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ABSTRACT

A study undertaken in Western Australia, the Western Australian School Effectiveness Study, explored the characteristics of effective high schools by investigating factors influencing science and mathematics achievement. A multilevel analytical model was used in the longitudinal study that focused on 1,024 students in 21 rural and urban high schools. The study confirms, as other research in Australia has suggested, that most variation in student achievement appears to be at the classroom and student level, with negligible amounts at the school level, particularly when prior achievement and student background effects are included in the model. When the classroom effects were studied, student aggregates appeared to be stronger than teacher effects. This study suggests that it is the classroom composite of peers that influences individual student achievement, rather than the particular teacher effects. An appendix discusses the variables and scales used in the analysis. (Contains 5 tables and 57 references.) (SLD)

Student Progress in Australian Schools

A Multilevel Multivariate Model

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Student Progress in Australian Schools
A Multilevel Multivariate Model

Introduction

The purpose of this study was to identify the characteristics of effective high schools in rural Western Australia by investigating factors influencing science and mathematics achievement. This paper reports findings from two years of a longitudinal study undertaken in a cohort of urban and rural schools in Western Australia, called the *Western Australian School Effectiveness Study (WASES)*. A multilevel analytical model was used to demonstrate that most variability in student achievement is at the classroom and student level, with negligible amounts at the school level. Upon further analysis of the residuals, this paper demonstrates that teacher effects were substantial and warrants further investigation.

Background

The concept of schools adding value to the achievement of students is used by researchers to refer to the extra or additional "value added" by schools to student achievement over and above the progress or improvement which was expected (Thomas et al., 1998; Mortimore, 1998; Sammons, Thomas & Mortimore, 1997). The most effective schools are those in which student progress in academic outcomes exceeds expectations. However, this study found little explanation for improved achievement at the school level. Rather, there appeared to be significant classroom and teacher effects, which accounted for the "value added" to student achievement. In this study, the "value added" to student achievement was measured while accounting for prior achievement (attainment) and student background.

The "value added" model is sometimes used to analyse cross-sectional research studies, by estimating prior attainment using a verbal reasoning test or some other measure of student ability. This type of measure is flawed in that it is really measuring something other than prior knowledge. In this study, prior attainment was measured using a similar science and mathematics test in the previous year. This longitudinal approach to measuring student growth over time in science and mathematics is now the new standard in educational effectiveness studies (Hill & Rowe, 1998; Sammons, Thomas & Mortimore, 1997, pp. 23–45).

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 in 1995 (Young, 1996; Young & Fisher, 1996a, 1996b, 1996c).

In the *Second Phase*, a three-year longitudinal survey was commenced in West Australian high schools in 1996. 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 were surveyed over a period of three years (1996 to 1998). The common longitudinal cohort was a smaller sample of 1024 students in 21 high schools. The reduction in size was due to many factors such as loss of students due to mobility, lack of teacher cooperation, insufficient data supplied in both years and lack of tracking forms by the school. Results from the WASES 1996 data collection have previously been reported in Young (1997a, 1997b, 1997c, 1998a, 1998b).

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 commenced in 1997 and selected from some outlier schools based on statistical data from WASES-II and WASES-III. While some interesting data has been collected and observations made at some of the more effective rural schools, further case study research is planned in an intensive study in 1999 continent upon further funding from the Australian Research Council.

In this study, student outcomes in science and mathematics in 1997 were adjusted for student background, gender, academic self-concept, grade and prior attainment (1996).

Table 1. Longitudinal sampling frame.

Phases of Study	Year of Study	Grade of Sample	Longitudinal Cohort of Schools	Longitudinal Cohort of Students
[WASES-I]	1996	Years 8, 9, 10	28 Secondary Schools	1247
[WASES-II]	1997	Years 9, 10, 11	21 Secondary Schools	1024
[WASES-III]	1998	Years 10, 11, 12	21 Secondary Schools	1024
[WASES-IV]	1999	Case Studies of Outliers	4–8 Rural and Urban Schools/Classrooms - Effective and Ineffective	

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, 1994a, 1994b): 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. 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.

There were 1024 students in the sample of students from 21 schools in 1997, who were also in the 1996 data collection and provided a complete set of information. These students were in Years 8, 9 and 10 in 1996 and in Years 9, 10 and 11 in 1997, respectively. The initial data collection in 1996 provided a much larger sample, however there were circumstances, which prevented a few schools from continuing in this study. Some of the problems included mobility of teachers and students, along with some schools simply withdrawing from continued participation in the study.

