achievement was significantly greater for students from more affluent home backgrounds, when compared with students from poorer homes. In this British study, Cuttance showed that school intake differences account for a large proportion of the variation in unadjusted variation in student achievement. Finally, Cuttance asserted that any analyses of the effectiveness of schools need to adjust for the social background and prior attainment of students.

The examination of social and gender differences in United States schools has led researchers such as Levine (1992) to recommend that multiple measures of students' social and economic background be used to control for social class influences on achievement. Levine et al. (1979) found that the frequently used US indicator, students' subsidised lunch status, was not useful due to highly variable reporting by principals. Levine also urged that schools be examined for their effectiveness in equalising the academic achievement of minorities and disadvantaged groups. The importance of examining the equity of the school, as well as the school's effectiveness, was advocated by US researchers who found that a school could be identified as highly effective, yet have lower class and minority students with poor academic performance (Brookover, 1985; Shoemaker, 1984; Lezotte, 1986).

The importance of the school and classroom environment in enhancing learning has been investigated by Fraser (1986, 1991), who found strong links between student outcomes and their educational environments. Fraser and Tobin combined qualitative and quantitative methodologies in their study of exemplary teachers and found the classroom learning environment was decisive in enhancing student learning in science (Fraser & Tobin, 1989; Tobin & Fraser, 1987). In addition, studies into factors associated with educational productivity found nine consistent factors: student ability, student development, student motivation, instructional time, instructional quality, home environment, classroom environment, peer groups and television viewing (Fraser, Walberg, Welch & Hattie, 1987).

CONTEXT STUDY IN SCHOOL EFFECTIVENESS RESEARCH

Educational researchers who were challenged by the Coleman report's conclusion that schools don't matter, set about to investigate schools that served low-SES students who performed well on standardised tests (Brookover et al., 1979; Brookover & Lezotte, 1979; Edmonds, 1979b; Glenn, 1981; Klitgaard & Hall, 1974; Venezky & Winfield, 1979). As the research developed on effective schools for the "urban poor", Edmonds repudiated Coleman and Jencks:

> Repudiation of the social science notion that family background is the principal cause of pupil acquisition of basic skills is probably prerequisite to successful reform of public schools.
>
> (Edmonds, 1979a, p. 23)

However, in a new phase of school effects research, sampling procedures were improved and the characteristics of effective schooling for students from a variety of contexts were questioned (Wimpelberg, Teddlie & Stringfield, 1989). These researchers began to ask what makes an effective school for the disadvantaged groups in our community. Further, Levine and Lezotte (1990) concluded that three types of school contexts should be studied in school effects research:

- Student body SES (socioeconomic status of the aggregated student population)
- Grade level of schooling
- Urbanity (rural versus urban)

Stringfield and Teddlie's ten year longitudinal study of effective schools in Louisiana cumulated in significant findings that there were six types of differentially effective schools (1993). These researchers found that students in more effective schools had higher future educational expectations than those from less effective schools. For these students, they felt less academic futility and perceived greater teacher push than did those students from less effective schools. There was a more positive educational climate for students from more effective schools.

While some effective-school characteristics were found regardless of the school SES, such as clear academic mission, orderly environment, high academic engagement and frequent monitoring of student's progress, there were a number of differences in characteristics of effectiveness between middle- and low-SES schools (p. 36). A difference in future educational expectations by teachers in the two types of schools was associated with effectiveness. They found that teachers in effective low-SES schools held high present, but more modest future, expectations for their students.

Of significant importance was the differences in effectiveness of schools depending upon the urbanity context of the school. Stringfield and Teddlie summarised 16 characteristics of differentiation between urban, suburban and rural elementary schools (1993, pp. 158-162). For example, 'in small towns, an effective rural principal can help the school to become the focal point of the community and garner additional resources along the way'.

CONCEPTUAL FRAMEWORK

A conceptual framework for school effectiveness described by Scheerens and Creemers (1989) in Figure 1. Scheerens and Creemers proposed a multi-level model of schooling which incorporates three organisational levels: the student, the classroom and the school (Creemers & Scheerens, 1994). These three levels were investigated using multilevel modelling of a large-scale, longitudinal survey data as suggested Stringfield and Teddlie's contextually sensitive research studies (1993). Three types of contexts will be included in this research: student aggregated SES, grade-level and urbanity.

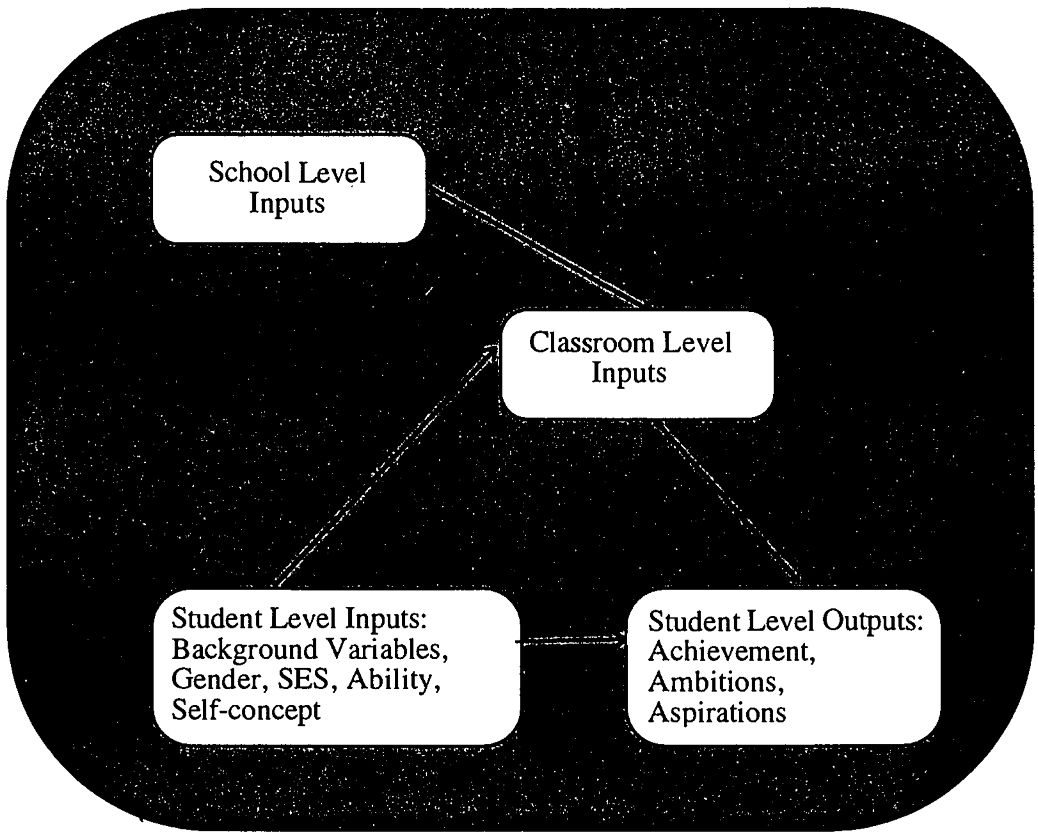

Figure 1. Multilevel Model of School Effectiveness
(Scheerens and Creemers, 1989)

RESEARCH DESIGN

This research study, the Western Australian School Effectiveness Study [WASES] involves three phases (Table 1). In the *First Phase*, the survey instruments were developed and piloted in two schools (1995).

In the *Second Phase*, a three year longitudinal survey was commenced in 28 West Australian high schools. Both Government, Catholic and Independent secondary schools were surveyed. The purpose of this survey was to evaluate the school and classroom climate and characteristics of effective schools in differential contexts. Because the growth model is particularly useful for measuring change over time in student outcomes, while controlling for other influencing variables which may also change over time, the same students at the same schools will be surveyed over a period of three years

(1996 to 1998). This phase will be called WASES-II in 1996, WASES-III in 1997 and WASES-IV in 1998 and is being funded in part by the Australian Research Council.

Finally, in the *Third Phase*, a case study approach will be used to examine some exceptionally effective schools in the rural and urban locations of Western Australia (1997-99). Case studies will commence in 1997 and selected from some outlier schools based on statistical data from WASES-II and WASES-III.

Table 1. Longitudinal sampling frame.

