Factors influencing the level of performance in Mathematics and Language among learners in South Africa: a multi-level analysis

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Introduction

The education system in South Africa has undergone tremendous transformation over the last eight years right from the classroom learning and teaching practices through to the management of education at the national, provincial and district levels. There has been numerous initiatives by both the government and non-governmental organisations to improve teaching and learning in schools. One such initiative is the *Quality Learning Project* (QLP) funded by the Business Trust and managed by the National Business Initiative (NBI) and the Joint Education Trust (JET). The QLP is a large-scale multiphase project that was designed for implemented over a five-year timescale. It drew service providers to schools from the non-governmental organizations and research organizations that specialise in various types of educational interventions. The service providers work in collaboration with education officials at national, provincial and district levels and with school principals, educators and learners at the school levels. The project also targets other stakeholders in education such as parents and members of school governing bodies. The QLP project targeted 500 high schools drawn from all the secondary schools in South Africa. The main objective of the project are to improve:

- Learning outcomes in the languages of instruction and mathematics in Grades 8-12
- Teaching of languages and mathematics,
- Governance and management of schools,
- Management of 17 district offices, and
- Support to schools by the district offices

The QLP evaluation design adopted a holistic approach comprising a baseline study at the beginning of the programme, a formative evaluation in year-three and a summative evaluation at the end of the project in year five. The results presented in this paper are based on the analysis of data of the baseline study conducted in 2001.

Factors influencing learner performance

Learner learning is, in part, a function of various characteristics of the schools and the process of schooling. Examining the characteristics of schools that are related to learning illuminates some of the reasons why learners are, or are not learning at optimum levels. Similarly, school quality is simultaneously related to several characteristics of school. It is a function of the training and talent of the teaching force, what goes on in the classrooms (including the size of classes, the pedagogical approaches used in them and the overall culture and atmosphere within a school. Researchers have found that learners learn from educators with strong academic skills (Ballou, 1996; Ehrenberg and Brewer 1994); hold a degree in the subject they are teaching (Darling-Hammond 2000) and from experienced educators (Darling-Hammond 2000). Researchers have also found that greater gains in learner achievement occur in classes with 13 to 20 learners compared to large classes, especially for disadvantaged and minority learners (Krueger 1998). These findings were examined in the case of South Africa using data for Grade 9 collected for the Quality learning project.

Methodology

Research design

Both survey and causal comparative (*ex post facto)* research designs were used in the study. In causal-comparative design, independent variables are studied retrospectively to find out their influence on certain dependent variables. In this design the investigator has no control over the independent variables because they are inherently not manipulable or because they have already occurred (Ary, *et al,* 1990). The investigator achieve the variation they want, not by direct manipulation of the variable itself but by selection of individuals in whom the variable is present or absent, strong or weak, and so on.

Sampling

The target population comprised of 17 district officials, 500 secondary schools, 1500 members of the School Governing Bodies, 500 principals, 10 000 educators and 500 000 learners (approximately 1000 per school). A representative sample of 20% of the target schools gave a total of 102 schools for the study. The schools were selected proportionally based on school size and the Senior Certificate Examination results.

Within each sampled school, a maximum of 40 learners was randomly selected from each of the two targeted grades (9 and 11). The learner sample size ensured a minimum sample of 15% in very large schools and would include the entire learner population in the targeted grades in small schools. The selection of the other respondents for the study was done such that a representative sample of each group was obtained. Data from the Grade 9 learners and educators were used for analysis reported in this paper and the sample of respondents is presented in Table 1.

Table 1: The total sample for the baseline study

Target group	Total
Learners	3584
Educators	228
School principals	102
Circuit Manager	70
District managers	18
District Mathematics learning area specialists	11
District Language learning area specialists	19

Instrumentation

Both questionnaires and assessment instruments for Mathematics, English and Afrikaans were developed to gather the pertinent data. These are briefly discussed below:

a) *District official questionnaire*. Was used to gathering information about district quality from the district education officials. District quality includes aspects such as organisational management and development, education policy development, administration, monitoring and evaluation, support to schools, management of the curriculum and capacity of district staff.

b) *School principal questionnaire*. Was used to gather information from the school principals regarding school quality. School quality includes aspects such as organisational management and development, governance, financial management, parent and community support, human resource management, instructional time, delivery of the curriculum, school administration, effective support from district office, physical resources, school profile and schools' previous achievement.

c) *Educator questionnaire*. Was used primarily to evaluate the teaching quality, which is affected by teaching load, class size, demands on time, educators' perceptions of working conditions, autonomy and collegiality.

d) To assess improved learning, an assessment was conducted on learners in mathematics, reading and writing in the language of learning and teaching. Besides two items on the Reading and Writing instruments, all other items were first developed in English, translated into Afrikaans and then back translated into English.

e) *Learner questionnaire*. Basic background information about the learners was gathered such as age, gender, home background and socio-economic conditions, participation of the learner in classroom and school activities, educator and learner interaction. Finally, information was gathered on learners' attitudes and aspirations in education, specific subject areas, schooling and the future.