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, was a measure of Academic Self-Concept comprised of 10 items. Examples of items from this measure is presented in Table 2. 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 scale involved the use of Confirmatory Factor Analysis and the method is described in a latter section of this paper.

Table 2. Description of some items from the Academic Self-Concept scales.

Scale	Academic Self-Concept Scale Items Example Items	No. Items
Academic Self-Concept	People come to me for help in most school subjects. 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.	10

Socioeconomic Status

Socioeconomic status of each student was constructed using two variables: mother's occupation code and father's occupation code. Students were asked to write down their mother's and father's occupation and these written responses were later coded using the Australian Standard Classification of Occupations (McLennan, 1997). These codes were later recoded using Frank Jones' occupational prestige recommended codes (Jones, 1989).

Science and Mathematics Achievement

For the purposes of this study, a relatively simple multiple-choice test of mathematics and science was employed in both 1996 and 1997. 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 and reports 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 (total of 36 items). 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 final science and mathematics achievement measures were constructed using the Rasch Model.

The Classroom Learning 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) developed a new learning environment instrument which incorporates scales that have been shown in previous studies to be significant predictors of outcomes (Fraser, 1994). 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.*

Table 3. Means, reliabilities and ANOVA F-test for student and teacher/school variables by location for 1996/7 cohort.

Variable	Total Mean	SD	Perth	Small Rural Centre	Other Rural Area	Remote Centre	Other Remote Area	ANOVA F test (Sig)	Cronbach's Alpha Reliability	Coefficient of Determination
Location of School (code)			1	2	3	4	5			
Gender	.47	.50	.45	.50	.43	.43	.54			
Socioeconomic Status	2.98	1.02	2.92	2.92	3.12	3.10	2.84	2.48*	.889	
Student Cohesiveness	3.57	.34	3.54	3.68	3.66	3.52	3.46	13.04**	.857	.937
Academic Self-Concept	3.90	.78	3.99	4.04	3.90	3.75	3.68	5.75**	.772	.945
Science Achievement 1997	1.06	1.25	.91	1.45	1.42	.73	.72	12.88**	1.00†	
Maths Achievement 1997	1.20	1.31	1.19	1.39	1.58	1.02	.63	12.74**	1.00†	

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.
† is the Infit Mean Square for the Achievement Tests provided by the QUEST software using the Rasch modelling technique. 1.00 indicates that the achievement measure is highly reliable.

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For the purposes of these analyses, one of the scales, *Student Cohesiveness*, was found to be significantly influential in its effect on student achievement and was therefore used as an explanatory variable in the multilevel model.

Comparisons of Schools by Location

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 (see Table 3). 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. Students perceived that teachers and their own peers were more supportive in the country schools. Further, 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.

Methodology

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, 1963, 1989). 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.

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). Fitting a congeneric measurement model allows for differences in the contribution each individual measure contributes to the overall composite scale (Fleishman & Benson, 1987).

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 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 Werts, Rock, Linn and Jöreskog (1978).

While Cronbach's Alpha Reliability coefficient is provided in Table 3, the Coefficient of Determination is given in order to show the true reliability. Composite scales 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, socioeconomic status 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.

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, MLwiN was chosen as the software program appropriate to study school and student effects relating to student outcomes (Goldstein et al., 1998). 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 and colleagues (1983), Bosker and Scheerens (1989), Bryk and Raudenbush (1986, 1989, 1992) and Goldstein (1984, 1987, 1995).

The Three-Level Multilevel Multivariate Model

The response variables for this analysis were science and mathematics achievement (each of which consists of 18 items). Because these response variables were conjointly affected by the explanatory variables, a multilevel multivariate model was selected for the analyses. A multivariate multilevel model is estimated by creating an extra lowest level which defines the multivariate structure, in this case science and mathematics achievement, a two–variate model. The responses were normally distributed. A more detailed discussion of this methodology is found in Goldstein and colleagues (1998, pp. 77-85) and Goldstein (1995, pp. 69-76).

