

EXPLORATORY DATA ANALYSIS USING THE BASELINE STUDY OF THE KHANYISA EDUCATION SUPPORT PROGRAMME

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1 Introduction

The Khanyisa Education Support Programme aims to facilitate the delivery of quality education services in Limpopo Province. The programme is being implemented over a seven year period from 2003 to 2009. A baseline study was carried out in two parts:

- a description of the management and classroom practices in a sample of 24 Khanyisa schools, together with a description of the home contexts from which learners are drawn
- learner performance tests in literacy and numeracy administered in 84 Khanyisa schools and 18 control schools.

Two pieces of analysis have already been produced:

- A baseline study of communities, schools and classrooms, dated April 2005
- A report on the baseline testing of Grade 3 and Grade 6 learners in Khanyisa schools, dated July 2005.

The purpose of this study is to push the analysis forward by carrying out multivariate analysis, including analysis between school-level, teacher- and classroom-level, home-level variables and test scores. However, at this stage, it would certainly be premature to try and assemble all the information from a very rich data set into a comprehensive multilevel model. Indeed, it is debatable whether it would ever be useful to do so, given some of the anomalous findings which will be reported. Instead, we shall concentrate on inputs and outputs at particular levels, concentrating on teachers and learners.

2 The issue of language

Appendix 1 tabulates information on language use in the 24 Khanyisa schools for which management information and classroom practices were available. Appendix 2 presents information on the home language of the teacher, the languages in which lessons in mathematics and language were observed, and the home language of the majority of learners. For each school, the description of the school language policy by the School Governing Board chairperson is tabulated along with his/her account of how the policy was decided. The description of the

policy by the school principal and an account of how it was decided is also included, along with the home language of each teacher observed, the language in which the lesson was given, the home language of the majority of learners and whether each teacher taught language or mathematics or both.

The table shows that:

- Four SGB chairpersons had nothing to say on language policy, one didn't know and three said there was no language policy. Two gave an irrelevant response. One thought that the SGB should not intervene in language policy. One reported that parents did not agree on language policy. Four pointed out that their policies were provisional, being 'verbal' or 'not in writing' or 'not finalised'. This leaves eight definite responses. Two said that English was the language of instruction. One school had Pedi as the mother tongue and English as the first additional language. One school had neatly inverted this situation. English was the medium of instruction, but educators were allowed to explain in Pedi if learners do not understand. One taught in Venda and English, and one taught in Venda up to Grade 3 and in English after that. Two taught in Tsonga up to Grade 3 and in English after that.
- On how policy was decided, seven SGB chairpersons had nothing to say, and three more said that no decisions had been taken. Three said that they had inherited decisions and one said that it was not the job of the SGB to decide. Three said they had followed Departmental policy. One said a meeting would be called if a change in policy was proposed. One said that language policy was determined by the home language of the majority of learners at the school, and that all relevant stakeholders had decided this. One said there was agreement among the parents. One said the SGB and the School Management Team (SMT) had decided. One said that the SGB and SMT had taken the matter to a meeting. One said the SGB, SMT and parents had had a meeting and one said that the SGB, parents and teachers had had a meeting.
- In three cases, where SGB chairpersons said nothing/don't know, principals clarified language policy. One school uses English, the second uses Venda to Grade 3 and the third uses English and Pedi to Grade 3 and English after that. In one case, where parents did not agree on language policy, learners were taught in English, Venda and Afrikaans. In three cases of a provisional policy, English and Venda are taught; in the fourth, English, Pedi and Afrikaans are used. Where the SGB responses are definite, there is nothing in the principal's comments to contradict them.
- Thirteen schools have a definite language policy, whether defined by the SGB or the principal. In four schools, teachers of mathematics were not teaching in the language they were supposed to, according to the policy. The 'language' observations were assumed to be of English classes if the language reported was English. Otherwise they were assumed to be of

classes in the language reported, so no language teacher, on this view, could be regarded as teaching in the wrong language.

- Most of the teachers had the same home language as the majority of pupils; in those cases communication in the relevant language would encounter few problems. However, communication by teachers in English is hampered by limited proficiency of teachers in that language.¹

The overall picture is little short of chaotic and is far from optimal, especially when it comes to teaching and learning in mathematics. It is likely to be representative of conditions in Black education in many parts of the country. Considerably more detailed analyses of language use throughout the school day, of the determinants of decisions by SGBs and principals, and of pupil ability in both the home language and English are needed to understand why things are as they are, and what can be done to improve them.