A pilot study for the questionnaires and the assessment instruments was conducted in 19 schools sampled from three provinces.

Analysis of hierarchical data

In hierarchical data, such as found in educational organisations, school effects and certain learner characteristics require simultaneous exploration of relationships at the within- and between- school levels. Early school effects research relied primarily on single-level multiple regression models at either the learner-level or the school-level. These designs failed to adequately model the multi-level structure of the learner-to-class-to-school relationships. Treating data as if they were all at the same unit of analysis has implications for statistical validity in that it has led researchers to misleading conclusions about the effects (or non-effect) of various aspects of the school environment on learner attributes.

The issue of statistical validity was illustrated by Goldstein, (1999) with an example of a well-known and influential study of primary school children that was carried out in the 1970's (Bennett, 1976). The study claimed that children exposed to the so-called 'formal' styles of teaching reading exhibited more progress than those who were not. The data were analysed using traditional multiple regression techniques which recognised only the individual children as the units of analysis and ignored their groupings within educators and into classes. The results were statistically significant. Subsequently, Aitkin et. al, (1981) demonstrated that when the analysis accounted properly for groupings of children into classes, the significant differences disappeared and the 'formally' taught children could not be shown to differ from the others. This reanalysis is the first important example of a multilevel analysis of social science data. Other problems experienced by conventional techniques in analysing hierarchical data include aggregation bias, biased estimated prediction coefficients, poor estimation of coefficients, and the "unit of analysis" problem (Bock, 1989).

The HLM approach allows for explicit modelling of effects at the various levels of the hierarchy. All estimated effects are adjusted for the individual level and group level influence on the dependent variables. HLM is a regression-like technique that proceeds as follows: A learner-level linear regression model is estimated for each school to predict learners' measure of performance using learners' characteristics. Simultaneously, at the school-level, a regression model is defined using school characteristics to estimate the parameters obtained at the Learner-level. Conceptually, HLM entails an estimation of regressions of regression results, except that the equations at each level are estimated at the same time and the variance at one level is taken into account in estimating the next level (Raudenbush, *et al.*, 2000). In addition, HLM allows the examination of the correlation of school characteristics with the between-learner characteristics.

Mathematics, Afrikaans and English scores were measured at the learner-level. Also collected at the learner-level were learner characteristics and other variables. Data was also collected from educators, school principals and district education officials about the learning and teaching conditions.

The data consist of learners nested within educators, educators nested within schools and schools nested within districts. The level-1 model, for example, represents the relationships among the learner-level variables, the level-2 model captures the influence of educator-level factors, and the level 3 model incorporates either school-level or district level effects. A three-level HLM model consisting of three sub-models, one for each level was envisaged for the analysis of the data to determine factors at the various levels that influenced learner performance in Mathematics and Language of instruction.

A variety of HLM models were developed and applied to the data to answer the following questions:

a) How much of the variability in learners' scores in Mathematics and Language were produced by learner, educator, school or district variables?

b) How did the factors at the various levels of the data interact to influence learners' scores in Mathematics and Language?

A number of models for analysis and interpretation of the QLP data were tested. Selection of representative samples of about 40 learners in each school implied that classroom differences were ignored and that analysis would be done only with learners nested within educators, educators nested within schools and schools nested within districts. An understanding of the equations of a three-level HLM model is critical for the interpretation of the results. These equations are presented and briefly explained for each model.

Definition and identification of variables for analysis

A number of techniques were used to identify variables for which data was collected. All the potential variables for analysis were defined or derived in either scores or scales. Factor analysis was used to determine the underlying constructs of learner perception of educator behaviour measured by 48 statements in the Learner questionnaire and school climate measured by 56 statements appearing in the Educator and Principal Questionnaires. Principal component factor analysis and Oblique rotation were used in each case. Nine factors with an "Eigen value" of at least one were derived from statements measuring learners' perception of their educator statements, but only four were interpretable. Three interpretable factors were derived for both the Educator and Principal Questionnaires. Descriptions of the derived factors and other variables are provided in the Appendix.

