Policy, Research, and External Affairs

WORKING PAPERS

Education and Employment

Population and Human Resources
Department
The World Bank
June 1991
WPS 705

What Causes Differences in Achievement in Zimbabwe's Secondary Schools?

Abby Rubin Riddell
and
Levi Martin Nyagura

Textbooks and teachers are important in raising achievement, but more research is needed on what characteristics differentiate high-achieving schools from low-achieving schools.

Policy, Research, and External Affairs

WORKING PAPERS

Education and Employment

WPS 705

This paper — commissioned by the Population and Human Resources Operations Division, Southern Africa Department, Africa Regional Office, jointly with the Education and Employment Division, Population and Human Resources Department and Zimbabwe's Ministry of Education and Culture — was prepared as a background paper for a review of primary and secondary education in Zimbabwe. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Cynthia Cristobal, room S6-214, extension 33640 (55 pages, with tables).

Riddell and Nyagura found that students who attended high-fee-paying (trust) schools, elite urban government schools, and mission schools scored better in mathematics and English achievement than did students in the less-well-endowed government schools and those established by local councils.

Much of the variation in student achievement was attributable to the schools the student attended. Examination results were higher in schools with a high proportion of trained teachers, with a good supply of textbooks, and with a stable faculty (high teacher retention).

But once researchers control for these factors, contrary to expectations, some underendowed local council and government schools are more effective at boosting achievement than their counterparts with more resources.

So, textbooks and teachers are important in raising achievement, but more research is needed into what characteristics differentiate high-achieving schools from low-achieving schools.

Table of Contents

Abby Riddell is an Education Researcher at the Harvard Institute for International Development; Levi Nyagura is a professor of Education at the University of Zimbabwe.

TABLES

GRAPHS

This study was commissioned by the Southern Africa Population and Human Resources Division of the World Bank as a background paper for a review of primary and secondary education in Zimbabwe.

I. INTRODUCTION

Background

Historically Zimbabwe inherited at Independence in 1980 an educational system which had denied educational opportunities to the majority African (black) population. The most distinguishing feature of the pre-independence educational system was its racial bias, characterized by limited provision of educational resources for the African population, especially in rural areas.

Before independence access to secondary education by African pupils was governed by strict selection policies not found in the European education sector. As a result of these harsh politically motivated selection policies, Grade 7/Form 1 transition rates before independence were below 35%. (Table 1.1)

TABLE 1.1: Grade 7/Form 1 Transition Rates (%), 1970/71 - 1988/89

Year:	70/1	71/2	72/3	73/4	74/5	75/6	76/7	77/8	78/9	79/80
Transition Rate:	30	33	31	30	27	25	23	22	22	27
Year:	80/1	81/2	82/3	83/4	84/5	85/6	86/7	87/8	88/9	
Transition Rate:	86	70	74	82	82	78	70	65	66	

Source: Calculated from Report for African Education, and Report of the Secretary for Education, various years, Government Printers, Salisbury and Harare, and "Teachers' Colleges and Schools: Staffing and Enrolment Statistics", various years, Ministry of Education, mimeo.

In addition to unequal access to education, there were political, social and economic disparities under colonial rule. Swift and decisive political action by an independent Zimbabwean government was, therefore, expected by the black majority in order to correct and reverse the imbalances and the gross inequalities prevailing in the society. Such swift action was taken in the education sector within six months of obtaining independence.

Expansion and Quality in Secondary Education

The dramatic changes in educational provision for the African population soon after independence were to a large extent motivated by the desire of ZANU (PF), the ruling party, to meet the high demand for education and the aspirations of thousands of black youths denied access to education by the colonial governments. Notably, education, rather than being viewed as a privilege, was declared to be a basic right. The Zimbabwe government committed itself to a number of objectives:

- the provision of universal primary education
- the abolition of a racial education system.
- the establishment of a uniform national system of education.
- the establishment of at least one government school in each of the rural administrative districts
- the training of more teachers for both primary and secondary schools.
- the expansion of secondary educational facilities especially in those areas previously neglected by the pre-independence regimes.

The reality of commitment is amply demonstrated by the statistics in Tables 1.2 and 1.3.

TABLE 1.2: Number of Secondary Schools and Enrolments, 1979 - 1989

Year	#Schools	School Index*	Enrolment	Enrolment Index+
1979	177	100	66215	100
1980	197	111	74321	112
1981	694	392	148690	225
1982	738	417	227647	344
1983	790	446	316438	478
1984	1182	668	416413	628
1985	1215	686	482000	728
1986	1276	721	537427	812
1987	1395	788	604652	913
1988	1484	838	653353	987
1989	1502	849	698828	1051

* School index baseline is the 1979 figure.
+ Enrolment index baseline is the 1979 enrolment figure.
Source: See Table 1.1

The data in Table 1.2 demonstrate the magnitude of expansion in both numbers of secondary schools and in enrolments. While there were only 177 secondary schools in 1979, the number increased to 1,502 in 1989 reflecting a phenomenal increase of 749%. In terms of enrolment, the relatively small figure of 66,215 students in 1979 jumped to 695,882 in 1989, an increase of 951%.

TABLE 1.3: Numbers of Teachers in Secondary Schools, 1979-1989

Year	#Teachers	Index*	% Untrained	% Underqualified+
1979	3534	100	n.a	6
1980	3736	106	3	7
1981	6112	173	5	7
1982	8349	236	12	12
1983	11191	317	22	46
1984	14718	416	41	18
1985	17315	489	45	19
1986	19487	551	47	17
1987	21981	622	49	16
1988	23899	676	n.a.	n.a.
1989	24856	703	50	n.a.

n.a. not available.
* The teacher index baseline is the 1979 figure.
+ Underqualified is defined as Standard 6 plus 2 years teacher training, Junior Certificate (J.C.) plus 2 or 3 years teacher training, and Cambridge School Certificate (C.S.C.) plus 2 or 3 or 4 years primary teacher training.
Source: See Table 1.1