In the model estimated here, each student has two records: either mathematics achievement or science achievement. These are the within-student measurements and there is a pair of dummy variables which indicate which response variable is present (z_1: 1=maths, 0=science; z_2: 1=science, 0=maths). A simplified model is written below with an explanatory variable, x_{jkl}. The y_{ijkl} represents the response variable for maths or science (level-1: *i*), for student *j*, in classroom *k* and school *l*.

$$y_{ijkl} = \beta_{01kl} z_{1ijkl} + \beta_{02kl} z_{2ijkl} + \beta_{11kl} z_{1ijkl} x_{jkl} + \beta_{12kl} z_{2ijkl} x_{jkl} + v_{1l} + v_{2l} + u_{1kl} + u_{2kl} + e_{1jkl} + e_{2jkl}$$

$$\text{var}(v_{1l}) = \sigma_{v1}^2 \quad \text{var}(v_{2l}) = \sigma_{v2}^2 \quad \text{cov}(v_{1l}\, v_{2l}) = \sigma_{v12}$$

$$\text{var}(u_{1kl}) = \sigma_{u1}^2 \quad \text{var}(u_{2kl}) = \sigma_{u2}^2 \quad \text{cov}(u_{1kl}\, u_{2kl}) = \sigma_{u12}$$

$$\text{var}(e_{1jkl}) = \sigma_{e1}^2 \quad \text{var}(e_{2jkl}) = \sigma_{e2}^2 \quad \text{cov}(e_{1jkl}\, e_{2jkl}) = \sigma_{e12}$$

Equation 1

There was no level-1 variation in this model, because the model existed solely to define the multivariate structure and level-1 defines the dependent variable: science achievement or mathematics achievement. The level-2 variances and covariances were the residual between-student variances: student level. The level-3 variances were residual between-class variances: teacher or classroom level; while the level-4 were between-school variances: school level. There were no missing data in this cohort.

Results of the Multilevel Multivariate Model

Model 1: Null Model

The multivariate model was used to simultaneously analyse mathematics and science achievement. The three-level model (student, class and school) was analysed firstly as a null model. This model is actually a four-level model, with the first level being a dummy variable indicating maths or science achievement. There were no explanatory variables in this model. The purpose of this analysis was to decompose the total unexplained variance in science or mathematics achievement into the three variance components. These results are presented below in Table 4, where it is clear that there is little variability between schools. That is, most of the variation in achievement occurs at the student and classroom levels. For science achievement, there was 67.3% variation between students, 27.8% between classes and 4.9% between schools. Similarly, there was 64.1% variation in mathematics achievement between students, 27.9% between classes and 8.0% across schools. The likelihood ratio statistic {-2*Log(likelihood)} was 4739.027 for science and mathematics achievement as a multivariate dependent model. So this analysis demonstrates the degree to which classroom effects appear to outweigh school effects.

Table 4. Parameter Estimates and Standard Errors for the Multivariate Multilevel Analysis of Science and Mathematics Achievement (Students, Classes and Schools): Model 1 (Null Model) and Model 2 (Gender, SES, Grade, Location, Prior Achievement and Academic Self-Concept).

	Model 1†		Model 2†	
	Science Achievement	Mathematics Achievement	Science Achievement	Mathematics Achievement
Fixed Parameters	Estimate (s.e.)	Estimate (s.e.)	Estimate (s.e.)	Estimate (s.e.)
Intercept	1.108 (0.110)	1.294 (0.126)	-4.718 (1.409)	-4.272 (1.099)
Gender			.094 (.073)	.008 (.066)
Socioeconomic Status			.023 (.031)	.048 (.028)
Grade (9,10,11)			.496 (.145)	.434 (.112)
Location			-.075 (.061)	-.111 (.049)
Achievement 1996 (Sci/Maths)			.180 (.041)	.337 (.028)
Academic Self-Concept			.272 (.047)	.336 (.043)
Random Parameters	Variance Estimate	Variance Estimate	Variance Estimate	Variance Estimate
School Variance	0.077 (0.080)	0.135 (0.104)	0.041 (0.049)	0.030 (0.031)
School Covariance	0.108 (0.086)		0.036 (0.034)	
Class Variance	0.437 (0.110)	0.471 (0.118)	0.248 (0.070)	0.127 (0.042)
Class Covariance	0.386 (0.103)		0.117 (0.044)	
Student Variance	1.056 (0.054)	1.080 (0.056)	0.972 (0.050)	0.811 (0.042)
Student Covariance	0.522 (0.043)		0.325 (0.034)	
-2 log(likelihood)	4739.027		4497.915	
Deviance*			241	
	Variance at Each Level for the Null Model 1 (%)		Variance Explained by Model 2 Parameters (%)	
School Level	4.9 %	8.0 %		
Class Level	27.8 %	27.9 %		
Student Level	67.3 %	64.1 %		
Total Variance Explained	100.0 %	100.0 %	19.7 %	42.6 %

* The deviance statistic is the difference in −2log(likelihood), which is a chi-squared distribution and significant.