To select the variables for the HLM analysis, three approaches were used, namely, a review of literature in school effectiveness, correlation and linear regression techniques. Language scores were highly correlated with

Mathematics scores and therefore learner variables that correlated significantly with both Mathematics and Language were selected. At the educator and school-levels, variables selected were those correlated significantly with the mean scores in Mathematics and Language.

Results

Description of assessment scores

Descriptive statistics percentage of raw scores in Mathematics and language of instruction are presented in Table 2.

Table 2: Descriptive statistics of test scores

Language of instruction	Learning Area	N	Min	Max	Mean	Std. Dev.
Afrikaans	Afrikaans	189	26.2	91.3	57.8	14.4
	Mathematics	181	7.6	76.3	27.1	12.4
English	English	3174	6.0	84.0	29.6	12.8
	Mathematics	2906	3.1	71.8	21.1	7.9

Learners whose medium of instruction was Afrikaans performed relatively better in both the language and Mathematics than those whose medium of instruction was English. These result can be explained by the fact that majority of the learners attending schools where Afrikaans was the medium of instruction were first language speakers of Afrikaans while majority of those attending school where English was the medium of instruction were second or third language speakers of English. Given the critical role that proficiency in language plays in the transfer of skills during the teaching/learning process these results are expected.

One-Way Analysis of Variance (ANOVA) results indicated statistically significant differences ($F=91.69$, $df=(1,3085)$, $p<0.05$) in mathematics scores

between learners whose language of instruction was either Afrikaans (Mean=27.1, std dev.=12.4) or English (Mean=21.1, std dev.=7.9).

The development of the Hierarchical Linear Models (HLM)

Although a three-level model was envisaged, the small number of districts and the large number of missing values in the district data disqualified such models. Despite this limitation, an unconditional HLM model with no predictors at any of the levels was tested and results showed no significant variations in mean score for Mathematics and Language of instruction at the district level. The district level variability accounted for an insignificant two percent of the total variation in Mathematics scores while the variation due to school factors accounted for 33 percent and that due to learner factors accounted for 65 percent. Similar results were obtained with Language as the outcome variable. Thus the three-level HLM model that involved district at the highest level was discarded.

A three-level model made of schools at level-3, educator at level-2, and learners at level-1 was also discarded because of the small number of educators per school. Thus, a series of two-level HLM models were developed for the analysis of either the school or the educator at level-2 and learner at level-1.

Variability of Mathematics scores at school- and learner-levels

To investigate the variability of Mathematics scores at school- and learner-level, an unconditional model was developed with Mathematics score as the outcome variable. No predictor at either the school- or learner-level was included in this model. The unconditional model is represented by the following equations:

Learner-level $(MATHS)_{ij} = \beta_{0j} + e_{ij}$

School-level $\beta_{0j} = \alpha_{00} + r_{0j}$

Where

$(Maths)_{ij}$ is the outcome variable

β_{pj} (p=0,1,....P) are level-1 coefficients

e_{ij} is the level-1 random effect, and

σ^2 is the variance of e_{ij}. It is assumed that the random term $e_{ij} \sim N(0, \sigma^2)$ is normally distributed with mean zero and standard deviation of σ.

α_{pq} ($q = 0,1,\ldots, Q_p$) are level-2 coefficients,

r_{pj} is a level-2 random effect.

We assume that, for each unit j, the vector $(r_{0j}, r_{1j},\ldots, r_{Pj})'$ is distributed as multivariate normal where each element has a mean of zero and the variance of r_{pj} is given by $Var(r_{pj}) = \tau_{\beta pp}$.

The results of the analysis of the model are presented in Table 3.

Table 3 One-Way random Effect ANOVA (Unconditional) Model

Fixed effects	Coefficient	SE	DF	T	p
School mean	21.05	.50	95	42.48	< 0.01

Random effects	Variance Component	% Variance. Component	χ^2	p
School mean	22.3	30	924.5	< 0.01
Learner–level,	52.1	70		<0.01
Reliability	0.9			

The school mean of 21.1 implies that Mathematics was poorly performed in the participating schools. The learner-level variance component (σ^2) was

52.11 while that of School-level (τ_{oo}) was 22.25. This means that most of the variation in Mathematics scores was at the learner-level, although a substantial proportion was between schools. The significant χ^2 -value further confirms the existence of significant variation among schools. The intra-class correlation index provides the amount of variance that is between schools. The results indicated that 30 percent of the variation in Mathematics performance was between schools. Conversely, 70% of the variance in Mathematics scores was potentially explainable by within-school factors. A reliability estimate of 0.95 indicates that the sample means were highly reliable indicators of the population school means in Mathematics.