Phases of Study	Year	Grade of Sample	Schools	Students
Phase 1				
[WASES-I]	1995	Year 10	2 Secondary Schools	163
Phase 2				
[WASES-II]	1996	Years 8, 9, 10	28 Secondary Schools	3,500
[WASES-III]	1997	Years 9, 10, 11	28 Secondary Schools	
[WASES-IV]	1998	Years 10, 11, 12	28 Secondary Schools	
Phase 3				
[WASES-V]	1997-99	Case Studies	8 Rural and Urban Schools - Effective and Ineffective	

Assessing the school environment

International research efforts involving the conceptualisation, assessment and investigation of perceptions of psychosocial aspects of educational environments have established educational environment as an important field of study (Fraser, 1994; Fraser & Walberg, 1991). One of the originators of this line of research, Moos (1974), found that the same three general categories can be used in conceptualising the individual dimensions characterising diverse psychosocial environments. This finding emerged from Moos's work in a variety of environments including hospital wards, school classrooms, prisons, military companies, university residences and work milieus. The three basic types of dimensions are: Relationship Dimensions (e.g., peer support, involvement) which identify the nature and intensity of personal relationships within the environment, and assess the extent to which people are involved in the environment and the extent to which they support and help each other; Personal Development Dimensions (e.g., professional interest) which assesses the basic directions along which personal growth and self-enhancement tend to occur; and System Maintenance and System Change Dimensions (e.g., innovation, work pressure) which involve the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change.

Recent classroom environment research has focused on science laboratory classroom environments (McRobbie & Fraser, 1993), constructivist classroom environments (Taylor, Dawson & Fraser, 1995) and computer-assisted instruction classrooms (Teh & Fraser, 1995), while other studies have focused on the school environment (Fisher, Fraser & Wubbels, 1993). However, a careful review of the potential strengths and problems associated with existing school environment instruments led to the development of a new school environment instrument named the *School Level Environment Questionnaire* (SLEQ) (Fisher & Fraser, 1990), which measures teachers' perceptions of psychosocial dimensions of the school environment. This instrument consists of seven scales, with two measuring Relationship Dimensions (Student Support, 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).

Table 2. Description of scales in SLEQ and their classification according to Moos' scheme.

Scale Name	Description of Scale	Sample Item	Moos's 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 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	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 pressures dominates school environment.	Teachers have to work long hours to keep up with the workload. (+)	System Maintenance and System Change

Items designated (+) are scored by allocating 5, 4, 3, 2, 1, respectively, for the responses Strongly Agree, Agree, Not Sure, Disagree, Strongly Disagree. Items designated (–) are scored in the reverse manner. Omitted or invalid responses are given a score of 3.

Fisher, Fraser and Wubbels (1993) have reported validation data for the SLEQ for a number of samples including one study of 46 teachers in seven Australian schools. The validation data include information about each scale's internal consistency (Cronbach alpha reliability), discriminant validity (mean correlation of a scale with the other seven scales) and the ability of the instrument to differentiate between the perceptions of teachers in different schools. The alpha coefficients for different SLEQ scales ranged from 0.65 to 0.92 suggesting that each SLEQ scale displays satisfactory internal consistency for a scale composed of only seven items.

The SLEQ consists of 56 items, with each of the eight scales being assessed by seven items. Each item is scored on a five-point scale with the responses of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree. Table 2 describes 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 provides information about the method and direction of scoring of SLEQ items.

For this study, all of the above mentioned SLEQ scales were used, however construction of the scales involved weights which were obtained via Confirmatory Factor Analysis and the method is described in a latter section of this paper.

Assessing the classroom environment

That classes and schools differ in terms of their learning environments, which in turn influence student achievement has been demonstrated by Hattie (1987) who showed that 20% of students in desirable climates are better off than students in average classrooms. In the last 25 years there have been instruments developed for a range of classroom contexts, such as individualised classrooms (Fraser, 1990) and constructivist classrooms (Taylor, Dawson & Fraser, 1995). These instruments have been employed in a range of studies, with different instruments and scales used in particular studies.

Recently, Fraser, Fisher and McRobbie (1996) began the development of a new learning environment instrument which incorporates scales that have been shown in previous studies to be significant predictors of outcomes (Fraser, 1994) and additional scales to accommodate recent developments and concerns in classroom learning, such as equity issues and the promotion of understanding rather than rote memorisation. The first version of the new instrument contained the following 9 scales, each scale containing 10 items: *Student Cohesiveness, Teacher Support, Involvement, Autonomy/Independence, Investigation, Task Orientation, Cooperation, Equity and Understanding.* The new instrument employed the same five-point Likert response scale (Almost Never, Seldom, Sometimes, Often, Almost Always) as used in some previous instruments.

For the purposes of this study, we used 6 of these scales in the student questionnaire, that is, *Student Cohesiveness, Teacher Support, Involvement, Autonomy/Independence, Task Orientation* and *Cooperation* (see Table 3). The construction of the scales involved weights which were obtained via Confirmatory Factor Analysis and the method is described in a latter section of this paper.

Table 3. Description of scales in the CLES and example items

Classroom Learning Environment	
Scale	Example Item
Student cohesiveness	Friendships are made among students in this class.
Teacher support	The teacher goes out of his/her way to help students.
Student involvement	Students talk with each other about how to solve problems.
Independence	I have a say in deciding what activities I do.
Task orientation	Class assignments are clear so everyone knows what to do.
Cooperation	Students share their books and other resources with each other when doing assignments.

Student perception of school climate

Students in this study were asked to respond to items regarding their satisfaction with the school. There were 18 items in this measure and three scales. These student satisfaction scales were Teacher Support, Friends' Support and Safety. The construction of the scales involved the use of Confirmatory Factor Analysis and the method is described in a latter section of this paper.

Table 4. Description of items in the student satisfaction scales.

Student Satisfaction Scale Example Items		
Scale	Example Item	No. Items
Teacher support	How well teachers understand my problems.	7
Friends' support	How easy it is to make new friends at my school.	5
Safety	How safe I feel at school.	6

Student self-concept

> "That self-concept is related to achievement presupposes that certain classroom environments enhance both aspects." (Hattie, 1992, p. 197).

In previous research about self-concept, the multidimensional nature has been well documented (Byrne, 1984; Hattie, 1992; Marsh, 1990, 1993; Marsh & Shavelson, 1985). The academic components of the model have been the focus of attention in relationship to external constructs such as academic achievement. We included two components of the Marsh Self Description Questionnaire (SDQII) designed to measure adolescent self-concepts (Marsh, 1992).

Included in this study, were two measures of Self-Concept, namely, General Self-Concept and Academic Self-Concept each comprised of 10 items. Examples of items from these two measures are presented in Table 5. The General Self-Concept scale describes the student's feelings about himself/herself. There are both negative and positive statements related to success and failure in life. The Academic Self-Concept scale measures the student's perceptions about their academic ability and potential to be a success at school. The construction of the Self-Concept scales involved the use of Confirmatory Factor Analysis and the method is described in a latter section of this paper.

Table 5. Description of some items from the student Self-Concept scales.

	Student Self-Concept Scale Items	
Scale	Example Items	No. Items
General Self-Concept	Overall, I have a lot to be proud of.	10
	Overall, I am no good.	
	Most things I do, I do well.	
	Nothing I do ever seems to turn out right.	
	Overall, most things I do turn out well.	
Academic Self-Concept	People come to me for help in most school subjects.	10
	I'm too stupid at school to get into a good university.	
	If I work really hard I could be one of the best students in my school year.	
	I get bad marks in most school subjects.	
	I learn things quickly in most school subjects.	

Science and mathematics achievement

For the purposes of this study, a relatively simple multiple-choice test of mathematics and science was employed. This test had already been validated internationally for use in the Third International Mathematics and Science Study (TIMSS) for 13-14 year old students. The TIMSS tested and questioned students, teachers and schools in 200 schools throughout Australia and in 50 other countries. The results of the TIMSS are available from the Australian Council for Educational Research (Lokan, Ford & Greenwood, 1996) and international findings may be viewed at the World Wide Web site Http://wwwcsteep.bc.edu/timss.

Three different rotated forms of the possible eight tests available were used and the open-ended/free response part of the test was not used due to time constraints. There were 18 mathematics test items and 18 science test items which had to be completed in 45 minutes. There was reading time and example test items provided prior to the commencement of the test.

Analysis of the test items involved a procedure called Rasch Modelling which scores the test items and then estimates the student's ability on that test item as a function of the difficulty of the test item and the student responses to other test items. The result is a score which has a range from approximately -3.10 to +4.10. The final science and mathematics achievement measures were constructed using the Rasch Model.

Table 6. Results for the student Mathematics and Science tests for all schools, by grade.