The rapid increase in student enrolments was matched by a rapid growth in the number of teachers. As can be seen from Table 1.3, the teaching force which stood at 3,534 in 1979 rose to 24,856 in 1989. However, the steady increase in numbers of teachers had another side to it, namely the increase in the number of untrained and underqualified teachers employed in secondary schools. Whilst only 3% of secondary school teachers were untrained in 1979 the percentage rose to 50% in 1989. The percentage of underqualified teachers has fluctuated between 7 - 46% in the period 1980 - 87. Government efforts to train more secondary school teachers have been significant. While there were only two secondary teacher training colleges in 1979, the number had increased to four by 1985 and a fifth college is due to open shortly in Chinhoyi. The data in Tables 1.2 and 1.3 clearly demonstrate that the Zimbabwean government has performed outstandingly in increasing the quantity of education - that is building more schools, hiring more teachers, and enrolling more pupils. However, the quality of teaching and learning in secondary schools as measured by academic achievement rates in public examinations shows a steady decline over the ten years of Independence. For example, in 1979 63% of those students sitting for the Cambridge 'O' levels passed in at least five subjects whereas only 13% attained the same standards in 1985. The situation in 1989 has not improved. Of about 169,000 students sitting for the Cambridge 'O' levels (in 1989) only about 22,000 (13%) passed in at least five subjects. Of course, whilst the percentages passing have decreased since Independence, the actual numbers of pupils sitting the examinations have increased.

This increase in access to secondary education has allowed pupils of low academic ability to enter secondary schools whilst the academically oriented curriculum of the pre-independence period has remained almost unchanged. Furthermore, these schools lack adequate resources such as qualified and experienced teachers, textbooks, library books, and other instructional materials.

A similar decline in educational quality is illustrated by the achievement rates of students in the Zimbabwe Junior Certificate (ZJC) English and Mathematics public examinations for the period 1984 - 88.

TABLE 1.4: Student Pass Rates in Mathematics and English at the ZJC Level, 1984 - 1988

	ENGLISH			MATHEMATICS		
Year	No. Sitting	No. Passing	% Pass Rate	No. Sitting	No. Passing	% Pass Rate
1984	101086	29300	29	101087	17701	18
1985	148670	80832	54	122461	15770	13
1986	129909	62660	48	130266	23865	18
1987	146674	62377	3	146241	13672	9
1988	169913	58252	34	169009	26716	16

Source: See Table 1.1

Table 1.4 provides data on pupils reaching a passing standard in the Zimbabwe Junior Certificate national examinations in Mathematics and English. Of 101,086 students who wrote the ZJC English examination in 1984 only 29 percent attained a passing standard, and the number of students successfully completing the ZJC English program has declined steadily since the leap in 1985. For Mathematics, the rate of student academic achievement is disappointingly low (9-18%).

Context of the Study

These declining levels of attainment signal the erosion of educational quality through pressures to expand the educational system in the face of diminishing resources. Within Zimbabwe such scarce resources include salaries, tuition expenditures, physical facilities, and instructional materials. What appears an appropriate strategy to curb the decline in educational quality in Zimbabwe secondary schools is to identify school, and class characteristics which boost student academic achievement. The principal aim of this study was to identify schools which produce the best and worst ZJC results in English and Mathematics after controlling for the students' academic background on intake and to determine the characteristics of effective and ineffective secondary schools. The results of the study were an important input into a joint Zimbabwe Ministry of Education and Culture and

World Bank education sector study carried out in May-June 1990. Major issues addressed in the sector study include: low levels of learning achievements, especially in the recently established secondary schools, the unattractive prospects for many school-leavers due to the high level of youth unemployment, whether the Government will be able to continue increasing its financial support to the education sector, whether existing esources are being used optimally, and what additional resources can be utilized for education.

II. RESEARCH DESIGN

Many countries produce 'league' tables of school examination results which are meant to identify the best and the worst schools. Such 'league' tables do, of course, tell us which schools produce the top grades, but as every parent and teacher knows, the schools which attract the best students, i.e. those having already proven academic ability, are bound to produce the best examination results. Such league tables are more indicative of the intake of schools than the actual output, for they do not account for the students' prior ability, and therefore they do not measure what has actually been achieved at school. Of far greater interest than a table showing which schools produce the top grades is a rather different sort of 'league' table, which shows the increment in achievement after controlling for schools' intake of students.

This study uses the exam results on the internally set Zimbabwe Junior Certificate (ZJC)[1].The choice of English and Mathematics, besides being two compulsory subjects whose examination results span different types of academic ability, was predicated on our being able to control for prior achievement in these subjects, their being the two subjects examined in Grade 7, the final year of primary school.

<u>Sample</u>

It was important that the sample of schools chosen for the analysis be representative of the national population of schools. Six schooltypes adequately reflect the most important, different kinds of schools operating in the country, namely: (1) former Group A government schools, which had catered for the European population before Independence, (2) former Group B urban government schools, (3) former Group B rural government schools, both of which had catered solely for the African population before Independence, (4) high fee-paying (trust) schools , similar to American 'private schools' or British 'public schools', (5) mission schools and (6) the new local-authority run district council schools.

In order that the students sampled in these six schooltypes also be representative of the major ethnic groups in Zimbabwe, but at the same time not too dispersed for follow-up school visits, four regions were selected for further sampling: Harare, the capital, Mashonaland West, the Midlands and

---

[1]Although it would have been preferable to use 'O' level examinations taken in what is, for most students, their final year of secondary school, the sector mission would not have had the opportunity to interview the students, who, had they been in Form IV last year, would already have left school.

Matabeleland North. A fair spread of Ndebele and Shona children attending both urban and rural schools could be obtained from these four regions, without, in addition, posing any security problems. A stratified random sample was drawn, proportional to the size of the districts in the chosen regions. The districts selected were: Mhondoro and Sanyati (Mashonaland West), Shurugwi and Takawira (Midlands) and Binga and Nkayi (Matabeleland North). Further sampling, proportional to the size of the secondary schools by the six schooltypes, was carried out in those districts.

Ideally, one would want to have the number of schools in each schooltype reflect the total school population. This was attempted, but the actual breakdown of secondary schools by schooltype, could not be obtained. In addition, there was the further constraint of having sufficient numbers of schools in each schooltype to make a reasonable analysis. It was decided that four schools per schooltype would suffice. Table 2.1 extrapolates from the known breakdown of schools for 1985, and includes "guesstimates" for 1989, given the known total school population.