Predictors of Mathematics scores at the learner-level

Initially the school-level predictors were held aside and the analysis focused on comparing some unconditional models. One approach would be to include all the learner-level predictors in the model, but there is a danger in this approach. If one overfits the model by specifying too many random learner-level coefficients, the variation is partitioned into many little pieces, none of which is of much significance. In general it is more productive to use a step-up strategy and include only those factors that are expected to make a significant contribution in explaining the variation in the outcome variable.

After trying different variables in the learner model to examine those that make a significant contribution to the variations in the Mathematics scores, only three variables, that is, GENDER, LANG (Language) and MTEACHEF (perceived effectiveness of Mathematics educator) were identified for further analyses. The model is represented by the following equations.

Learner-level $(MATHS)_{ij} = \beta_{0j} + \beta_{1j}(LANG)_{1j} + \beta_{2j}(GENDER)_{2j} + \beta_{3j}(MTEACHEF)_{3j} + e_{ij}$

School-level

$$\beta_{0j} = \alpha_{00} + r_{0j}$$

$$\beta_{1j} = \alpha_{01} + r_{1j}$$

$$\beta_{2j} = \alpha_{02} + r_{2j}$$

$$\beta_{3j} = \alpha_{03} + r_{3j}$$

where,

$\mathbf{X}_{ij}$ are level- 1 predictors e.g. LANG, GENDER and MTEACHEF

β_{pj} (p=0,1,....P) are level-1 coefficients

α_{pq} ($q = 0,1,\ldots, Q_p$) are level-2 coefficients,

r_{pj} is a level-2 random effects.

The results presented in Table 4 indicated that learners who had high scores in the Language also had high scores in Mathematics. Male learners performed relatively better than female learners in Mathematics. The results also indicate that learners who perceive their Mathematics educator as effective scored higher in Mathematics than those who perceive their Mathematics educator otherwise. The variance components of the three predictors, though small, were significant. The three predictors accounted for about 5 percent of the total variance, school accounted for 19 percent while learner level variation accounted for 76 percent of the total variation. The reliability coefficient for school means was high for Mathematics, moderate for Language and low for perceived Mathematics educator effectiveness.

Table 4 Unconditional Model with learner–level factors

Fixed effects	Coefficient	SE	DF	T	p
School mean, α_{00}	20.59	0.360	92	56.92.	< 0.01
LANG Slope	0.15	0.02	92	1.19	< 0.01
GENDER Slope	-1.22	0.23	92	-5.25	<0.05
MTEACHEF Slope	1.04	0.22	92	4.82	< 0.01

Random effects	Variance component	% Variance component	χ^2	p
School mean	11.10	18.6	924.50	< 0.01
LANG slope	0.014	0.02	330.74	> 0.05
GENDER slope	1.57	2.6	140.15	< 0.01
MTEACHEF slope	1.16	2	149.37	< 0.01
Learner –level,	45.76	76.8		

Reliability coefficients

Random Effects	Reliability coefficients
School mean	0.866
LANG	0.625
MTEACHEF	0.236

Predictors of Mathematics scores at the school-level

Having estimated the variability of Mathematics scores across schools, we sought to build an explanatory model to account for this variability. That is, we sought to understand why some schools had higher means in Mathematics score than others. We also sought to know why in some schools the

association between some key variables and Mathematics score was stronger than in others.

We retain the same learner-level model and expand the school model to incorporate predictors that showed significant relationship with school mean scores. In our case LANG, GENDER and MTEACHEF remained in the Learner-level model. Included in the school-level were Mean school score in Language (MEANLANG), Number of learners in the school (NLEARNER) and Adequacy of physical resources (PHYRESOUR). None of the variables made any significant contribution to the variance of Mathematics scores. However, learners in schools with adequate physical resources performed slightly better than their counterparts in schools with inadequate physical resources, however, the difference was insignificant. Although some variables at the School-level showed some relationship with Mathematics they made an insignificant contribution to the overall variation in learner scores. It is likely that other school factors not considered in the study could be responsible for the school-level variations.