Student Tests	*WA Mean*	*Minimum*	*Maximum*
Mathematics (All)	1.08	-3.09	4.00
Year 8 Mathematics	0.80		
Year 9 Mathematics	1.12		
Year 10 Mathematics	1.40		
Science (All)	1.13	-3.07	4.10
Year 8 Science	0.74		
Year 9 Science	1.07		
Year 10 Science	1.74		

THE SAMPLE

Western Australian schools are located in a variety of locations, which have previously been categorized into three groups in other analyses (Tomlinson, 1994; Young, 1994b, 1994d): metropolitan Perth, rural and remote. Unfortunately, these three categories did not account for rural cities and other types of rural locations (similarly for the remote category). Subsequently, these categories have been expanded by the Department of Primary Industries and Energy and the Australian Bureau of Statistics (DPIE, 1994) into seven categories, five of which were then used in this study (Table 7a). The five categories were Metropolitan (Capital City), Small Rural Centres, Other Rural Areas, Remote Centres and Other Remote Areas and these were incorporated into this study. In Western Australia, only these five categories are applicable.

Table 7a. Rural location categories.

Classification	Category	Population Size
Metropolitan:	Capital City	
	Other Metropolitan Centre	urban centre pop ≥ 100,000
Rural:	Large Rural Centres	urban centre pop 25,000 - 99,999
	Small Rural Centres	urban centre pop 10,000 - 24,999
	Other Rural Areas	< 10,000
Remote:	Remote Centres	urban centre pop ≥ 5,000
	Other Remote Areas	< 5,000

Additionally, the sample was stratified further into three categories of Socioeconomic Status (SES). Socioeconomic strata was defined using the student SES consisting of mother and father's occupation and education. This SES measure was then aggregated to the school level and categorised into three groups of Low, Medium and High average socioeconomic status. For this Western Australian study, therefore, the total number of strata were 5 Location strata by 3 SES strata or 15 strata altogether (Table 7b).

Table 7b. Stratified sample design.

Stratified Sample Design	
Strata Type	Strata Categories
Location	Metropolitan Perth, Small Rural Centres, Other Rural Areas, Remote Centres and Other Remote Areas
SES	Low, Middle and High Socioeconomic Status

Sampling techniques used in this study were developed by Kish (1965) and further refined by Ross (1976, 1987). The applicant has had long experience in the use of the stratified complex sample design (Young, 1991a). An important feature of this study involves the inclusion of Non-government schools. These included Catholic, Anglican and other types of Non-government schools, although no stratification was used for these school types.

There were 3397 students in the achieved sample of students from 28 schools (see Tables 7c and 7d below). While the three categories of SES were constructed so as to include approximately equal thirds of students, this did not eventuate with the five categories of location. Unfortunately, the metropolitan schools sampled were from low and medium SES catchments and this had the effect of an empty strata for high SES metropolitan schools. Similarly, high SES schools in remote centres were not sampled. In the second stage of this study, 1997, a further sampling will occur and these strata will be filled at this time.

Table 7c. Sample size by rural location.

Sample Size	Perth	Small Rural Centre	Other Rural Area	Remote Centre	Other Remote Area	Total Students
Students	619	747	1013	633	385	3397
Schools	4	6	9	5	4	28

Table 7d. Sample size by rural location and average socioeconomic status.

Student Sample Size by SES	Perth	Small Rural Centre	Other Rural Area	Remote Centre	Other Remote Area	Total Students	Total Schools
Low SES	276	355	152	98	156	1037	10
Medium SES	343	339	42	535	21	1280	10
High SES	-	53	819	-	208	1080	8
						3397	28

Note: While all strata were not filled, this was a problem in terms of sampling by persuasion. It is hoped that the smaller cells (strata) will be filled by additional schools being added in 1997.

METHODOLOGY

Students from 28 schools were asked to complete a questionnaire, along with a combined mathematics and science test. Students in Years 8, 9 and 10 participated, with this cohort to be surveyed and tested at least one more time (1997) and preferably two more times (1997 and 1998), depending upon availability of the cohort and continuation of funding. The student questionnaire consisted of background and socioeconomic questions, along with questions about their rural life.

In this questionnaire, students completed satisfaction items (3 scales) and self-concept items (2 scales). For the *Student Satisfaction* Scales, the item responses were a five point measure from Very Happy (coded 5) to Very Unhappy (coded 1) with the described support. Similarly, the *Self-Concept* scales consisted of a set of statements to which the student responded on a five point measure, from False, Mostly False, Neither False nor True, Mostly True to True (coded 1 to 5). Each student was also asked about their *Classroom Learning Environment* and these scales were also estimated for reliability (6 scales). A sample of 3397 students was achieved for the 1996 data collection.

The 106 Science/Mathematics teachers participating from each of the 28 schools completed a Teacher Questionnaire, consisting of the *School Level Environment Questionnaire* (SLEQ), including 8 scales and 56 items, and a few other background questions. The SLEQ has already been described previously. Teachers mailed their completed questionnaires directly to the research project using a reply-paid envelope.

Confirmatory factor analysis

These student and teacher composite scales consisted of items which were categorical, not continuous. Additionally, these items varied in their loadings which indicated that Confirmatory Factor Analysis was crucial to the effective construction of the composite scale. When the observed variables (items) are non-normal and non-continuous, the use of product-moment correlations can lead to large negative biases in their estimates (Jöreskog, 1990; Carroll, 1961). It is therefore a significant feature of this study that Structural Equation Modelling techniques (WLS) were used which assume that the observed variables are measured on an interval scale with non-normal distributions. Jöreskog (1994, p. 383) observed that ordinal variables represent a set of ordered categories, such as the five-category Likert scale, which need to be treated differently:

> "It is common practice to treat scores 1, 2, 3, 4, 5, representing the ordered categories of an ordinal variable as numbers on an interval scale and use a covariance matrix computed in the usual way to estimate a structural equation model. What is so bad with this is not so much that the distribution is non-normal; more importantly the distribution is not continuous: there are only four distinct values in the distribution."

The Weighted Least Squares (WLS) method available in LISREL 8 was developed to assist with the analysis of non-normally distributed variables by providing an appropriate weight matrix, correct parameter estimates, standard errors and a fit statistic. "The weight matrix required for such an analysis is the inverse of the estimated asymptotic covariance matrix **W** of the polychoric and polyserial correlations" (Jöreskog & Sörbom, 1993, p. 45).

In this study, the polychoric correlation matrix and asymptotic variance-covariance matrix were produced using Weighted Least Squares (WLS) PRELIS, which was then analysed using LISREL. This procedure was used to calculate each composite scale, assuming the one-factor congeneric measurement model.

The one-factor congeneric measurement model (Jöreskog, 1971) was used in order to construct a set of factor score regression weights using LISREL (Jöreskog & Sörbom, 1996). This type of measurement model assumes that the error variances (δ) and regression coefficients (λ) vary (are non-equivalent) as depicted in Figure 2.

Fitting a congeneric measurement model allows for differences in the contribution each individual measure contributes to the overall composite scale (Fleishman & Benson, 1987). In the generalised one-factor congeneric measurement model (Figure 2), ξ is the latent variable (composite scale); x_1, x_2, x_3, and x_4 are the observed indicator variables; δ_1, δ_2, δ_3, and δ_4 are the errors associated with the measurement of x_1, x_2, x_3, and x_4 respectively; and λ_1, λ_2, λ_3, and λ_4 are the regression coefficients of ξ in the regression of x_1, x_2, x_3, and x_4 on ξ respectively (Jöreskog, 1971; Holmes-Smith & Rowe, 1994).

The estimated composite score ξ_i for each person is calculated by multiplying each item x_i by its factor score regression weight. The factor score regression weights are produced by LISREL output when a one-factor congeneric measurement model is estimated for a set of items (the output line must include the command FS for factor scores to be displayed). These weights (w_1, w_2, w_3, w_4) represent the contribution each item x_i makes to the latent variable ξ_i.