TABLE 2.1: Breakdown of Secondary Schools by Schooltype in Sample and Guesstimates in Total Population, 1989

	No. in sample	%	Estimate 1989	%
Former Group A	4	8	34+	2
Former Group B (urban)	4	8	)	)
Former Group B (rural)	6	13	) 158+	)11
High Fee-paying	4	8	38	3
Mission	6	13	172	11
District Council	24	50	1006	67
Other	-	-	94	6
TOTAL	48	100	1502+	100

+ Actual Figures

Variables

The time frame within which the study was conducted produced certain constraints. A decision had to be made as to which variables (from the ideal set of variables one would like to include in a study such as this) could realistically be obtained in the time from mid-February, when the sampling was carried out and the data collection begun, and mid-April, when the schools closed for Easter and the analysis began.

The main prerequisites of the study were that the ZJC English and Mathematics results as well as the Grade 7 English and Mathematics examination scores were reported for each student sampled. (All Form II students in 1989 whose names were on the ZJC entry forms for each of the 48 sampled schools were included.) As most secondary schools have a record of their students' Grade 7 scores, we sent the ZJC entry form print-out to each of the head teachers of the 48 schools sampled and requested that they fill in each 1989 Form II student's Grade 7 marks. The Grade 7 examination scores allow a control to be made for intake ability in each of the subjects, enabling us to model the increment in achievement that could be attributed to the secondary school, rather than the child's previous schooling. Whilst we would have liked to have had a measure of each student's socio-economic background, something which we could have obtained through a detailed questionnaire, along with other, student-level information, it was thought unrealistic to expect the head teachers to administer such questionnaires in the time available.[2] Besides the four grades for each pupil, the two subjects for the two examinations - the other pupil-level variables which we were able to include in the study were the sex and age of the pupils, which were obtained from the ZJC entry forms.

It was also possible to match each pupil with her/his Form II English and Math teachers as well as classmates by using information from the school heads on the deployment of the Form II English and Math teachers in each class. This enabled us to carry out a three-level analysis, including the class as well as the school and pupil levels.

---

[2] In a 1985 study of 'O' level results in English and Mathematics (Riddell 1988), both an intake variable and a pupil-level background index variable were included, but the influence of the intake variable was much larger than the socio-economic variable. In fact, while modelled separately, it was questionable to what extent the intake variable covered for some of the influence of the background variable.

Aside from one further variable collected from the head teachers, namely, how many pupils had to share each textbook in Math and in English, the remaining class and school level information was collected from statistical returns to the Ministry of Education and Culture, on the ED.46 (Part II) form. This narrowed down the optimal list of variables to include the following, additional class level variables: the qualifications and years of experience of the Form II Math and English teachers and the class size, and the following, additional school level variables: the percentage of teachers in the four different qualification bands, ranging from untrained to certificated graduate, the average years of teaching experience at the school, the average years of teaching at the particular school, whether the school was day or boarding, the size of the school, the overall teacher pupil ratio and the percentage of Africans at the school. A list of all the variables in the study can be found in Appendix 1.

Methodology

The choice of a multilevel model was an obvious one, given the objective of the study. Whilst ordinary least squares regression could control for the intake ability of the students, it would not have been possible to infer at the class and school levels the implications of this control and other parameters. Similarly, if one focussed on the school level, it would not have been possible to adequately account for the prior ability of the students. This would be rather like seeking explanations for the development of a hybrid species without knowing the constituent breeds. The arguments concerning the appropriateness of multilevel modelling for nested, hierarchical data found in an education system in which pupils are nested in classes, which in turn are nested in schools, have been put forward in several contexts, e.g. (Burstein 1980a, 1980b, Goldstein 1987, Riddell 1988, 1989). One of the main advantages of using a multilevel model for a study such as this is the ability to portray simultaneously the influence of different factors at all the levels one chooses to specify, so there is no need to be limited by 'a' unit of analysis. The richness of interpretation made possible by multilevel modelling will become clear in the discussion of the results. The multilevel package used for the analysis was ML3 (Rasbash, Prosser, Goldstein 1989).

Description of Sample

Of the 48 schools originally sampled, some 33 (69%) returned sufficient data by the second week of April, enabling us to include them in the study. The final numbers and percentage breakdowns by schooltype, by school, by class and by pupil can be found in Table 2.2. The final sample consisted of 5,293 Form II pupils in 138 classes in 33 schools. Table 2.3 illustrates the data that are missing from the original sample, and from the final sample, by numbers of pupils and by subject. Pupils were eliminated from the sample if either of the two grades for each subject was missing. Table 2.4 reports the means and the standard deviations of all the computable variables in the study, by schooltype. Both the ZJC and the Grade 7 examination are graded on a scale of 1 to 9, 1-6, being passing grades with 1 the top grade, and 7-9 being failing grades. In order for the results of the regression analysis to be interpreted easily, these grades were transposed, so that 9 is now the highest grade and 1 the lowest.

TABLE 2.2

Description of Final Sample: No. of Schools by Schooltype, No. of Classes, No. of Pupils (%)

School Type	No. Schools (%)	No. Classes (%)	No. Pupils (%)
Former Gp A	3(9)	22(16)	735(14)
Former Gp B (urb.)	4(12)	48(35)	2008(38)
Former Gp B (rur.)	3(9)	15(11)	537(10)
High Fee-paying	2(6)	6(4)	155(3)
Mission	6(18)	19(14)	801(15)
District Council	15(46)	28(20)	1057(20)
TOTAL	33(100)	138(100)	5293(100)

TABLE 2.3

Missing Data from Original Sample: No. Schools by Schooltype (%); Missing Data from Final Sample by Subject: No. Pupils

	No. Schools Orig.Sample	No. Schools Final Sample	No.Pupils Final Sample	No.Pupils English	No.Pupils Math
Former Gp A	4	3 (75)	735	584 (79)	611 (53)
Former Gp B (urb.)	4	4 (100)	2008	1432 (71)	1456 (73)
Former Gp B (rur.)	6	3 (50)	537	433 (81)	431 (80)
Higher Fee-paying	4	2 (50)	155	134 (86)	133 (86)
Mission	6	6 (100)	801	735 (92)	733 (92)
District Council	24	15 (63)	1057	829 (78)	826 (78)
TOTAL	48	33 (69)	5293	4147	4190

TABLE 2.4

Average Values of Variables by Schooltype (S.D.)