How much does the language confusion matter? A partial answer can be found in the next section

3 What makes a good teacher?

The study observed 39 teachers over the 24 schools. In fourteen schools, only one teacher was observed. In six schools, two teachers were observed, in three schools three teachers and in one school four teachers.

This highlights one of the problems in studies of this kind. It is relatively easy to assemble large groups of learners, test them and ask them about home circumstances, but unless the study is massive, the number of teachers involved will be relatively small. Statistical tests can be applied to teacher variables, but the power of the tests (the chances of not missing a relationship when it is there) is relatively low.

The other methodological problem is one of exposure. Grade 3 learners have not been exposed to one teacher. They have usually been exposed to three. It is possible in the Khanyisa data set to identify the Grade 3 teacher (the learners were tested at the beginning of Grade 4), but not the Grade 1 or Grade 2 teachers. The only way to assess the effectiveness of teaching is by experiment: getting teachers to teach a new topic for an appropriate length of time, to do a classroom observation during that period and testing learners on that topic alone at the end.

With those caveats, we start the analysis by observing that each teacher may be working in mathematics or language or both. It is quite possible that a teacher is better in one subject than in another. Nonetheless, a mathematics observation and a language observation for a given teacher are not independent, because the teacher has a single set of qualifications, length of experience and other personal characteristics.

¹ See the Khanyisa baseline study, p 38

The teacher level variables are:

- Teacher qualification
- Experience

The subject level variables are:

- Planning
- Assessment
- Curriculum coverage
- Teacher-learner and learner-learner interaction
- Micro-pacing
- Promotion of reading and writing
- Complexity of written language tasks
- Complexity of written mathematics tasks
- Conceptual knowledge, appropriate skill development and level of complexity
- Result of teacher mathematics test
- Result of teacher English test

The first task is to specify the variables.

The *planning indicator* was taken to be the sum of whether the teacher could show a long-term planning document (2=yes, 0=no) the length of the planning cycle (1=term, 2=semester, 3=year) and the level of detail (1=low, 2=medium, 3=high) if the teacher could show a long-term planning document. To this was added whether a teacher could show a lesson plan (2=yes, 0=no) and the level of detail in the lesson plan (1=low, 2=medium, 3=high).

The *assessment indicator* was taken to the sum of whether the teacher could show a record of assessments (2=yes, 0=no) , how often assessment takes place (3=at least six times per term, 2= 4 or 5 times per term, 1= 2 or 3 times per term and 0= less than twice per term) , the nature of the feedback on tests (0=no feedback, 1= simply signs books, 2=indicates right/wrong, 3=corrections given), and the frequency of the feedback on written work (0=less than monthly or never, 1=monthly, 2=weekly, 3=two or more time as week).

The *curriculum coverage indicators* for language and for mathematics were coded 0 (very low coverage) to 3 (high coverage).

The educator-learner interaction indicator and the learner-learner interaction were both coded 0 (worst) to 3 (best). These indicators were summed to give a *communication* variable.

The *micro-pacing* indicator was coded 0 to 3.

The *promotion of reading and writing* score was taken as the sum of quantity of writing (3=36 or more over the year, 2=24 to 35, 1=12 to 23, 0=less than twelve), the presence of textbooks (3=textbooks are available to learners to take home, 2=textbooks are available in the class but learners may not take them home, 1=textbooks are shared for use in the classroom only, 0=no textbooks available) and the use of reading material (3=learners given the opportunity to read and interpret on their own, 2= teacher reads, then learners read, 1=teacher reads and interprets, then learners read and interpret, 0=only teacher reads).

The *complexity of written tasks in mathematics and language* are coded from 0 (least complex) to 3 (most complex).

The *conceptual knowledge* indicator, the *appropriate learner skill development* indicator and the *level of complexity of instruction* indicator were all coded 0 (worst) to 3 (best).

The result of the *teacher mathematics and teacher language* tests were taken as raw scores (maximum: 24).

This is a great deal of information and to make the analysis manageable, one looks for techniques of reducing dimensionality. This is done in stages:

- 1 The variables conceptual knowledge, appropriate skill development and level of complexity were highly correlated among both mathematics and language teachers, so first factors *performance in mathematics classes* and *performance in language classes* were extracted from them.
- 2 Correlation matrices were constructed for all variables for mathematics and languages separately. These are presented in Appendix 3.