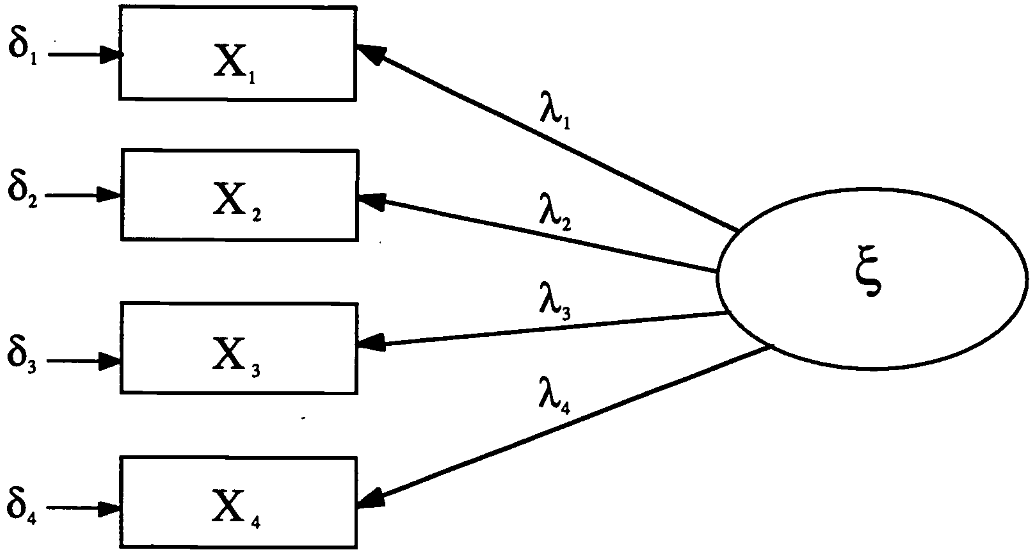

Figure 2. Generalized one-factor congeneric measurement model

The composite scale construction procedure was then performed as follows:

$$\xi_i = w_1 * x_1 + w_2 * x_2 + w_3 * x_3 + w_4 * x_4$$

where $$w_i = \frac{\text{(factor score regression weight for item } x_i)}{\text{sum(factor score regression weights)}}$$

Each weight (w_i) was calculated by dividing the factor score regression weight for each item by the total sum of the factor score regression weights. This had the advantage of producing a proportionately weighted composite scale variable which is adjusted for measurement error (individual and joint), is continuous in measurement and ranges from 1 to 5. Missing data were deleted using a listwise deletion method.

Once each scale was computed for each teacher, all teacher results for each school were aggregated to the school level (averaged) and presented as a mean.

Reliability

That reliability is the consistency of measurement is a concept which has developed from classical test theory and assumes that a single true score underlies a measure (Bollen, 1989, p. 221). While Cronbach's (1951) alpha coefficient is the most popular reliability coefficient in social science research, it has the weakness of underestimating reliability for congeneric measures. Bollen (1989, p. 222) recommends using the Coefficient of Determination R^2_{xi}, as a viable alternative for measuring reliability, where structural equations are being used. This is the measure of the proportion of variance in a measure which is explained by the variables that directly effect x_i.

For the purposes of this research, the Coefficient of Determination was used as the measure of reliability. The method used was based upon the following formula (Werts, Rock, Linn & Jöreskog, 1978), where the reliability (r_c) of a composite (ξ_c) is given as:

$$r_c = \frac{\omega_c'(\Sigma - \Theta_\delta)\,\omega_c}{\omega_c'\,\Sigma\,\omega_c}$$

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where ω is a vector of the factor score regression weights, Σ is the matrix of covariances among the observed indicator variables and Θ_δ is the matrix of variances and covariances amongst the measurement error terms δ_1, δ_2, δ_3, and δ_4

Where the composite scale is obtained by using unit weights, and the vector of weights will be a vector of ones and the reliability of the composite becomes (Jöreskog & Sörbom, 1996, p. 27):

$$r_c = 1 - \frac{|\Theta_\delta|}{|\Sigma|}$$

where $|\Theta_\delta|$ is the determinant of the matrix of variances and covariances amongst the measurement error terms δ_1, δ_2, δ_3, and δ_4 and $|\Sigma|$ is the determinant of the matrix of covariances among the observed indicator variables

While Cronbach's Alpha Reliability coefficient is provided in Table 8, the Coefficient of Determination is given in order to show the true reliability. All composite scales given in Table 8 were prepared using the confirmatory factor analysis described above with factor score regression weights, except for Socioeconomic Status which was not weighted due to the different metrics used. Instead, SES was calculated with unit weighting and the appropriate reliability coefficient used.

The achievement test scores were constructed using Rasch modelling procedures and therefore the Infit Mean Square is provided as an alternative test of reliability. Further, the achievement test scores were kept separate by Year due to the test being different for each year, although of equal ability requirement.

RESULTS

Once the scales were constructed and checked for reliability, they were compared by the five location categories and significant differences were found for all scales, except general self-concept (see Table 9). The Analysis of Variance results showed that there were significant differences between schools from the urban and rural locations.

All scales tended to be lower for students from Remote Centres, however it was suspected that these variations may be related to socioeconomic status. Teachers perceived that students were more supportive in the metropolitan schools, students perceived that teachers and their own peers were more supportive in the country schools. While General Self-Concept of students was equal across the five locations, students from remote locations had significantly lower Academic Self-Concept.

Students in country schools (rural and remote) appeared to be more satisfied with their schools. They felt that teachers were more supportive, friends were more supportive and generally felt safer. Science and Mathematics Achievement scores were not comparable due to the lack of a prior achievement measure in this stage of the study. That is, while there were differences in achievement between students from rural and urban locations, the scores were more a reflection of the students' ability than a random selection.

The numbers of Aboriginal students in this study was higher in the remote centres and areas, leading to some confounding of results. Therefore, a further analysis was conducted combining all of these possible effects into a single multilevel model of analysis.

Table 8. Frequencies, means and reliabilities for student and teacher/school variables.

Variable	Sample Size	Number of Items	Mean	Cronbach's Alpha Reliability	Coefficient of Determination
Teacher: School Level Environment					
Student Support	106	7	3.60	.894	.995
Affiliation	106	7	4.22	.871	.955
Professional Interest	106	7	3.39	.765	.912
Mission Consensus	106	7	3.64	.907	.981
Empowerment	106	7	3.40	.715	.885
Innovation	106	7	3.55	.842	.967
Resources	106	7	3.57	.753	.879
Work Pressure	106	7	3.91	.807	.930
Student Classroom Learning Environment					
Student Cohesiveness	3397	10	3.51	.881	.910
Teacher Support	3397	10	2.31	.919	.951
Involvement/ Negotiation	3397	10	3.26	.877	.933
Autonomy/Independence	3397	10	4.11	.691	.922
Task Orientation	3397	10	3.45	.885	.925
Cooperation	3397	10	3.40	.900	.942
Student Self-Concept					
General Self-Concept	3397	10	3.48	.888	.944
Academic Self-Concept	3397	10	3.52	.889	.946
Student Satisfaction					
School Safety	3397	6	3.83	.783	.867
Friends Support	3397	5	3.52	.785	.859
Teacher Support	3397	7	3.05	.848	.885
Socioeconomic Status	3397	4	3.95	.498	.795
Student Achievement			Mean(SD)	Infit MNSQ (SD)	
Science Achievement	3397	18			
Year 8	1346		0.00 (.78)	1.00 (.08)	
Year 9	1214		0.00 (.77)	1.00 (.08)	
Year 10	1008		0.00 (.71)	.99 (.10)	
Maths Achievement	3397	18			
Year 8	1346		0.00 (.78)	1.00 (.11)	
Year 9	1214		0.00 (.80)	.99 (.12)	
Year 10	1008		0.00 (.76)	.99 (.10)	

The Three-Level Multilevel Linear Model: Background

While there appeared to be differences between rural, remote and metropolitan schools in the initial analyses, some of these differences could be due to socioeconomic factors rather than rurality. Further, there could be other school or teacher effects which contribute towards explaining these differences. Therefore, it is not enough to simply examine location differences and report these individually. In order to investigate the influence of location and rurality in explaining differences in student achievement, a multilevel linear model of analysis was employed. In this case, a three-level model was used where student, class and school comprised the three levels of analysis.

Traditional linear models on which most researchers have relied upon, 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 will give rise to problems of aggregation bias (within-group homogeneity) and imprecision (Burstein, 1980; Raudenbush, 1988).

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, MLn was chosen as the software program appropriate to study school and student effects relating to student outcomes. 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. This study endeavoured to explain variations in student outcomes by first decomposing observed relationships into between- and within-school components.

Previous studies have shown clearly that educational researchers need to account for the inherent multilevel structure of data collected from schools and this literature includes Mason et al. (1983), Bosker and Scheerens (1989), Bryk and Raudenbush (1986, 1989, 1992) and Goldstein (1984, 1987, 1995).

Table 9. Means and ANOVA F-test for student and teacher/school variables by location and for total sample.