	All Schools	Former Gp A	Former Gp B(urb)	Former Gp B(rur)	High Fee Paying	Mission	District Council
Pupil level							
ZJCE	3.8(2.2)	5.9(2.1)	3.0(1.6)	3.3(1.5)	7.1(2.1)	5.57(1.9)	2.4(1.4)
ZJCM	2.5(1.9)	2.7(1.9)	1.8(1.1)	2.1(1.3)	5.0(2.4)	4.5(2.5)	1.7(1.0)
GR7E	6.4(1.7)	7.7(1.2)	5.8(1.4)	6.2(1.4)	8.6(.7)	7.6(1.1)	5.3(1.5)
GR7M	7.0(1.8)	7.5(1.6)	6.6(1.7)	7.1(1.9)	8.3(.9)	8.2(1.3)	6.2(1.9)
AGE	16.1(1.6)	15.2(.9)	16.2(1.3)	16.5(1.9)	14.6(.6)	15.8(1.1)	16.9(2.3)
Class level							
EQUAL	2.2(1.4)	1.5(.7)	1.9(1.6)	2.5(1.1)	1.0(0)	1.6(.5)	3.6(.8)
MQUAL	2.6(1.5)	1.1(1.6)	2.6(1.7)	1.0(1.0)	1.4(.5)	2.8(1.2)	3.3(1.1)
EXPER	6.9(19.5)	3.3(8.7)	11.5(30)	2.3(2.0)	2.2(.8)	4.9(3.2)	1.9(1.0)
MEXPER	3.9(13.0)	1.7(4.3)	5.1(20)	1.9(2.3)	3.6(2.2)	1.9(1.3)	2.0(1.3)
CLSIZE	33.2(13.5)	34.6(4.6)	29.4(17)	35.8(2.5)	27.0(5.3)	42.9(4.5)	39.3(7.2)
School level							
TCHQUAL							
1	21.9(23)	53.6(11.4)	9.3(3.4)	7.4(4.7)	64.8(1.5)	50.2(14.7)	3.3(6.5)
2	38.3(16.7)	34.7(12.0)	39.8(12.4)	59.0(11.6)	29.8(5.9)	35.0(10.6)	31.1(23.1)
3	5.9(9.8)	0.9(1.9)	9.6(13.9)	6.8(2.7)	0(0)	7.3(5.0)	1.7(5.1)
4	33.5(26.6)	10.8(1.9)	41.3(16.2)	22.1(17.4)	5.4(4.4)	7.6(7.7)	63.8(27.5)
TCHEXPER	3.5(2.5)	7.1(2.5)	2.0(0)	3.8(1.3)	5.2(1.0)	5.3(3.2)	2.1(.8)
TCHTHIS	2.6(1.6)	3.7(1.0)	1.7(.4)	2.7(.5)	5.2(1.0)	4.4(2.4)	1.7(.7)
ETEXT	.53(.3)	.79(.2)	.38(.2)	.42(.1)	1.0(0)	.84(.23)	.4(.1)
MTEXT	.53(.3)	.79(.2)	.38(.2)	.42(.1)	1.0(0)	.84(.23)	.4(.1)
SIZE	1029(558)	1296(407)	1503(319)	995(424)	600(125)	644(178)	314(86)
TPR	26.4(3.9)	26.6(3.3)	28.5(1.5)	21.4(4.4)	14(2.5)	26.6(3.3)	26.3(1.8)
PERCTAF	96.1(12.9)	87.3(4.0)	100(0)	100(0)	26.6(4.4)	100(0)	100(0)

The average ZJC English grade across all the schooltypes was 3.8, with the lowest average, 2.4 reported for district council schools and the highest, 7.1. for high fee-paying schools. For ZJC Mathematics, the average grades were much lower, 2.5 for all schooltypes, and a low of 1.8 for the former Group B urban schools and 5.0 for high fee-paying schools. The grades on the Grade 7 examination were much higher across the board, the averages for English and Mathematics being 6.4 and 7.0, respectively, with the lowest averages reported for the district council schools in both subjects, 5.3 and 6.2, respectively, and the highest reported in the high fee-paying schools, 8.6 and 8.3, respectively. The average age of the pupils in the sample was 16.1. The lowest, 14.6, was found, not surprisingly, in the high fee-paying schools, where the children's education is least likely to have been interrupted, and the highest, 16.9, was found, in the district council schools, where the opposite would be the case.

The teacher qualification codes, used for the EQUAL and MQUAL variables, denote the qualification bands of the Form II English and Math teachers, but the same coding also applies to the school level variables, TCHQUAL1-4, being the percentage of teachers in the whole school in the four bands. Bands 1 and 2 comprise fully trained teachers, band 1 being certificated and uncertificated graduates, and teachers holding unrecognized degrees, and band 2 being 5/4 years of teacher training or 'O' level plus 3/2 years teacher training. Bands 3 and 4 comprise underqualified and untrained staff, namely band 3 being the old teacher training qualifications of J.C. plus 2/3 years teacher training and Standard 6 plus 2 years teacher training, and band 4 comprising either untrained teachers or teacher trainees. At the class level, the actual Form II English and Math teachers averaged on the trained side across all the schooltypes, but ranged from averages of all fully qualified at the high fee-paying and former Group B (urban) schools to the underqualified and untrained side of the scale for district council schools in both subjects. A contrast is found for the years of teaching experience in both subjects. The averages across all schooltypes were 6.9 and 3.9 for English and Mathematics respectively, but ranging from less than two years for district council and former Group A urban schools to 11.5 and 5.1 years of experience in the former Group B urban schools for both subjects, respectively. Class sizes were smallest in the high fee-paying schools, averaging 27 pupils per class, whereas the largest average class sizes were found in the mission schools, with 42.9 being the average for that schooltype.