Learner and educator factors influencing learner performance in Mathematics

The contribution of some learner and educator factors in the prediction of Mathematics scores were estimated using a two-level HLM model. Learner-level factors accounted for 68 percent, educator effects for 17 percent, MTEACHEF 11 percent and EDCLMANA accounted for 4 percent. Perceived effectiveness of the educator in teaching Mathematics by the learner had a large influence on Mathematics scores at Grade 9. Much of the variation remained at the Learner-level at 73 percent while educator effect accounted for 21 percent.

None of the educator factors identified in this study had any significant influence on learner performance in Mathematics at grade 9.

Factors influencing performance in language at the learner- and school-levels

To investigate the influence of learner- and school-factors on performance in Language a two-level HLM model was used with Language as the outcome variable. The Language comprised scores in English and in Afrikaans. As indicated by the descriptive statistics results learners whose language of instruction was Afrikaans did better than the others.

The analysis followed the same procedure applied in the case of Mathematics as the outcome variable. Firstly, an unconditional HLM model was used to determine the variance components at learner and school levels and the reliability of the school mean scores in Language. Secondly, the learner level predictors were fitted into the learner level model while the school level predictors were held aside. And finally, the same learner level model was retained and the school model expanded to incorporate predictors that showed significant relationship with school mean score in language. These results are discussed and presented in table 5.

Table 5: Unconditional HLM model with Language as outcome variable

Fixed effects	**Coefficient**	**SE**	**DF**	**T**	**p**
School mean	32.39	0.77	91	42.14	< 0.01

Random effects	**Variance component**	**% Variance component**	χ^2	**p**
School mean	53.08	36.5	3008.8	< 0.01
Learner –level,	92.22	63.5		
Reliability	0.97			

The mean of 32.39 implies that schools performed better in Language than in Mathematics. Most of the variation in Language scores was at the Learner-

level (63.5 percent) although a substantial proportion is between schools (36.5 percent). The significant χ^2 value further confirms the existence of significant variation among schools. A reliability estimate of 0.97 indicates that the sample school means were highly reliable indicators of the population school means in Language scores.

A two-level unconditional model was used to determine the influence of learner factors on scores in the Language. The following six learner-level variables were included in the model:

a) a measure of the language mostly spoken at home (HOMLANG).
b) learner's interest in Language (LANGINTE).
c) learners' perception of their educator as authoritative (EDUAUTHOR).
d) Parental motivation of the learner in language (PARMOTIV).
e) Amount of extra work given to learners (EXTRAWOR).

The results presented in Table 6 indicated that only three of the six variables that is, HOMLANG, LANGINTE and EDUAUTHOR had significant influence on learner performance in Language. The results show that learners who spoke the Language of instruction most of the time at home, had interest in learning the language and perceived their educator as authoritative, performed significantly better than the others.

Much of the variation in language scores was at the learner-level accounting for 57 percent of the variance, while the school and the HOMLANG contributed 23 percent and 16 percent respectively. Although other predictors such as GENDER had contributed to the total variation in test scores the proportion of variance accounted for by such predictors was quite small.

Table 6: Unconditional Model with learner –level variables and Language as outcome

Fixed effects	Coefficient	SE	DF	T	p
School mean, α_{00}	31.98	0.61	91	52.58	< 0.01
GENDER slope	0.11	0.32	91	0.34	>0.05
HOMLANG slope	0.38	1.08	91	0.36	<0.05
PARMOTIV slope	-0.07	0.20	91	-0.36	> 0.05
EXTRAWOR slope	-0.04	0.11	91	-0.41	>0.05
LANGINTE slope	3.25	0.22	91	14.82	< 0.01
EDAUTHOR slope	2.74	0.19	91	15.00	< 0.01

Random effects	STD Dev	Variance component	Percent Var Comp	DF	χ^2	p
School mean	5.57	30.98	22.75	48	545.48	< 0.01
Gender slope	1.80	3.24	2.38	48	92.39	< 0.01
HOMLANG slope	4.560	21.08	15.48	48	102.91	< 0.01
PARMOTIV slope	0.77	0.60	0.44	48	59.72	>0.05
EXTRAWOR slope	0.64	0.41	0.30	48	107.45	<0.01
LANGINTE slope	1.13	1.28	0.94	48	63.17	<0.05
EDUAUTHOR,	1.18	1.39	1.02	48	72.83	<0.05
Learner-level	8.78	77.17	56.68			

Having estimated the variability of Language scores across schools, an explanatory model was developed using school-level predictors to account for this variability. We retained the same Learner-level model and expanded the school model to incorporate predictors that showed significant relationship with school mean scores. In this case, HOMLANG, LANGINTE and EDUAUTHOR remain in the Learner-level model. At the School-level only PHYRESOUR (adequacy of physical resources in school) had a significant contribution to the total variation of Language scores.