Variable	Perth	Small Rural Centre	Other Rural Area	Remote Centre	Other Remote Area	Total	ANOVA F test (Sig)
Teacher School Level Environment							
Student Support	3.32	3.91	3.84	2.85	3.97	3.60	9.63**
Affiliation	4.36	4.40	4.08	4.16	4.12	4.22	1.30
Professional Interest	3.63	3.70	3.49	3.64	3.91	3.39	0.99
Mission Consensus	3.27	3.74	3.30	3.09	3.59	3.64	2.53*
Empowerment	3.38	3.56	3.41	3.16	3.50	3.40	0.88
Innovation	3.36.	3.79	3.38	3.57	3.78	3.55	1.37
Resources	3.68	3.69	3.45	3.32	3.92	3.57	1.61
Work Pressure	3.89	4.01	3.87	4.02	3.64	3.91	0.54
Student Classroom Learning Environment							
Student Cohesiveness	3.39	3.52	3.58	3.42	3.57	3.51	10.00**
Teacher Support	2.19	2.30	2.37	2.32	2.42	2.31	8.33**
Involvement/Negotiation	3.20	3.23	3.29	3.20	3.44	3.26	7.79**
Autonomy/Independence	4.13	4.13	4.11	4.04	4.06	4.11	1.60
Task Orientation	3.33	3.53	3.51	3.32	3.47	3.45	12.42**
Cooperation	3.33	3.39	3.45	3.35	3.48	3.40	4.01**
Student Self-Concept							
General Self-Concept	3.45	3.51	3.49	3.36	3.64	3.48	10.02**
Academic Self-Concept	3.40	3.54	3.58	3.44	3.60	3.52	10.66**
Student Satisfaction							
School Safety	3.87	3.86	3.84	3.76	3.64	3.83	5.57**
Friends Support	3.37	3.61	3.51	3.41	3.72	3.52	16.69**
Teacher Support	2.94	3.07	3.14	2.91	3.18	3.05	16.72**
Student Achievement							
Science Achievement	1.21	1.15	1.29	0.93	0.82	1.12	15.64**
Maths Achievement	1.24	1.11	1.28	0.75	0.67	1.07	27.10**
Socioeconomic Status	3.69	3.79	4.21	3.96	4.12	3.95	15.73**
Aboriginal Percentage	3.37	4.58	2.46	9.58	12.00	5.31	17.28**
Student Numbers	619	747	1013	633	385	3397	

Note: * indicates that the F test was significant at $p < 0.05$ level.
** indicates that the F test was significant at $p < 0.01$ level

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The Three-Level Multilevel Linear Model: The Variables

The response variables for this analysis were Science and Mathematics Achievement (two 18 item scales). There were six different types of variables used in the multilevel analysis (shown below). While some analyses described earlier suggested that rural schools may be disadvantaged, the findings were unclear. The multilevel analyses combined all of the possible explanatory variables under investigation here and revealed how they combine to influence student attitudes.

Science Achievement	A student science achievement test consisting of 18 multiple choice response format test items selected from the Third International Mathematics and Science Study (TIMSS) and total score estimated using the Rasch Model.
Math Achievement	A student math achievement test consisting of 18 multiple choice response format test items selected from the Third International Mathematics and Science Study (TIMSS) and total score estimated using the Rasch Model.
Student Satisfaction	A student measure described previously as the student's attitude to and satisfaction with the school (continuous and standardized).
Location	A five category measure described previously: Metropolitan Perth, Small Rural Centre, Other Rural Areas, Remote Centre and Other Remote Areas (1 to 5).
SES	Socioeconomic Status of the students consisting of mother and father's occupations and education (continuous and standardized).
Average SES	Socioeconomic Status of the students in the school aggregated to the school level (continuous and standardized).
SLEQ Scales	Eight measures of the teachers' perceptions of the school environment aggregated to the school level (continuous and standardized).
CLE Scales	Six measures of the students' perceptions of the classroom learning environment kept at the student level (continuous and standardized).
Self-Concept	Two measures of the students' self-concept: Academic Self-Concept and General Self-Concept (continuous and standardized).

The Three-Level Multilevel Linear Model: Unconditional Statistical 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 simplest model was used first, that is, the fully unconditional model with no predictor variables specified. The outcome measures, science and mathematics achievement, were free to vary across three different levels of analysis: student, class and school. This model is described below in Equations 1, 2 and 3.

Student-Level Model. Science/Mathematics Achievement for each student was estimated as a function of the class average plus random error:

$$Ach_{ijk} = \pi_{0jk} + e_{ijk} \qquad \text{Equation 1}$$

where

Ach_{ijk} represents the Science/Mathematics Achievement of each student i in class j and school k.

π_{0jk} represents the class mean Science/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.

Class-Level Model. Science/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 Science/Mathematics achievement in school k.

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

School-Level Model. Science/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 Science/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, Science/Mathematics achievement, into its three components: students within classes (σ^2), classes within schools (τ_π) and between schools (τ_β).

The Three-Level Multilevel Linear Model: Contextual/Student Background Statistical Model

In order to investigate the effect of the student background and context variables upon student achievement in science and mathematics, this model was estimated first using Average Socioeconomic

Status (AvSES) of students in school j, Location of school j, Socioeconomic Status (SES) of student i, Sex of student i, Aboriginality (Ab) of student i, and English speaking background (Eng) of student i. For the purposes of this model, the intercept 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 below and results presented in the next section (Tables 10a and 10b). Ach_{ijk} represents Science and Mathematics achievement which were estimated in separate models.

In the equation presented below, Ach_{ijk} is the Science/Mathematics achievement of student i in class j and in school k. This is the student level equation. There is one random equation and six fixed effects equations presented next, with the mean achievement π_{0jk} allowed to vary between classes. This is the classroom level equation. Finally, there is one random equation at the school level, where the grand mean achievement β_{00k} is allowed to vary across schools. This is the school level equation. Together these separate equations make up the statistical model used to estimate the effects of context and student background variables on student achievement. Two separate analyses were conducted for science and mathematics achievement.

$$\text{Ach}_{ijk} = \pi_{0jk} + \pi_{1jk}(\text{AvSES}_{ijk}) + \pi_{2jk}(\text{Location}_{ijk}) + \pi_{3jk}(\text{SES}_{ijk}) +$$

$$\pi_{4jk}(\text{Sex}_{ijk}) + \pi_{5jk}(\text{Ab}_{ijk}) + \pi_{6jk}(\text{Eng}_{ijk}) + e_{ijk}$$

$$\pi_{0jk} = \beta_{00k} + r_{0jk} \qquad \pi_{4jk} = \beta_{400}$$

$$\pi_{1jk} = \beta_{100} \qquad \pi_{5jk} = \beta_{500}$$

$$\pi_{2jk} = \beta_{200} \qquad \pi_{6jk} = \beta_{600}$$

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

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

Equation 4

The Three-Level Multilevel Linear Model: Four Conditional Statistical Models

Upon estimation of the contextual/student background model, four further conditional models were estimated in order to investigate the effects of the school environment, student satisfaction, classroom learning environment and student self-concept on achievement. For each of these four models, the contextual effects and home background were controlled for. Additionally, these models were estimated separately for science and mathematics achievement. The four generic statistical equations are presented below (Equations 5 to 8).

For the first model estimating the effect of the School Level Environment Questionnaire on student achievement, eight school level variables were included (Equation 5). These were teacher variables which were aggregated to the school level. For the purpose of the statistical model, they really were π_{7jk} to π_{14jk} as the eight variables were estimated separately. These were Student Support, Affiliation, Mission, Professional Interest, Empowerment, Innovation, Resources and Work Pressure (described previously).