Grouping the teacher qualification bands 1 and 2 together to obtain the percentage of trained teachers results in an average of 60.2% trained teachers across all the schooltypes, but with a range from 34.4% in the district council schools to 94.6% in the high fee-paying schools. Average years of teaching experience is highest in the former Group A schools, at 7.1 years, and the lowest, at the former Group B urban schools, at 2.0 years, with an average of 3.5 years across all schooltypes. The number of years teachers have spent at the particular school in question ranged from 1.7 years in both the former Group B urban and district council schools to 5.2 years in the high fee-paying schools, the average across all schooltypes being 2.6 years. The variables ETEXT and MTEXT represent the availability of textbooks in the two subjects as judged by the head teachers. If each child has her/his own textbook, the variable's value is 1.0, if shared between two pupils, then 0.50

and so forth. The range for the averages of these variables was from .38 for both subjects at former Group B urban school to 1.0 at the high fee-paying schools, with an average for all schooltypes of 0.53. The smallest schools on average were the district council schools, averaging 314 pupils in size, and the largest, not surprisingly the former Group B urban schools, averaging 1503 pupils in size. Teacher pupil ratios ranged from 14 in the high fee-paying schools to 28.5 in the former Group B urban schools, with an average across all the schooltypes of 26.4. The percentage Africans comprising the student bodies of the different schooltypes ranged from 26.6% in the high fee-paying schools to 100% or a predominant majority in most of the other schooltypes. A list of schooltype categories can be found in Appendix 2.

III. THE PROGRESSION TOWARD 'FINAL' MODELS FOR ZJC ENGLISH AND MATHEMATICS ACHIEVEMENT

Plugging in variables into a sophisticated regression model can assume a life apart from reality. Endless testing of different fixed and random parameters can easily remove one from the subject under study. The aim of this section, however, will be to interpret the meaning behind a web of complicated statistics and hopefully to bring to life different explanations of Mathematics and English achievement at Form II in Zimbabwe's secondary schools in 1989.

Not only is one's subject matter in the social sciences of the real world, but so are the methods which one uses for analysis. This study is certainly no exception, and whilst multilevel models are in the process of superseding ordinary least squares (OLS) regression analysis when applied to nested, hierarchical data such as are found in educational systems, the programmes facilitating such modelling have not gone through the years of testing that single level programmes have undergone.

A prefatory caveat is needed to explain why some analyses were carried out in this study and not others. Numerous problems were encountered in using ML3, the multilevel regression programme. The size of the data set and the numbers of variables collected, though in fact, quite limited, as discussed above, were at times too great for the capacity of the programme. Certain combinations of variables overran the workspace; certain deletions of missing data seemingly occupied more, not less workspace, frustrating the testing of potential models; and reading data into the workspace was not always a straightforward exercise. Nonetheless, it was still thought preferable to continue using ML3, even with its remaining 'bugs', for a picture is painted which is far closer to reality than any single level model can paint.[3/]

In single level regression models, there is a single residual term illustrating the variance which has not been explained. In multilevel models, residual terms at each level are specified. For example, in the three-level models described below, three residual terms reflect the differing effects of the explanatory variables at the pupil, the class and the school levels. In other words, instead of being 'throw-away', error terms, the residual

---

[3/] In fairness, many of these 'bugs' have been eliminated since the first writing of this report, and in addition, an extended memory version of ML3 is up and running, facilitating the inclusion of more variables. However, the limited number of schools in the study still constrains the number of school level variables which can be fit successfully in any one model.

parameters are a separate focal point of the analysis. (See Goldstein 1987 for technical background.)

In each of the models, together with the significance of the fixed parameters which are tested, we are interested in the reductions made to the overall variance by the inclusion of different explanatory variables, as well as the changes in the distribution and size of the components of this overall variance at each of the three levels.

BACKGROUND MODELS: ADJUSTING FOR INTAKE

Model A: The Variance Components of Grade 7 Scores

Tables 3.1 and 3.2 report the results of the initial models for Mathematics and English respectively. Model A, shows the variation in Grade 7 scores between schools and between students. Model A is a two level model because we do not know the classes in which the 1989 ZJC candidates sat their Grade 7 examinations. For Mathematics, 40% of the variation in achievement is between schools; for English, the figure is 53%. The average Grade 7 marks for both subjects across all schooltypes are 6.4 for English and 7.0 for Mathematics.

Model 1: The Variance Components of ZJC Scores

Model 1 is really the starting point of this analysis. It illustrates the total variance to be explained in subsequent models and how it is partitioned between the three different levels. For Mathematics achievement, 47% of the variance is between schools, 14% between classes and 39% between students. For English achievement, the figures are comparable, with 47% also between schools, 18% between classes and 34% between students.

Model 2: Controlling for Grade 7 Scores

Model 2 illustrates the effect of controlling for the Grade 7 scores in English and Mathematics of each individual Form II pupil. In Mathematics one-third of the overall variance is accounted for by the prior Grade 7 achievement, and one-half in the case of English. The between school variances in both subjects are significantly reduced by the inclusion of this variable, one-third in the case of Mathematics and two-thirds in the case of English. This means that some of the observed between school differences have nothing to do with differences in school or classroom practices but rather the selection into the schools on the basis of the students' prior achievement. In a single level model, because it is not possible to distinguish between these different components of variance, these selection differences are confounded with 'real' school differences. The class level variances in English were reduced by two-thirds with the inclusion of the Grade 7 score, but only by 12% for Mathematics, indicating that classes are more differentiated according to Grade 7 achievement levels in English than they are for Mathematics.

The relationship between prior achievement in English and subsequent achievement at Form II is stronger than for Mathematics, judging by the coefficients of the fixed parameters. For every point increase in Grade 7 mark, there is more than a third of a point increase at ZJC for Mathematics, but more than two-thirds for English.