Again, as in Mathematics, learners in schools with good physical facilities performed better than their counterparts in schools with poor physical facilities. However, the difference was insignificant. It is likely that other factors not considered in the study could be responsible for the School-level variations.

The influence of learner and educator factors on performance in Language

As alluded earlier in the paper, the educator data had large amount of missing information. Efforts to develop a three- level model with school at level-3, educator at level-2 and learner at level-1 were compromised by the small number of educators per school. In most cases there was only one educator per subject per school with adequate data for HLM analysis. Thus two-level HLM models were developed for each learning area with the educator at level-2 and the learner at level-1. The results of these analyses are presented next.

The results presented in Table 7 indicate that learners in Grade 9 had a class mean of 34.1 and a reliability coefficient of 0.88. These results imply that the sample mean scores were reliable indicators of the population means. Thus, the Language scores were reliable measures of learners' achievement in the respective languages (English or Afrikaans). Learner factors accounted for 55 percent while educator factors accounted for 45 percent of the variability in Language scores. The influence of educator factors on the performance of learners in the Language was quite significant.

Table 7: Unconditional two-level HLM model with Language scores as outcome

Class	Fixed effects	Coef.	SE	DF	T	p
Grade 9	Class mean	34.09	1.15	76	29.69	< 0.01

Random effects	STD Dev	Variance component	%Variance component	p
Class mean	7.66	90.17	45	<0.01
Learner-level	8.21	108.87	55	<0.01
Reliability coefficient				
Grade 9	0.88			

Educator factors included in a two-level HLM model had the potential to influence learner performance in Language. The factors considered and explained in the Appendix were: HOMLANG (Language spoken most often by the educator at home), DAYABSENT (Number of days absent), ACCESSEQ (Access to equipment), QUALITEQ (Quality of equipment) and DCOMPET (Perceived competence of the district officials by the educator). HOMLANG and DAYABSENT contributed significantly to performance in Language. Learners who had high scores were taught by educators who used either of the Languages (Afrikaans or English) often at home. DAYABSENT was negatively related to scores in Language. The results indicate that learners taught by educators who were often absent from school performed relatively poor compared to the others. The contributions of the educator factors to the prediction of scores in Language are summarized in Table 8.

Table 8: Two-Level HLM model for Educator factors with Language as the outcome variable

Fixed effects	Coef.	SE	DF	T	p
School mean	34.07	0.97	76	35.03	< 0.01
HOMLANG Slope	7.91	3.31	68	2.39	<0.01
DAYABSENT Slope	-0.048	0.02	68	-2.00	<0.01

Random effects	STD Dev	Variance component	% Variance component	χ^2	p
School mean	8.4	70.3	39	15	<0.01
Learner-level	10.4	108.9	61		

Using both educator and learner data, learner factors that were identified as contributing significantly to the prediction of Language scores were: HOMLANG; LANGINTE; EDUCOMPET and EDAUTHOR. Although a substantial proportion of the variability in language scores was accounted for by the learner factors 48 percent, variation among educators accounted for 23 percent. HOMLANG had the highest contribution of 18 percent to the prediction of scores in Language among the learner factors included in the HLM model. Learners who often spoke one of the languages of instruction at home had relatively higher scores than those who did not.

Limitations of the study

a) The number of sampled districts was inadequate to include districts in the Hierarchical Linear Models. High instances of missing information in the district-level variables also made it impossible to provide empirical evidence of the influence of district-level variables on learner performance in Mathematics and Language.

b) There were high instances of missing data especially at the school and educator level. This led to a reduction of units of analysis at the two levels.