In both the mathematics and language matrices, there are correlations significantly different from zero between communication, micropacing and performance. These three variables can therefore be replaced by the first factor from a factor analysis, which can be called *classroom proficiency*. In the case of language only, the reading and writing variable is highly correlated with communication, micropacing and performance as well, but to maintain symmetry of treatment between language and mathematics, reading and writing is maintained as a separate variable.

We thus end up with seven variables with very little correlation between them. Further factor analysis will not suffice to take the final step to yielding a measure of good teaching.

There are two ways of getting around this difficulty. The first is to take a normative view of the relative importance of the various components going to make a good teacher. The outcome one gets will depend on the weightings used.

The approach here is to calculate z-values for each of the seven and then apply weights as follows:

Classroom performance:	1.00
Content knowledge: (Teacher test)	1.00
Curriculum coverage:	0.75
Reading and writing:	0.75
Complexity of tasks:	0.75
Assessment:	0.50
Planning	0.50

This leads to a quality score for language and quality score for mathematics. These are transformed into z-scores and the final score takes the form of the percentile on the standard normal distribution to which the z-score corresponds. The final mathematics and teacher scores range between zero and a hundred. It was possible to compute language scores for twenty-two teachers and mathematics scores for twenty-two teachers. Either the remaining teachers did not teach mathematics or language or the information for them was too fragmentary to yield a result. The mathematics scores, and the language scores are presented in Appendix 4. Among teachers for whom both a mathematics score and a language score available, there is a high and significant correlation between the two scores. On the other hand, there is no correlation between level of qualification or years of experience and teacher mathematics scores or teacher language scores.

The second way of getting round the problem is to regress mathematics and language scores on the tests taken by learners at the beginning of Grade 4 on the mathematics and language characteristics of the teachers (planning, assessment, curriculum coverage, content knowledge and classroom skills) who taught them in Grade 3. However, only seventeen such teachers can be identified for mathematics and seventeen for language, so the variables in such a regression are too many for the number of teacher observations.

4 The influence of home variables on test scores

Information on conditions and practices at home were collected from learners and these variables can be matched to test outcomes and to teachers who taught learners in Grade 3. The home-based questions dealt with the composition of the household, reading practices, homework practices, main language at home, and use of English. Test results came from test administered at the beginning of Grade 4.

The variables selected for analysis were:

- 1 How often do you read by yourself at home? Score: 1-4, best=4

- 2 How often do you do homework? Score: 1-4, best=4
- 3 How often do you speak English at home? Score: 1-3, best=3
- 4 How often do you watch TV at home? Score: 1-4, best=4
- 5 How often do you listen to the radio in English? Score: 1-4, best=4

The correlation matrix for these five variables is:

	1	2	3	4	5
1					
2	0.358				
3	0.197	0.132			
4	0.152	0.186	0.184		
5	0.181	0.152	0.278	0.250	

All coefficients are significantly different from zero at the 5% level. On the basis of the correlation matrix, two first factors were extracted, the first from variables 1 and 2 (diligence) and the second from variables 3, 4 and 5 (exposure to English at home).

Correlation matrices were set up for the potential explanatory variables for the maths and literacy test results. These variables were:

Socio-economic status [1] of the subplace within which the school lies. Using each school name and EMIS code, it is possible to look up the subplace in the 2001 population census within which the school falls, using Eduaction’s update and extension of the 2000 School Register of Needs. Simkins has elsewhere computed an SES indicator for each subplace in South Africa as the first factor from the following indicators:

- Mean years of education of those over 25
- Labour absorption ratio among those aged 15-64. The labour absorption ratio is the number of employed people divided by the population
- Logarithm of mean household income
- A services index based on access to water, electricity for lighting, toilets, refuse removal and telephones

The list of schools and the SES of the subplace within which they are located is presented as Appendix 5. The factor is negative for all but four of the schools, showing that the majority are in the bottom 50% of all subplaces nationally. In using the data for the sample, the SES score was transformed into a score with zero mean and unit standard deviation for the 24 schools.

The **maths teacher score** [2] and the **language teacher score** [3] of the Grade 3 teachers.