† N = 1024 students within 21 schools

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Model 2: Context and Student Background Model

The next multivariate analysis used a four-level model, the first level is not referred to here in these discussions as it indicates which achievement variable is being estimated (science or maths). The four levels included the response variable (science or maths), the student level, the class level and the school level.

- *Mathematics or Science Achievement*
- *Student Level*
- *Classroom Level*
- *School Level*

In preliminary analyses, the explanatory variables included gender, socioeconomic status, grade, location, previous achievement and student academic self-concept. These were largely student background variables, with grade to compensate for the three grade levels analysed, location to measure the effect of the location of the school (rurality) and previous achievement being the science and mathematics achievement score from the 1996 WASES data set.

Results from these analyses, provided in Table 4 Model 2, demonstrated that these variables accounted for 19.7% and 42.6% of the total unexplained or residual variation in science and mathematics achievement, respectively. However, the significance of Gender, SES and Location was minimal. These three variables were removed from the next two estimated models. The likelihood ratio statistic was now 4497.915 for science and mathematics achievement. The difference was a deviance statistic, which was statistically significant at 241 (a chi-squared distribution on six degrees of freedom – that is, six additional fixed parameters were estimated).School location was found to have little effect upon student achievement once student background and prior achievement was accounted for. This is an important finding in this study, as there were demonstrated significant differences in achievement across different locations in previous analyses. However, it appeared that the significant effects of academic self-concept, grade and prior achievement scores on a similar test accounted for most of these differences.

Models 3 and 4: Classroom and Peer Model

Further to the previously estimated Model 2, a reanalysis was conducted with three explanatory variables, which had been demonstrated to be statistically significant in explaining variations in student achievement. Model 3, therefore, included Academic Self-Concept, Previous Achievement and Grade.

Results from Model 3 provided a baseline for comparing the effect of three classroom variables in Model 4, that is, Cohesion, Socioeconomic Status and Academic Self-Concept. These three variables were classroom average measures of the degree to which students felt their classroom was cohesive, the average socioeconomic status of the students in the classroom and the average academic self-concept of the students.

Table 5. Parameter Estimates and Standard Errors for the Multivariate Multilevel Analysis of Science and Mathematics Achievement (Students, Classes and Schools): Model 3 (Academic Self-Concept, Prior Achievement and Grade) and Model 4 (Cohesion, Average SES and Average Academic Self-Concept).

	Model 3†		Model 4†	
	Science Achievement	Mathematics Achievement	Science Achievement	Mathematics Achievement
Fixed Parameters	Estimate (s.e.)	Estimate (s.e.)	Estimate (s.e.)	Estimate (s.e.)
Intercept	-4.801 (1.401)	-4.539 (1.083)	-7.975 (1.382)	-7.133 (0.991)
Academic Self-Concept	0.273 (0.047)	0.342 (0.043)	0.243 (0.048)	0.305 (0.045)
Achievement 1996 (Sci/Maths)	0.191 (0.040)	0.345 (0.028)	0.191 (0.040)	0.345 (0.028)
Grade (9,10,11)	0.492 (0.146)	0.439 (0.112)	0.459 (0.132)	0.380 (0.091)
Classroom Cohesion			0.320 (0.189)	0.405 (0.151)
Classroom Socioeconomic Status			0.281 (0.126)	0.045 (0.100)
Classroom Academic Self-Concept			0.446 (0.187)	0.455 (0.147)
Random Parameters	Variance Estimate	Variance Estimate	Variance Estimate	Variance Estimate
School Variance	0.043 (0.050)	0.053 (0.039)	0.000 (0.000)	0.030 (0.020)
School Covariance	0.045 (0.038)		0.000 (0.000)	
Class Variance	0.257 (0.072)	0.126 (0.042)	0.171 (0.046)	0.047 (0.024)
Class Covariance	0.123 (0.045)		0.053 (0.025)	
Student Variance	0.973 (0.050)	0.813 (0.042)	0.981 (0.050)	0.823 (0.042)
Student Covariance	0.322 (0.034)		0.331 (0.035)	
-2 log(likelihood)	4506.953		4477.895	
Deviance*			29	
	Variance Explained by Model 3 Parameters (%)		Variance Explained by Additional Model 4 Parameters (%)	
Total Variance Explained	18.9 %	41.2 %	7.7 %	5.5 %

* The deviance statistic is the difference in −2log(likelihood), which is a chi-squared distribution and significant.

† N = 1024 students within 21 schools

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Discussion

The analyses presented in this paper were based on data collected from students and teachers participating in the *Western Australian School Effectiveness Study* in 1996 and 1997. The cohort of students was longitudinal, yet smaller than had been hoped. While providing a rich source of information, the size of the sample became reduced as missing data was removed and students dropped out of the study. Yet, this was a valid cohort, which provided useful information about what makes a school effective.