Conclusion and recommendations

a) The multi-level structure of data in education require statistical methods that are appropriate to avoid the pitfalls of using the conventional techniques that do not take into consideration the structure of such data and lead to invalid inferences. Hierarchical Linear Modelling (HLM), using the computer program HLM 5 (Raudenbush, et al., 2000), offers methods that can be used to determine the variations of variables at different levels of the hierarchical data. It is important that in the development of the various HLM models, the research questions and the nature and level of measurement of the variables be critically examined. Correct interpretation of the results is also critical in using the findings to draw valid inferences.

b) Although much of the variability in performance in Mathematics and Language was due to learner factors, there was considerable variability in test scores due to school factors.

c) Learners' factors found to have significant influences on performance in Mathematics were the Language, gender, and learners' perception of the effectiveness of the Mathematics educator. On the other hand, performance in Language was influenced by home language, interest in language and perceived educator control of the class. At the school-level, adequacy of physical resources influenced both Mathematics and Language scores.

d) Educator effect had almost equal influence on learner performance in Language. Home language of the learner had a significant influence on the level of performance. Learners who often spoke one of the languages of instruction at home performed better. Whether the language the educator spoke often was one of the languages of instruction influenced learner

performance in that language. Rate of absenteeism had a negative influence on learner performance in the Language.

e) Performance in Mathematics was influenced most by learner factors that accounted for about 75 percent of the total variability in Mathematics scores. As identified in previous analyses, learner factors that had the greatest influence included learners' perception of how well their Mathematics educator managed the class and how effective the educator was in teaching Mathematics. None of the educator factors had any significant influence on performance in Mathematics.

f) The results of this study did not support research findings by Ballou (1996), and Darling-Hammond (2000) that have found that teacher characteristics such qualification and experience had significant influence in learner performance

g) Except for gender none of the learner's personal characteristics exhibited significant influence on performance. Thus these results did not concur with research that have support that learner's background especially the social economic status influenced performance.

h) The language policy in South Africa should be re-examined to address the disparity in performance caused by the use of different languages of instruction.

These results indicated that the quality of the school environment which is to a great extend influenced by the quality of educators have significant influence on learner performance. However, much of the level of performance is determined by factors associated with the learner.

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Appendix B

Table 1 Description of variables at the Learner-level

Variable	Description
MATHS	Percentage score in Mathematics test
ENGLSCOR	Percentage score in English test
AFRIKAANS	Percentage score in Afrikaans test
GENDER	Gender of the learner, code Male=0, Female=1
HOMLANG	Language spoken most at home, code, 1= Language of instruction, 0=other languages
RACE	Race of the learner- 1=Black, 2=Coloured, 3= Indian, 4=White
LANGINST	Frequency of speaking English/Afrikaans -Scale Never=0 to A lot=3
HOMEBACK	A composite measure of home background Scale Low=1 to High=16 measured by the total number of important items at home
BOOK	Books available at home scale ranges from Fewer than 10=0 to more than 200=4
MEALS	Meals Scale Never=0 to Every day=4, measures the extent to which learner has meals
EDMOTHER	Education of mother scale Lowest=1 to Highest=8
EDFATHER	Education of father Lowest=1 to Highest=8
PARMOTIV	Scale 1-4 extent to which learners are motivated by their parents
TIMESPE	Scale 0-3 extent to which time is spend on education related activities
EXTRAWOR	SCALE 1-3 Extent to which learners take extra work outside school
HOMEWORK	Scale 0-3 Frequency of being given homework
TIMETABL	Scale 1-2- Availability of time tables and if they are followed
DISCIPL	Scale 0-4 School discipline-high score means high indiscipline in the school
SCHATTIT	Scale 1-4- high means positive attitude toward school
MATERIAL	Score of 0 to 4- Availability of learner instructional materials
LANGATT	Scale 1-4 Attitude towards Language- high means positive attitude
LANGINTE	Scale 1-4 interest in Language, high means high interest
MOTIVATE	Scale 1-4 Leaner motivation for learning- High=positive
LTEACHEF	Scale 0-3 Educator effectiveness in teaching Language
EDCOMPET	Scale 0-4 derived from factor analysis - Learner perception of educator competency in the subject (statements; 1, 2, 5, 9, 10, 13, 14, 17, 18, 25, 26, 29, 33)
EDCLMANA	Scale 0-4 derived from factor analysis Learner perception of