The *diligence* [4] and *exposure to English* [5] scores
 The *literacy test result* [6]

In respect of mathematics test results the correlation matrix was as follows:

	1	2	4	5	6
1					
2	-0.293*				
4	-0.036	0.006			
5	0.260*	0.121*	0.292*		
6	0.171*	-0.178*	0.178*	0.152*	

In respect of language test results the correlation matrix was as follows:

	1	3	4	5
1				
3	-0.263*			
4	-0.030	-0.012		
5	0.261*	-0.156*	0.285*	

Notice the negative correlations between [1] and [2] and [1] and [3]. The best teachers (for the subset considered here) are in the worst places on the SES measures. Though this point is worth noting, our immediate concern is with reducing dimensionality. In both matrices, there is a positive correlation between [1] and [5] i.e. higher SES and more use of English in the home. There is also a correlation between diligence and the use of the English in the home. However, none of these correlations are at a level to cause a serious multicollinearity problem in what follows.

We now consider two regressions. The first is a regression of the score in the learner literacy test against SES, the language teacher score, the diligence factor, the exposure to English factor, and whether or not the language in which the test was written was the same as the home language. Variables with coefficients not significantly different from zero were eliminated one by one until a final regression was reached where the coefficients on all the variables were significantly different from zero. The second is the score in the learner mathematics test against SES, the mathematics teacher score, the diligence factor, the exposure to English factor, the learner literacy score and whether or not the language in which the test was written was the same as the home language.

The results are tabulated below:

Language

	Initial regression	Final regression
Constant	43.12*	42.37*
SES	-1.746	2.925*
Teacher score (language)	-0.0468	
Diligence	5.230*	4.931*
Exposure to English	2.843	
Same language	1.795	
	$R^2 = 0.114$	$R^2 = 0.080$
	N = 207	N = 567

Mathematics

	Initial regression	Final regression
Constant	-0.08	4.35
Literacy score	0.306*	0.292*
SES	4.982*	4.176*
Teacher score (maths)	0.126*	0.103*
Diligence	-0.298	
Exposure to English	0.266	
Same language	3.183	
	$R^2 = 0.159$	$R^2 = 0.154$
	N = 383	N=432

The implications of these findings can be understood more fully, if we consider a hypothetical case where everything is at the 90th percentile – SES, diligence, teacher score (mathematics). Then the expected score for language would be 52.4% and the expected score for mathematics would be 36.6%. At the 50th percentile the expected scores are 42.3% for language and 21.9% for mathematics.

5 Bringing the schools in

Indicators for schools are defined as follows:

1 *Purpose:*

- Does the school exhibit a sense of purpose towards teaching and learning?

Time Use:

- Are learners out of class during teaching time?

- Is there a system for monitoring out of class children?
- Does the long break take place at the time specified on the timetable?
- Do pupils return promptly after long break?
- Did the first lesson begin on time?

A single *time use* indicator was constructed by counting each desirable answer to the time use questions as one and adding the points up.

There was a correlation of 0.506 (significant at the 5% level) between sense of purpose and time use, and a single factor was extracted from the two variables. This factor, we called *time on task*.

2 *Teacher register:*

- Is there an attendance register for teachers?
- Was it completed on the day of visit?

Learner register:

- Is there an attendance register for learners?
- Was it completed on the day of visit?

One mark was assigned for each positive answer. The teacher register and the learner register answers were highly correlated at 0.700 (significant at the 5% level) and a single factor (the *register* factor) was extracted from the two variables.

The augmented time use and register factors were uncorrelated.

3 Next comes a set of five *planning and monitoring* questions:

- Does the school management team/principal monitor whether teachers have developed teaching plans? (2=yes, 0=no)
- Does the school have a policy on curriculum planning? (2=yes, 0=no)
- How frequently are teacher planning documents reviewed (0=never, 1=less than once a term, 2=at least once a term)
- Is feedback given on the plans (2=yes, 0=no)
- Is the school currently implementing any performance appraisal systems for teachers? (2=yes, 0=no)

The sum of scores constitutes the planning score.

4 Four *assessment* questions were considered next:

- Does the school have an assessment policy?
- Are class test and exam papers checked for quality by school management?

- Is learner performance monitored by school management?
- Does the SGB monitor learner performance at school?

Two points were awarded for each correct answer and the assessment score was obtained by addition.