Student Level. This study demonstrated that, while rural differences were apparent in student outcomes such as science and mathematics achievement and academic self-concept, these differences were of no consequence when investigated using sophisticated multilevel modelling techniques. That is, rural schools were not disadvantaged by their location. Rather, rural students were disadvantaged by their self-concept. Students in rural schools did tend to have a weaker belief in their own academic ability to perform, irrespective of their actual ability. Relative to prior achievement, self-concept and grade, this study demonstrated negligible gender differences and socioeconomic differences in achievement.

- *Previous Achievement*
- *Perception of Academic Ability*
- *Grade*

Class Level. There were sizeable variations in science and mathematics achievement across classes, with little found between schools. When these classroom differences in achievement were examined further, individual student effects accounted for a big portion of the class-level differences (40% for science; 70% for maths) with other students in the classroom accounting for a lot as well (20% for science; 17% for maths). Classroom effects that were significant in explaining differences in achievement included:

- *Achievement of Peers*
- *Previous Achievement of Peers*
- *Perception of Academic Ability of Peers*
- *Classroom Cohesiveness*
- *Grade*

School Level. This study demonstrated negligible school level differences in achievement, with 5% in science achievement and 8% in maths achievement varying across schools. These small differences were entirely accounted for by the student and classroom level variables described previously.

Limitations of the Study

Student achievement in mathematics and science was measured as an essential and unique feature of this study. While difficult, time-consuming and expensive, this approach provided the study with the same achievement measure for all students. Teachers who participated in this study were active partners in collecting and coordinating the testing procedure. However, it should be noted that this study required more funding than other comparable studies of school effectiveness. Additionally, in Western Australia the rural high schools are spread much further apart making it much more difficult to visit them without expending considerable funds in travel costs. It would have been advantageous if more funds had been available for supporting this study; however the competition for grant funding is critical.

This study was limited not only by financial and strategic considerations in the management of a large study, but also by problems with student mobility. Further complicating effects include the primary school attended and neighbourhood membership. Hill and Goldstein have developed an approach for modelling "cross-classified" (Hill & Goldstein, 1998; Goldstein, 1995, pp. 113-124) students. This is obviously an important step to improve the "school effectiveness statistical models". That is, variations in student outcomes may be attributed to the neighbourhood where the child comes from and/or the primary school previously attended, as well as the high school currently attended. A single school may contain children from many neighbourhoods and primary schools. Further, a single student may attend multiple schools throughout the course of the study. In the WASES study, these students simply dropped out, with subsequent data loss.

These limitations have highlighted the need for an improved research design in future studies. Improvements in financial planning, strategies for retaining the cohort in a longitudinal study and attention to quality control all point to a new longitudinal study of school effectiveness and improvement in Western Australia.

Conclusions

Student achievement varies between students, classrooms and schools. These variations have been investigated using multilevel modelling techniques, however they are not fully explainable by these procedures. That school effects on student achievement tend to be minimal in Australia, has already been found by Hill and Rowe (1996, 1998) in another Australian study, the Victorian Quality Schools Project (VQSP), as well as earlier studies by Young (Young, 1998b; Young & Fraser, 1993). These studies confirm that most variation in student achievement appears to be at the classroom and student level, with negligible amounts at the school level particularly when prior achievement and student background effects were included in the model. When the classroom effects were investigated, student aggregates appeared to be stronger than teacher effects. That is, this study suggests that it is the classroom composite of peers which influence individual student achievement, rather than the particular teacher effects.

Further analysis of teacher and classroom effects in a longitudinal, school effectiveness and school improvement model are strongly recommended in order to understand the effect of teacher and classroom variables on a variety of student outcomes.

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APPENDIX A

Variables and Scales used in the Multilevel Multivariate Model

Variable	Coding and Recoding
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. There were two measures used here: science score for 1996 and 1997.
Mathematics Achievement	A student mathematics 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. There were two measures used here: maths score for 1996 and 1997.
Ach96	Science and mathematics achievement scores from 1996 estimated separately using the Rasch Model (see above).
SES	Socioeconomic Status of the students consisting of mother and father's occupations and education (continuous and standardised).
Gender	1 = males; 0 = females
Self-Concept	A measure of the students' self-concept: Academic Self-Concept (continuous and standardised).
Class Cohesion	A measure of the students' perceptions of the classroom learning environment kept at the student level (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).

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