For the second model estimating the effect of Student Satisfaction on student achievement, three student level variables were included (Equation 6). These were Teacher Satisfaction, Friends and Safety, as described previously.

$$
\begin{aligned}
Ach_{ijk} = \; & \pi_{0jk} + \pi_{1jk}(AvSES_{ijk}) + \pi_{2jk}(Location_{ijk}) + \pi_{3jk}(SES_{ijk}) + \\
& \pi_{4jk}(Sex_{ijk}) + \pi_{5jk}(Ab_{ijk}) + \pi_{6jk}(Eng_{ijk}) + \pi_{7jk}(SLEQ_{ijk}) + e_{ijk}
\end{aligned}
$$

$$
\begin{aligned}
\pi_{0jk} &= \beta_{00k} + r_{0jk} & \pi_{4jk} &= \beta_{400} \\
\pi_{1jk} &= \beta_{100} & \pi_{5jk} &= \beta_{500} \\
\pi_{2jk} &= \beta_{200} & \pi_{6jk} &= \beta_{600} \\
\pi_{3jk} &= \beta_{300} & \pi_{7jk} &= \beta_{700} \\
\beta_{00k} &= \gamma_{000} + \mu_{00k}
\end{aligned}
$$

Equation 5

$$
\begin{aligned}
Ach_{ijk} = \; & \pi_{0jk} + \pi_{1jk}(AvSES_{ijk}) + \pi_{2jk}(Location_{ijk}) + \pi_{3jk}(SES_{ijk}) + \\
& \pi_{4jk}(Sex_{ijk}) + \pi_{5jk}(Ab_{ijk}) + \pi_{6jk}(Eng_{ijk}) + \pi_{7jk}(TeachSat_{ijk}) + \\
& \pi_{8jk}(Friends_{ijk}) + \pi_{9jk}(Safety_{ijk}) + e_{ijk}
\end{aligned}
$$

$$
\begin{aligned}
\pi_{0jk} &= \beta_{00k} + r_{0jk} & \pi_{5jk} &= \beta_{500} \\
\pi_{1jk} &= \beta_{100} & \pi_{6jk} &= \beta_{600} \\
\pi_{2jk} &= \beta_{200} & \pi_{7jk} &= \beta_{700} \\
\pi_{3jk} &= \beta_{300} & \pi_{8jk} &= \beta_{800} \\
\pi_{4jk} &= \beta_{400} & \pi_{9jk} &= \beta_{900} \\
\beta_{00k} &= \gamma_{000} + \mu_{00k}
\end{aligned}
$$

Equation 6

$$
\begin{aligned}
Ach_{ijk} = \; & \pi_{0jk} + \pi_{1jk}(AvSES_{ijk}) + \pi_{2jk}(Location_{ijk}) + \pi_{3jk}(SES_{ijk}) + \\
& \pi_{4jk}(Sex_{ijk}) + \pi_{5jk}(Ab_{ijk}) + \pi_{6jk}(Eng_{ijk}) + \pi_{7jk}(CLE_{ijk}) + e_{ijk}
\end{aligned}
$$

$$
\begin{aligned}
\pi_{0jk} &= \beta_{00k} + r_{0jk} & \pi_{4jk} &= \beta_{400} \\
\pi_{1jk} &= \beta_{100} & \pi_{5jk} &= \beta_{500} \\
\pi_{2jk} &= \beta_{200} & \pi_{6jk} &= \beta_{600} \\
\pi_{3jk} &= \beta_{300} & \pi_{7jk} &= \beta_{700} \\
\beta_{00k} &= \gamma_{000} + \mu_{00k}
\end{aligned}
$$

Equation 7

$$
\begin{aligned}
Ach_{ijk} = \; & \pi_{0jk} + \pi_{1jk}(AvSES_{ijk}) + \pi_{2jk}(Location_{ijk}) + \pi_{3jk}(SES_{ijk}) + \\
& \pi_{4jk}(Sex_{ij}) + \pi_{5jk}(Ab_{ijk}) + \pi_{6jk}(Eng_{ijk}) + \pi_{7jk}(AcSelfCon_{ijk}) + \\
& \pi_{8jk}(GenSelfCon_{ijk}) + e_{ijk}
\end{aligned}
$$

$$
\begin{aligned}
\pi_{0jk} &= \beta_{00k} + r_{0jk} & \pi_{4jk} &= \beta_{400} \\
\pi_{1jk} &= \beta_{100} & \pi_{5jk} &= \beta_{500} \\
\pi_{2jk} &= \beta_{200} & \pi_{6jk} &= \beta_{600} \\
\pi_{3jk} &= \beta_{300} & \pi_{7jk} &= \beta_{700} \\
\beta_{00k} &= \gamma_{000} + \mu_{00k} & \pi_{8jk} &= \beta_{800}
\end{aligned}
$$

Equation 8

For the third model, the effect of six Classroom Learning Environment scales were estimated as described previously, and shown in Equation 7. These were student level variables and included Cohesion, Teacher Support, Involvement, Independence, Task Orientation and Cooperation.

The fourth model estimated the effect of two student level variables: Academic Self-Concept and General Self-Concept. These were described previously and the statistical model presented in Equation 8.

DISCUSSION

The Three-Level Multilevel Linear Model: Student Achievement and Contextual/Background Effects

Firstly, the variation in student science and mathematics achievement was decomposed at the three levels as shown in Tables 10a and 10b. Most of the variation in science achievement was found to be at the student level (63.9%), with 34.4% variation between classes and 1.7% variation between schools (Table 10a). Similarly, the variation in mathematics achievement was mostly between students, with 59.3% of the total variance between students, 34.6% between classes and 6.0% between schools. These variance components are further illustrated in Figures 3 and 4 for Science Achievement and Mathematics Achievement respectively. In these figures, the variance between schools, classes and students is represented as a pie diagram.

Table 10a. Variance components for three-level multilevel model for science achievement.

Level of Analysis	Parameter	Estimate (s.e.)	
Fixed Model	Constant	1.078 (0.070)	
Random Model	Parameter	Variance Estimate (s.e.)	Percentage of Total Variance
School	Constant	0.025 (0.038)	1.7 %
Class	Constant	0.531 (0.074)	34.4 %
Student	Constant	0.985 (0.025)	63.9 %
Total		1.541	100.0 %

Table 10b. Variance components for three-level multilevel model for mathematics achievement.

Level of Analysis	Parameter	Estimate (s.e.)	
Fixed Model	Constant	0.988 (0.095)	
Random Model	Parameter	Variance Estimate (s.e.)	Percentage of Total Variance
School	Constant	0.113 (0.068)	6.0 %
Class	Constant	0.655 (0.091)	34.6 %
Student	Constant	1.123 (0.029)	59.4 %
Total		1.891	100.0 %

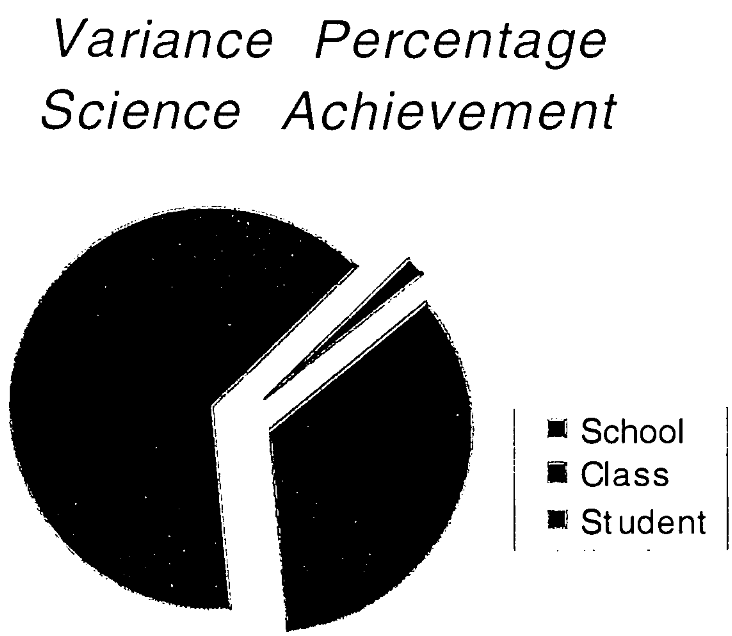

Figure 3. Pie Diagram Depicting Variance Components for Science Achievement

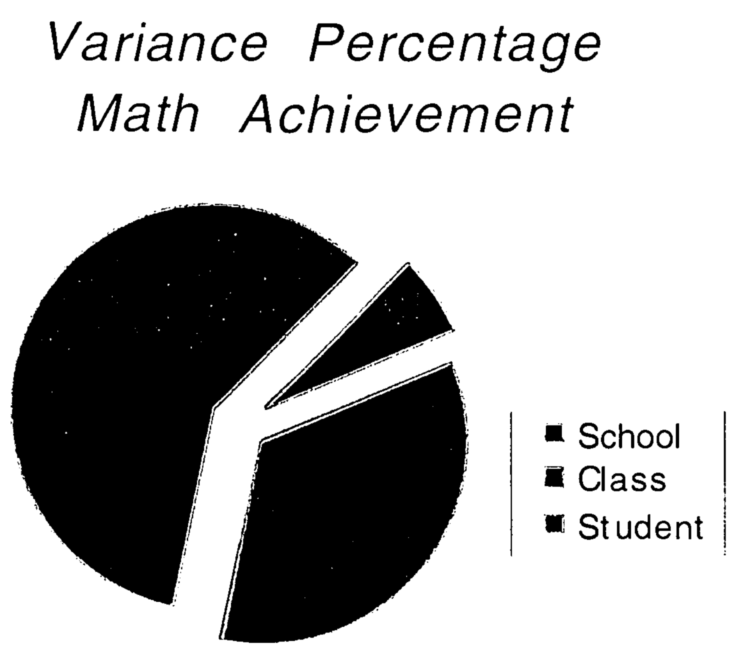

Figure 4. Pie Diagram Depicting Variance Components for Mathematics Achievement

Second, two school level variables were estimated with a reduction in school level variance (see Table 11). The effects were positive for school average SES, that is achievement was higher for those students attending schools where their peers came from higher socioeconomic backgrounds. The effect was also strong and positive for school location, that is achievement was higher for those students attending rural and remote schools, even when average SES was accounted for. It was interesting to note that these two school variables differentiated between classes for both science and mathematics achievement. They were also statistically significant for science and mathematics achievement, with the estimated effects being greater than 2 standard errors.