	educator classroom management skills- (statements, 11, 15, 19, 20, 23, 24, 27, 30, 31, 34, 38)
EDAUTHOR	Scale 0-4 derived from factor analysis - Learner perception of educator authoritative nature- (statements; 35, 36, 39, 43, 47, 48)
EDSTRING	Scale 0-4 derived from factor analysis Learner perception of how stringent their educator is- (statements; 28, 40, 44)
EDCONF	Scale 0-4 derived from factor analysis -Learner perception of educator confidence- (statements; 3, 4, 7, 8, 16)
CLACLIMA	Score of 0-25 Perceived Classroom climate- -sum of qns1 to 25 pg 11
MMOTIVA	Score Motivation to do well in maths
MATHSINT	Scale 0-3 Learner interest in maths Sum of maths qns 1,2,6,7
MATHPERC	Scale1-4 Perceived difficulty of maths- sum of qns 3,8
MTEACHEF	Scale 1-4 Maths class environment – high means good environment for studying maths
MCOMPET	Scale 0-4- Derived from factor analysis -Learner perception of educator competency in the subject (statements; 1, 2, 5, 9, 10, 13, 14, 17, 18, 25, 26, 29, 33)
MCCLMANA	Scale 0-4- Derived from factor analysis-Learner perception of educator classroom management skills- (statements; 11, 15, 19, 20, 23, 24, 27, 30, 31, 34, 38)
MAUTHORI	Scale 0-4- Derived from factor analysis -Learner perception of educator authoritative nature- (Statements 35, 36, 39, 43, 47, 48)
MSTRING	Scale 0-4- Derived from factor analysis- Learner perception of how stringent their educator is- 28,40,44
MCONFID	Scale 0-4- Derived from factor analysis- Learner perception of educator confidence- (Statement 3, 4, 7, 8, 16)
MCLCLIMA	Scores 1-25 sum of the Maths class climate scores

Description of variables at the educator level

Variable	Description
IDSCHOOL	Id of school
IDEDUCAT	Id of educator
GENDER	Gender 0=male 1=female
GRADE	Either 9 or 11
AGE	Age of educator range from 1< 25 to 9>60
RACE	Black=1 Coloured=2, Indian=3, White=4
HOMLANG	Language spoken at home
EDEXPERI	Experience in years
HQUALIF	Highest qualification- lowest=1, highest=14
WITLEARN	Average of scale on Time spent with learner
OTHERACT	Average of scale on Time spent in other activities
PROFACTI	Time spent in professional activities
DAYABSEN	Days absent
ACCESSEQ	Access to equipment
QUALITEQ	Quality of equipment
SUPERVIS	Frequency of supervision
PROFDEVE	Attendance to activities for professional development
CAREFREE	Derived from factor analysis of school climate statements- enforcement of on key school responsibilities of educator
LDISCPIN	Derived from factor analysis of school climate statements- discipline of learner
PROFCOOP	Derived from factor analysis of school climate statements- Cooperation with other educators
EDINVOLV	Derived from factor analysis of school climate statements- Involvement of educators in running of school
DCOMPET	Perceived competency of district officials by educator
LTMATERI	Availability of learning teaching materials
ATTITUDE	Learners attitude towards learning measured on a 5-point scale- Lowest is negative, highest is positive
ASPIRATI	Learner aspiration to excel in learning measured on a 5-point scale- Lowest is negative, highest is positive
PERIODS	Educator's workload in periods taught
PERLOST	Periods lost
CEQUIP	Adequacy of classroom facilities measured on 4-point scale 1=totally insufficient, 4= totally sufficient
TINSTRUC	Time spent on various instructional activities

CURRCOV	Coverage of the curriculum measured on total scores

Table 3 Description of School Variables drawn from the Principal's Questionnaire

Variables	Description
IDPROV	Id of the province
NDISTR	Id of district
IDSCHOOL	Id of school
AGE	Age category of the educator 1< 25 yrs to 9>60 yrs
GENDER	0=Male and 1=Female
RACE	Black=1, Coloured=2, Indian=3, 4=White
EXPERIEN	Length of service measured in years
QUALIF	Qualification rated on highest level reached, 1=lowest 14=highest
NLEARNER	Total number of learners from Grade 8 to 12
NCLASSES	Number of classes from Grade 8 to 12
SSIZE	Class size derived by (NLEARNER/NCLASSES)
TPRATIO	Educator/pupil ratio
EDUCMAT	Number of Educators of Mathematics
EDUCENG	Number of Educators of English
EDUCAFR	Number of Educators of Afrikaans
SGBODY	Scale on how functional SGB is- High means functional
FEPAID	Percentage of learners who have paid fees
PRNSUPP	Support received from parent and community on scale of five 1=less often, 2=monthly, 3=every term 4=Every 6 months, 5=weekly
INMSHORT	Shortage of instructional materials, Average of five statements, range from lowest =0 highest=3- High means shortage
LABSENT	Learner Absenteeism
EABSENT	Educator Absenteeism
PHYRESOUR	Physical resources in the school, scale derived by reversing the rating and averaging the 15 statements