Model 2a: Allowing the Grade 7 Intake Variable to be Random at the School Level (for English)

Whereas Model 2 assumes that the relationship between Grade 7 achievement and Form II achievement is the same in all schools, Model 2a allows this relationship to vary, so that some schools may produce better results than others, given particular levels of student achievement on intake. This model proved to be significant only in the case of English, and not Mathematics, for which a constant slope - or constant relationship - was evident. For English, however, taken at the average Grade 7 score of 6.4085, this model resulted in a reduction in the between school variance of 5%, to 28% of the overall variance. The total variance itself was reduced by 10%, when compared with Model 2.[6]

Model 3: Schooltype Differentiation

Dummy variables were created for the different schooltypes under investigation in the study, the Group A schools serving as the reference point. The inclusion of these 5 schooltype variables eliminated the between school variance (it was no longer statistically significant at the 5% confidence level) and substantially reduced the total variance. For English,

---

[6] A further model was tested which allowed the Grade 7 score to be random at the class level as well. This means that different classes have different relationships between intake and outcome. Taken at the average GR7E, the total variance explained was less than for Model 2a, but variance remained to be explained at all three levels after the inclusion of these random parameters. This model produced the following statistics: fixed coefficients: CONS - .7024 (.12) GR7E .6736 (.04); random parameters: school level: CONS .05875 (.09) GR7E .02445 (.01) covariance -.03657 (.028); class level: CONS .408 (.17) GR7E .03067 (.007) covariance -.1104 (.04); pupil level: 1.349 (.03)

compared with Model 2, the total variance was reduced by 19%, and for Mathematics, by 26%. Although taken separately, the fixed coefficients for these schooltype variables are not significant, the chi-square statistic for their simultaneous contrast showed that the schooltypes were significantly different from zero, for both subjects. For English and Mathematics, the greatest contrast is between the high fee-paying and mission schools, on the one hand, and the Group B and district council schools, on the other. This was also the case in 1985 for English, though these schooltype differences were not significant in the case of Mathematics in the previous study.[5/]

[5/] The 6 schooltypes which formed the basis of the stratified sampling were collapsed into three for further investigation: Government (the reference point), high fee-paying and mission, and district council schools. Although the differentiation which does exist - as can be seen from Model 3 - between the Group A and Group B schools is lost by such a regrouping, the contrasts are otherwise more striking between the remaining classifications. The fixed coefficients for this model for English are: CONS -.15 (.23), GR7E .6345 (.02), HIGHMISS 1.059 (.33), DC -.7904 (.29); and the random parameters are: school level CONS .3804 (.13), class level CONS .3543 (.06) and pupil level CONS 1.393 (.03).

The fixed coefficients for this model for Mathematics are: CONS -.4986 (.24), GR7M .384 (.01), HIGHMISS 1.871 (.34), DC -.201 (.30); and the random parameters are: school level CONS .4299 (.14), class level CONS .3022 (.05), and pupil level CONS 1.377 (.03).

TABLE 3.1

Fixed and Random Parameters (Standard Errors) of Initial Variance Components Models for Mathematics (Pupil Level Variables)

Models	A	1	2	3	4	5
Response Variable	GR7M	ZJCM	ZJCM	ZJCM	ZJCM	ZJCM
Fixed						
CONS	6.98 (.1017)	2.517 (.2529)	-.1297 (.216)	-.109 (1.293)	2.259 (.2508)	-.2058 (.2159)
GR7M			.3852 (.0128)	.384 (.0406)		.3738 (.0128)
SEX(M)					.4383 (.0449)	.2891 (.0415)
GPBURB				-.579 (2.25)		
GPBRUR				-.51 (2.25)		
HIGHFEE				1.571 (2.25)		
MISSION				1.454 (1.443)		
DC				-.59 (1.358)		
Random						
School(%)	1.329 (40%) (.1699)	1.873 (47%) (.5196)	1.146 (40%) (.3153)	.406 (.512)	1.801 (45%) (.5062)	1.141 (41%) (.3149)
Class (%)	-	.5774 (14%) (.0858)	.3045 (11%) (.0489)	.302 (.157)	.6202 (15%) (.0936)	.3148 (11%) (.0502)
Pupil (%)	2.023 (60%) (.0439)	1.557 (39%) (.0318)	1.377 (49%) (.0306)	1.377 (.0899)	1.607 (40%) (.0357)	1.36 (48%) (.0302)
TOTAL	3.352	4.0074	2.8275	2.085	4.0282	2.8158
No. Pupils	4385	4933	4189	4189	4189	4189
No. Classes	-	139	138	138	138	138
No. Schools	33	33	33	33	33	33

Note: Percentages may not sum to 100 due to rounding.

TABLE 3.2

Fixed and Random Parameters (Standard Errors) of Initial Variance Components Models for English (Pupil Level Variables)

Models	A	1	2	2a	3	4
Response Variable	GR7E	ZJCE	ZJCE	ZJCE	ZJCE	ZJCE
<u>Fixed</u>						
CONS	6.384 (.1066)	3.709 (.2983)	-.2395 (.2018)	-.4588 (.1441)	1.009 (1.08)	3.675 (.2998)
GR7E			.6375 (.0161)	.6483 (.0357)	.631 (.0634)	
SEX(M)						.06429+ (.0442)
GPBURB					-1.61 (1.168)	
GPBRUR					-1.605 (1.25)	
HIGHFEE					.44 (1.386)	
MISSION					-.238 (1.169)	
DC					-1.93 (1.114)	
<u>Random</u>						
School(%)(CONS)	1.491(53%) (.1867)	2.547(47%) (.7224)	.8568(33%) (.2483)	.1971 (.1466)	.139+ (.257)	2.559(47%) (.0725)
GR7E				.03119 (.0102)		
COVAR.				-.06352 (.03512)		
Class (%)		.9816(18%) (.1426)	.3611(14%) (.0568)	.316 (.05)	.362 (.171)	.9813(18%) (.1426)
Pupil (%)	1.304(47%) (.0283)	1.85(34%) (.0379)	1.394(53%) (.0311)	1.369 (0.307)	1.393 (.0908)	1.849(34%) (.0379)
TOTAL	2.795	5.3786	2.6119	2.3489*	1.894	5.3893
No. Pupils	4380	4900	4147	4147	4147	4899
No. Classes	-	139	138	133	138	139
No. Schools	33	33	33	33	33	33

+Not significant

* The total variance depends on the value of GR7E, but calculated at the average GR7E([illegible]), the total variance is 2.3489. Similarly, at the average GR7E, the between school variance is [illegible] or [illegible] of the total variance at this mean score, the between class variance being [illegible].

Models 4 and 5: Controlling for the Sex of the Pupils

Model 4 examines the effect of sex on Mathematics and English achievement without including Grade 7 achievement. The model tests for boys, with girls as the reference point. The sex of the pupils was found to be a significant variable for Mathematics, accounting for not quite an extra half-point for boys. It was not found to be significant in the case of English achievement.