Third, four student level variables were included in this three level model: student socioeconomic status (SES), student sex (Sex), Aboriginality (Ab) and English Speaking Background (Eng). The SES effect was weak and positive (and significant being greater than two standard errors), while the gender effect was strong and positive (significant). That is, boys were outperforming girls in both mathematics and science. While the effect of being Aboriginal or Torres Strait Islander was strong and negative, the effect of speaking English in the home most of the time was positive on achievement. These effects, were both strong and accounted for a significant proportion of variation in student achievement. The effect of School mean SES, Location, SES, Gender, Aboriginality and English Speaking Background on science achievement explained 10.0 % of the total residual variance for science achievement and 11.2 % for mathematics achievement (Table 11).

Overall, these student background and contextual effects accounted for a significant proportion of unexplained variance in science and mathematics achievement. It is clear that they cannot be ignored when estimating the effects of other organisational or teacher factors.

The Three-Level Multilevel Linear Model: Student Achievement and the School Level Environment Questionnaire (SLEQ)

The teachers participating in this study completed a School Level Environment Questionnaire (SLEQ) in order to measure their perception of this school's work environment. These results were aggregated to the school level and the effect on achievement estimated with the three-level multilevel linear model. There were no significant effects upon student achievement noted. Further, the SLEQ variables did not explain residual variance in student achievement. These results are depicted in Table 12 for Science and Mathematics Achievement.

The Three-Level Multilevel Linear Model: Student Achievement and Student Satisfaction

Students were asked to report on their satisfaction with the school in terms of teachers, friends and their perception of safety at the school. Effects upon achievement were small, with little of the variation in achievement explained either in science or mathematics (Table 13). Student satisfaction with their teachers was the most positive and significant effect on achievement.

The Three-Level Multilevel Linear Model: Student Achievement and the Classroom Learning Environment

Of the six Classroom Learning Environment scales, there were few significant effects. The supportiveness of the teacher was positively related to achievement, while independent/autonomy learning in the classroom was negatively related to achievement. For both science and mathematics achievement, little of the residual variance was explained by the Classroom Learning Environment: 3.6 % for science achievement and 3.0 % for mathematics achievement (see Table 14).

The Three-Level Multilevel Linear Model: Student Achievement and Student Self-Concept

There were two Self-Concept measures estimated in this study. Academic Self-Concept had a strong and positive effect upon both science and mathematics achievement (Table 15). That is, students who perceived that they were capable and confident of their academic ability, tended to outperform their peers in both science and mathematics achievement. While the effect of general self-concept was also estimated, it had a weak effect upon achievement which was not explainable. Overall, Self-Concept accounted for 6.3 % of the residual variance in science achievement and 9.8 % in mathematics achievement.

Table 11. Three-level multilevel analysis of student SES, school mean SES, location, gender, Aboriginality and English-speaking background for science and mathematics achievement.

		Science Achievement		Matheamtics Achievement	
Level of Analysis	Parameter	Estimate (s.e.)	Total Percentage Variance Explained	Estimate (s.e.)	Total Percentage Variance Explained
Fixed Model	Constant	0.998 (0.173)		1.273 (0.196)	
	Average SES	0.202 (0.058)		0.223 (0.067)	
	Location	-0.144 (0.047)		-0.200 (0.054)	
	SES	0.071 (0.018)		0.093 (0.020)	
	Gender	0.224 (0.035)		0.145 (0.038)	
	Aboriginal	-0.526 (0.066)		-0.584 (0.071)	
	English Spk Bk.	0.477 (0.089)		0.316 (0.096)	
Random Model		Variance Estimate		Variance Estimate	
School	Constant	0	1.6 %	0.001 (0.035)	5.9 %
Class	Constant	0.445 (0.057)	5.6 %	0.593 (0.083)	3.3 %
Student	Constant	0.942 (0.024)	2.8 %	1.085 (0.028)	2.0 %
Total		1.387	10.0 %	1.679	11.2 %

Table 12. Three-level multilevel analysis of school level environment for science and mathematics achievement.

		Science Achievement		Matheamtics Achievement	
Level of Analysis	Parameter	Estimate (s.e.)	Further Percentage Variance Explained	Estimate (s.e.)	Further Percentage Variance Explained
Fixed Model	Constant	1.083 (0.182)		1.421 (0.204)	
	Average SES	0.256 (0.077)		0.313 (0.087)	
	Location	-0.177 (0.052)		-0.254 (0.058)	
	SES	0.071 (0.018)		0.093 (0.020)	
	Gender	0.224 (0.352)		0.145 (0.038)	
	Aboriginal	-0.530 (0.066)		-0.589 (0.071)	
	English Spk Bk.	0.478 (0.089)		0.314 (0.096)	
SLEQ	Student Support	-0.038 (0.086)		-0.128 (0.098)	
	Affiliation	-0.089 (0.108)		-0.246 (0.123)	
	Mission	-0.012 (0.086)		-0.062 (0.098)	
	Professional Int	0.061 (0.110)		0.008 (0.125)	
	Empowerment	-0.028 (0.110)		0.139 (0.125)	
	Innovation	0.124 (0.091)		0.235 (0.103)	
	Resources	-0.013 (0.073)		0.084 (0.083)	
	Work Pressure	-0.084 (0.058)		-0.036 (0.066)	
Random Model		Variance Estimate		Variance Estimate	
School	Constant	0	0 %	0	0 %
Class	Constant	0.431 (0.056)	0.9 %	0.561 (0.071)	1.7 %
Student	Constant	0.942 (0.024)	0 %	1.085 (0.028)	0 %
Total		1.373	0.9 %	1.646	1.7 %

Table 13. Three-level multilevel analysis of student satisfaction with school for science and mathematics achievement.

		Science Achievement		Matheamtics Achievement	
Level of Analysis	Parameter	Estimate (s.e.)	Further Percentage Variance Explained	Estimate (s.e.)	Further Percentage Variance Explained
Fixed Model	Constant	1.007 (0.173)		1.281 (0.195)	
	Average SES	0.204 (0.058)		0.224 (0.066)	
	Location	-0.148 (0.047)		-0.203 (0.054)	
	SES	0.067 (0.018)		0.089 (0.020)	
	Gender	0.223 (0.035)		0.143 (0.038)	
	Aboriginal	-0.517 (0.065)		-0.577 (0.070)	
	English Spk Bk.	0.480 (0.089)		0.316 (0.095)	
Student Sat	Teacher Satisfaction	0.093 (0.020)		0.076 (0.022)	
	Friends	-0.052 (0.021)		-0.049 (0.023)	
	Safety	-0.005 (0.022)		0.010 (0.024)	
Random Model		Variance Estimate		Variance Estimate	
School	Constant	0	0 %	0	0 %
Class	Constant	0.446 (0.057)	0 %	0.587 (0.074)	0.3 %
Student	Constant	0.934 (0.024)	0.5 %	1.080 (0.027)	0.3 %
Total		1.380	0.5 %	1.667	0.6 %

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Table 14. Three-level multilevel analysis of the classroom learning environment for science and mathematics achievement.