5 *Class size* in Grade 3 and *annual payment per child* (school fees multiplied by the fraction of parents paying) are included. From class size a *crowding* variable was derived by setting it to one if class size is 40 or below and zero otherwise.

6 A set of questions about *relationships* in the school were considered:

- How decisions are made
- Relationship between principal and other members of staff
- Relationship between principal and the SGB
- Relationship between principal and learners
- Relationships between members of staff
- Relationships between teachers and learners
- Relationships among learners
- School approach to discipline
- Safety situation at school.

Each question was scored between zero and two and scores summed into the relationship indicator.

7 *Inventory management*

- Does the school have an inventory system?
- Is it up to date?

One point was given for each positive answer.

A correlation matrix was constructed using nine variables: time, register, plan, assess, relate, inventory, crowd, payment and SES and is displayed as Appendix 6. The pattern of significant correlations suggests the extraction of the first factor from register, plan, assess and relate, which can be regarded as a *school organization factor*. There are no significant correlations between this factor and remaining variables: time on task, inventory management, crowding, average fee paid per learner and SES. We are therefore faced with the same problem as we had with teachers and recourse to a normative view at the level of the school is necessary. Again z-scores are constructed and coefficients are applied to them as follows:

School organization	1.00
Time management	1.00
Crowd	1.00

Inventory management	0.50
Effective fee per pupil	0.50

The resulting score is converted to a z-score and then to a percentile in the same way as in the teacher section. Appendix 7 sets out school scores. This school score is what is used for the regressions, which is covered in section 6 below.

6 The model

The overall model inserts the school score into the home and teacher models for mathematics and science. Again initial and final regressions are computed. The final regression for language is exactly the same as before, since the school score drops out in the first elimination. The final regression for mathematics is different and is as follows:

Constant	4.99*
Literacy score coefficient	0.312*
School score coefficient	0.117*
SES	2.456*

$$R^2 = 0.203$$

$$N = 753$$

The mathematics teacher score drops out, and the school score comes in. At the 90th percentile on all relevant variables, the mathematics score is 35.0%, and at the 50th percentile it is 24.0%.

The correlation matrix between mean teacher mathematics score, mean teacher language score, school score and SES is as follows:

	Tmaths	Tlang	Sscore	SES
Tlang	0.672*			
Sscore	0.534*	0.543		
SES	-0.204	-0.155	-0.340	

* denotes significance at the 10% level².

There is a correlation between the quality of teachers and the quality of schools, but none between both and SES.

² Using the 10% level runs a greater risk of regarding relationships which are not significant as significant, but it also increases the power of the tests (i.e. makes it less likely that a significant relationship will be overlooked).

7 Conclusions

The main purpose of this undertaking was to determine what factors affect learning outcomes at the school level, the teacher level and classroom level, and the learner level. A considerable number of variables were collected in the study. However, at this stage, it would certainly be premature to try and assemble all the information from a very rich data set into a comprehensive multilevel model. Instead, we concentrated on inputs and outputs at particular levels, concentrating on teachers and learners. Factor analysis and normative scoring was used to boil down the considerable number of variables down into dominant factors which could be correlated with learner performance (learner test score on mathematics and literacy).

The results indicate that the only variable which affects learner literacy score is diligence - other home factors, language teachers and schools make no significant difference. Therefore, the more work done by learners at home either by doing homework or by reading by oneself, the better the literacy score is. This comes as no surprise.

The case of mathematics is more complex. Mathematics scores depend on literacy scores and SES and either mathematics teachers (if school scores are left out) or school scores. In other words the better a learner does in literacy, the better the mathematics score. Additionally, if the learner is in a reasonably decent school (school in the upper half of the distribution), and the learner has a reasonably good teacher, the better the mathematics score attained will be.

However, the correlation between mathematics teacher scores and school scores makes identification difficult. The results found are what one would expect: mediocre to poor results in language and very poor results in mathematics. It is difficult to see how manipulation of school conditions and teacher performance can turn expected values of either learner literacy score or the learner mathematics score to passing levels of 50%. In other words, if all scores were in the 90th percentile, the overall score is still far from a pass. It is likely that the teaching of mathematics in English as opposed to in the learners' home language may be holding up the mathematics score. Therefore language practices in accordance with sound educational theory may help to improve the performance of learners in mathematics.

A diagrammatic representation of this model is displayed in Appendix 8.