Model 5 is constructed for Mathematics, alone, given the significance of sex as an explanatory variable. Both Grade 7 and sex are included. Whilst the coefficient for sex is reduced, it remains significant. The inclusion of this variable has a marginal effect in explaining the total variance and its different components, comparing the results for Model 5 with Model 2 for Mathematics.

WHICH VARIABLES TO CHOOSE?

Testing Class and School Level Variables for Possible Inclusion

Due to some of the practical problems experienced in using ML3, and the time constraints of this report, it was not possible to test all the variables using a multilevel model. Single level regressions were employed as a means of weeding out variables with less explanatory power than others. Although the standard errors are underestimated in the single level regressions, it was thought that some variables might reasonably be eliminated by putting the information gained from such an exercise together with the results of a similar study conducted in 1985 (Riddell 1988).

Class size, the age of the pupils, the average years of teaching experience of all the teachers and the teacher pupil ratio were excluded from the analysis on the above grounds. All of these variables were found to be statistically insignificant, with the exception of class size for Mathematics achievement, but with little explanatory value (below 10% R^2), and with the exception of the age of the pupils for the regression on English achievement. Even this latter variable, however, had an anomalous, if understandable coefficient. As was shown in the previous section, older pupils on average were found in the less well-provided schools, e.g. the district council schools. A reasonable explanation for the negative coefficient found on all the age parameters is that one is really accounting for a schooltype difference, describing the school, rather than the relationship of age to achievement in a more straightforward sense.[6]

Due to multicollinearity, it was not possible to fit many single variables at each level, and index variables had to be constructed for the three levels under study. For example, once the percentage of trained teachers in a school was found to be a significant variable when tested with ML3, other variables such as the average years of teaching experience at a school were unlikely to be fitted successfully. Judgements were made, clearly, from the standpoint of educational significance, if not solely from the standpoint of statistical significance, regarding the inclusion of different variables. The variables schoolsize, the percentage of Africans in

---

[6] Indeed, the coefficient of age in the multilevel model which regressed a constant, the Grade 7 intake score and age on ZJCE, was -.135 (.06), explaining a further 8% of the overall variance, when compared with Model 2 but eliminating the between school variance.

the student body, and whether the school was day or boarding were not specifically tested, being relatively non-manipulable variables.

Unsuccessful Models

Besides the models reported in Tables 3.3, 3.4 and 3.5 below, the following variables were tested using ML3, with no significant results: EQUAL, MQUAL, EXPER, MEXPER. It is interesting that school, rather than class level variables, ostensibly reporting the same type of information, were found to be significant. For instance, whether or not a particular class is taught by a trained and experienced teacher was not found to be significant, whereas the percentage of trained teachers overall in a school, was found to be a significant variable. Except for the final three English models, the school level variance in both subjects is greater than the class level variance, and it may be that as was the case with the 1985 study, the class level variance is more intractable in the face of these more readily obtainable data and that classroom observations alone will provide the clue to explaining class level differences in achievement.

A sex and Grade 7 interaction term was tested for Mathematics achievement. Whilst statistically significant, the explanatory power of the model was hardly improved and so further modelling with this variable was discontinued. A variable comprising the top three grades in the Grade 7 examination was composed for both subjects and found to be significant in the case of English but not of Mathematics. The coefficient of this variable 'HIGH' for English was 1.47 (.05). This means that a stronger relationship exists between high achievement in Grade 7 English and ZJC results than for the whole range of achievement, whose fixed coefficient was .64. It was not possible to combine this variable with other variables found to be of importance in subsequent analyses, without the loss of statistical significance, however. The variable 'HIGH' for English was tested for a random effect at the school level, but none was found, meaning that the same relationship between high prior ability in English and subsequent Form II achievement was prevalent across different schools.

Although as reported above, a random effect of Grade 7 for further English achievement was found, it was not possible to build upon this model without the loss of further explanatory power of other significant variables as discussed below. Nor was it possible to build substantially on the schooltype differences uncovered in Model 3.[7] Given the small number of schools in the sample (33), there were only so many explanatory variables which one could pack into a model, and as the aim was to explain as much of the variance as possible for the purpose of ranking the secondary schools, one had to be discerning in the choice of variables for any potential 'final' model. Nonetheless, the individual variables of significance in intermediate models provide a background tapestry.

TEXTBOOKS, TRAINED TEACHERS AND TEACHER TURNOVER

Textbooks, trained teachers, and the continuity of employment at any particular school were found to be three key variables in this study. All three contributed significantly to explaining between school differences in

---

[7] For further investigation of contextual effects on achievement, see Lockheed, et. al., 1991.

academic achievement in English and Mathematics. Models 6, 7 and 8, each of which regresses ZJC scores in the two subjects on these variables are presented in Tables 3.3 and 3.4 below.

Model 6: The Availability of Textbooks

Head teachers were asked to report for their Form II English and Mathematics classes, how many students had to share a textbook. While such data may not be as reliable as an actual textbook count, undoubtedly, the head teachers have a good grasp of the scarceness of such resources and their replies have legitimacy. For Mathematics, we shall be comparing Model 5 with Model 6 because it was felt that both sex and Grade 7 scores should be included in the basic background model for that subject. For English, in which the regression on sex was not significant, the comparison is between Models 2 and 6.

The inclusion of the textbook variable for Mathematics has the effect of reducing the total variance by 17% but the school level variance in particular, by 59%, the school level variance comprising some 29% of the total variance by this stage. The importance of the textbook coefficient can be loosely interpreted as follows: if a student has a textbook to her/himself, rather than having to share it, it could result in an increment in her/his achievement at ZJC by as much as two and a half grade points. Even if s/he had to share it with only one other student, the increment could be by as much as a full grade point.