		Science Achievement		Matheamtics Achievement	
Level of Analysis	Parameter	Estimate (s.e.)	Further Percentage Variance Explained	Estimate (s.e.)	Further Percentage Variance Explained
Fixed Model	Constant	1.007 (0.168)		1.279 (0.192)	
	Average SES	0.183 (0.056)		0.206 (0.065)	
	Location	-0.134 (0.045)		-0.189 (0.053)	
	SES	0.058 (0.018)		0.084 (0.020)	
	Gender	0.283 (0.036)		0.191 (0.039)	
	Aboriginal	-0.480 (0.065)		-0.540 (0.070)	
	English Spk Bk.	0.411 (0.088)		0.254 (0.095)	
CLE	Cohesion	0.003 (0.024)		-0.003 (0.026)	
	Teacher Support	0.074 (0.024)		0.048 (0.027)	
	Involvement	0.046 (0.027)		0.016 (0.029)	
	Independence	-0.154 (0.020)		-0.149 (0.021)	
	Task Orientation	0.005 (0.024)		0.025 (0.026)	
	Cooperation	0.038 (0.026)		0.035 (0.028)	
Random Model		Variance Estimate		Variance Estimate	
School	Constant	0	0 %	0.003 (0.033)	0 %
Class	Constant	0.410 (0.053)	2.3 %	0.552 (0.077)	2.2 %
Student	Constant	0.921 (0.023)	1.3 %	1.070 (0.027)	0.8 %
Total		1.331	3.6 %	1.625	3.0 %

Table 15. Three-level multilevel analysis of student self-concept on science and mathematics achievement.

		Science Achievement		Matheamtics Achievement	
Level of Analysis	Parameter	Estimate (s.e.)	Further Percentage Variance Explained	Estimate (s.e.)	Further Percentage Variance Explained
Fixed Model	Constant	0.961 (0.165)		1.225 (0.184)	
	Average SES	0.186 (0.055)		0.202 (0.062)	
	Location	-0.123 (0.045)		-0.174 (0.051)	
	SES	0.044 (0.018)		0.060 (0.019)	
	Gender	0.226 (0.034)		0.147 (0.036)	
	Aboriginal	-0.476 (0.064)		-0.522 (0.068)	
	English Spk Bk.	0.458 (0.087)		0.294 (0.092)	
Self-Concept	Self-Concept (Academic)	0.243 (0.027)		0.317 (0.029)	
	Self-Concept (General)	0.004 (0.026)		-0.006 (0.028)	
Random Model		Variance Estimate		Variance Estimate	
School	Constant	0	0 %	0.006 (0.030)	0 %
Class	Constant	0.395 (0.051)	3.2 %	0.483 (0.068)	5.8 %
Student	Constant	0.894 (0.023)	3.1 %	1.010 (0.026)	4.0 %
Total		1.289	6.3 %	1.499	9.8 %

The importance of the positive effect of Academic Self-Concept upon student performance was noted to vary across classrooms, as well as between students. That is, students who resided in classrooms where their peers had strong Academic Self-Concept tended to outperform students who resided in classrooms where their peers had weaker perceptions of themselves. This classroom effect accounted for 3.2 % of the residual variance in science achievement and 5.8 % of the residual variance in mathematics achievement. This effect was interesting in that it was more than half of the student level variance explained.

DISCUSSION

In these tables (Tables 11 to 15) a number of different school and classroom effects were measured for their effect upon student achievement, while accounting for student background, school location and average SES of the school. While these background/context variables were statistically significant and explained a large amount of the variance in achievement, little was found to influence student achievement at the school or classroom level of analysis. To start with, the school effect was negligible (1.7 % for science achievement and 6.0 % for mathematics achievement). Teacher scales did little to explain student achievement, nor did student satisfaction with the school. The student level effects of the classroom learning environment and student self-concept were more influential, with 3.6

% and 3.0 % of the variance explained by the classroom learning environment and 6.3 % and 9.8 % explained by student self-concept (for science and mathematics achievement respectively).

DEFINING AN EFFECTIVE SCHOOL

In this paper, it has been assumed that an effective school will produce students of higher achievement, a greater sense of satisfaction with the school, friends and teachers, and a more positive perception of their classroom. Further to this, the teachers will feel more satisfied with their leadership and their workplace.

However, there is a more important aspect which some researchers purport that defines an effective school. This is value adding. For a school to be truly effective in producing students of higher performance than when they arrived at the school, the school must consider itself as an organisation designed and purposed to add value to their cliental: the student. While the happiness of the teachers, parents and leadership is a considerable asset to the improved functioning of the school, the improvement of the student must be its primary goal.

How can a school add value and how can this be measured? Schools can add value to the students' self-esteem (self-concept), attitude and achievement (Hill, 1996). Of course, mathematics and science achievement are only two measures of achievement. Others may include reading, English, numeracy etc... Schagen defines the term "Value-Added" as:

> The assessment of pupil performance taking into account the prior attainment of the pupils concerned. It is largely synonymous with "Progress", the increase in some form of educational attainment made by an individual pupil during a period of schooling. (Schagen, 1996)

So how can the research deal with these issues in a manageable methodology?

There are two approaches which may be taken. Student ability could be measured using an ability test or intelligence test. However, these are only practical if the tests are paper and pencil. Credible and reliable ability tests are usually oral and involve a trained psychologist who works with the student on an IQ test one to one. This is unreasonably expensive when there are a large number of students involved. If ability was successfully measured, it would usefully control for student ability when investigating the effects of other variables on achievement (e.g., location). It would also be most useful for successfully controlling for uneven sampling of intact classes within schools, where the intact classes are streamed into ability groups (as happened with this study).

A second approach is the longitudinal method. By measuring student cognitive ability (achievement) and attitudes over more than one time point, the effectiveness of the school in adding to the students' performance and attitudes can be more adequately measured. This procedure is more expensive and time consuming for the researcher, but provides a useful way to account for students' prior ability in a subject area and their attitudes as well.

This research study intends to follow the longitudinal approach and collect data from this cohort of students over three time points. In 1997, the same cohort of students will be tested and surveyed, along with an addition to the cohort of some other schools which will fill out the sampling frame (Table 1). These additional schools will probably be tested only for two time points, although this decision will probably depend upon available funding and time. It is expected that the quantitative stage of this study will finish in 1998, although some case study work may still continue into 1999.

CASE STUDIES OF EFFECTIVE SCHOOLS

Although funding has not been provided to cover adequate case study analyses of the outlier schools, this is considered to be an important component to the overall strategy of the Western Australian School Effectiveness Study. Therefore, case studies will commence in 1997 and funding will be applied for. Case studies are expected to take two to three years to complete and hopefully form a complete study in their own right.

Outlier schools are those schools which show particular interest in terms of their effect on students, teachers and parents. Some variables not mentioned previously will be examined, such as teacher satisfaction with the leadership and parental satisfaction with the school, and a few schools selected for intensive case study work. While many schools have already volunteered to participate in this aspect of the study, careful checking of the data will be done first and then selections made on this basis.

SCHOOL FEEDBACK

An important feature of this study is the school feedback. Each school has been provided with a report for each of the scales described in this study with a description of the scale and a comparison with the mean score for all schools participating.

Many principals, deputy principals and teachers have commented on the usefulness of this report, especially as a platform for staff discussion. It has also helped me to identify some inadequacies of this research such as the limited teacher sample from some schools. In every case, the schools were satisfied that the findings were constructive to their own understanding of their school and provided the school with the opportunity to improve some of the factors which could help with school development.

CONCLUSION

For this type of response variable, most of the variation in both science and mathematics achievement was at the student level. While the rural location and the socioeconomic status of the student's school were an important part of this study, and there were class and school effects, the student's self-concept was the most influential variable investigated here. For students from country schools and city schools, the important feature here was their own self-concept. How they believed in their own ability, their self-esteem, their belief that they can and will do well - these were the factors which influenced their achievement. It was also an important finding that the student's classroom peers' self-concept affected that student's achievement. Perhaps self-concept has a mass effect within the classroom. Further, the supportiveness of the teacher and the students' satisfaction with the teachers positively influenced the science and mathematics outcomes.

This paper incorporated a comparison of five rural locations. Because the results are based upon streamed classes of both high and low ability students, how the variables interacted were unclear, so the multilevel linear model was used to combine all of the variables under investigation. By building the model in a step-wise fashion, the amount of variance explained by each set of variables was determined. This is a very useful statistical tool, which is not exploratory, but rather confirmatory in approach. That is, we set out to test the hypothesis that these variables were explanatory of student achievement in science and mathematics.

There is still a great deal of student variance left unexplained by this model. It is therefore important to continue to test further hypotheses in order to determine what makes a student happy and content with the school and what can improve student achievement.

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