TABLE 3.3

Fixed and Random Parameters (Standard Errors) of Further Models for ZJC Mathematics

Models	6	7	8	9	10
Fixed					
CONS	-1.674 (.3729)	-1.317 (.3643)	-1.121 (.3211)	-1.437 (.366)	-1.683 (.3804)
GR7M	.3731 (.0128)	.3734 (.0129)	.3734 (.0128)	.3846 (.0128)	.3844 (.0128)
SEXM	.2891 (.0415)	.2898 (.0415)	.2915 (.0415)		
MTEXT	2.599 (.5827)				2.053 (.7839)
%TRDTCH		.01947 (.0055)		.01304 (.0061)	.0069* (.0069)
TCHTHIS			.3344 (.0953)	.206 (.1051)	
Random					
School (%)	.6771 (29%) (.1987)	.7927 (32%) (.2288)	.8013 (32%) (.2305)	.7196 (30%) (.2091)	.6623 (28%) (.1942)
Class (%)	.3113 (13%) (.0497)	.3138 (13%) (.0504)	.3137 (13%) (.05)	.3020 (13%) (.0486)	.3014 (13%) (.0484)
Pupil (%)	1.36 (58%) (.0302)	1.36 (55%) (.0302)	1.36 (55%) (.0302)	1.377 (57%) (.0306)	1.377 (59%) (.0306)
TOTAL	2.3484	2.4665	2.475	2.3986	2.3407
No. Pupils	4189	4189	4189	4190	4190
No. Classes	138	138	138	138	138
No. Schools	33	33	33	33	33

* Not significant

TABLE 3.4

Fixed and Random Parameters (Standard Errors) of Further Models for ZJC English

Models	6	7	8	9	10
Fixed					
CONS	-1.617 (.3392)	-1.542 (.2841)	-1.292 (.2515)	-1.813 (.2563)	-1.824 (.3089)
GR7E	.6361 (.0161)	.6361 (.0161)	.6373 (.0160)	.6359 (.0160)	.6356 (.0161)
ETEXT	2.42 (.5228)			1.165+ (.6142)	
%TRDTCH		.02295 (.0042)		.0156 (.0042)	.0162 (.0054)
TCHTHIS			.3894 (.0727)	.2551 (.0701)	
Random					
School(%)	.4736 (21%) (.1516)	.3781 (18%) (.1284)	.3968 (18%) (.1324)	.2351 (12%) (.0914)	.3331 (16%) (.1168)
Class (%)	.3575 (16%) (.0558)	.3627 (17%) (.0567)	.358 (17%) (.0559)	.36 (18%) (.0561)	.3611 (17%) (.0564)
Pupil (%)	1.393 (63%) (.0311)	1.393 (65%) (.0311)	1.393 (65%) (.0311)	1.393 (70%) (.0331)	1.393 (67%) (.0311)
TOTAL	2.2241	2.1338	2.1478	1.9881	2.0872
No. Pupils	4147	4147	4147	4147	4147
No. Classes	138	138	138	138	138
No. Schools	33	33	33	33	33

+Not significant

Similar results hold for English achievement as well, the coefficients being close in value, and the effect of the inclusion of this explanatory variable on the total variance also being similar, a reduction of some 15%, the reduction at the school level being 45%. For English, the school level variance of this model is 21% of the total variance.

Model 7: The Percentage of Trained Teachers in Secondary Schools

The percentage of trained teachers in the sampled schools was obtained from the schools' statistical returns, combining the first two teaching bands TCHQUAL1 and TCHQUAL2 which comprise the trained teacher segment, in order to get an overall percentage figure. For both subjects, the inclusion of this variable was significant, but it had a larger impact on the English model than the Mathematics one. The reduction in the total variance for Mathematics was 13%, the impact on the school level variance being a reduction by nearly a third; for English the reduction in the total variance from the inclusion of this variable was also 18%, but on the school level variance, a reduction of more than half the previous variance. The coefficients of the fixed parameters for the two subjects ware similar, implying, again, to be taken loosely, about an increase of 2 grade points if the teaching force is completely trained. As can be seen from Tables 3.3 and 3.4, the variance components for Models 6, 7 and 8 are similar within each subject, the school level variance for Mathematics ranging from 29-32% of the total variance across these three models and for English, from 18-21% across these three models.

Model 8: Teacher Turnover in Secondary Schools

The variable for this analysis was also taken from the statistical return and consists of the years each teacher has been at the particular secondary school in which s/he was teaching in 1989. These figures were then averaged for the whole teaching force in each school. The values of the coefficients of this variable (loosely) imply an increase of about one grade point if the teachers at the school have been teaching there for three or four years, for Mathematics and English, respectively. The effect of this variable on the components of variance and the total variance for each subject is about the same as for Model 7, a reduction in the school level variance of 30% for Mathematics and 54% for English, and reductions of 12% and 18% on the total variances, respectively.

THE EFFECT OF DIFFERENT COMBINATIONS OF THE SCHOOL LEVEL VARIABLES: THE SEARCH FOR THE 'BEST' MODEL

Different combinations of the above three variables were tested to see which produced a model with the greatest explanatory power. The 'final' Model 11 for each subject is reported in Table 3.5. Besides comparing the different candidate 'final' models in this section, comparisons need to be made with Model 1 for each subject, for Model 1 illustrates the initial total observed variance and how this is broken down between the three different levels. How much of this observed variance is explained by the 'final' models can then be analyzed.

Models 9, 10 and 11:

For Mathematics, it was not possible to test combinations of school level variables whilst keeping sex as a background variable, so it was removed from the final models tested as the explanatory power of the combinations of school level variables was greater than with only one of these plus the pupil's sex. Models 9 and 11 were possible candidates for 'final' model. Model 10 unsuccessfully combined MTEXT and %TRDTCH: %TRDTCH lost its statistical significance in combination with the other variable. Model 11 both explained more of the total variance than Model 9, and the coefficients of its fixed parameters lost less in combination than was the case for the alternative model. In Model 11 44% of the total variance of Model 1 has been explained, 70% of the between school differences and 48% of the b. een class differences, but 88% of the between pupil differences remain.

For English, also, Models 9 and 11 were the possible candidates for 'final' model. Model 10 unsuccessfully combined ETEXT and %TRDTCH, but with the opposite effect to that for Mathematics: ETEXT lost significance. There wasn't much in the choice between the two remaining models, their explanatory power being virtually identical but perhaps the strength of the coefficients of the fixed parameters in Model 11 being slightly greater. Model 11 tells us more about English achievement than the similar model for Mathematics. Sixty-three percent of the total variance observed in Model 1 has been explained, 91% of the between school differences and 64% of the between class differences, but 75% of between pupil differences are left unexplained.

THE 'FINAL' MODELS FOR ZJC MATHEMATICS AND ENGLISH ACHIEVEMENT: COMPARISON WITH THE RESULTS OF THE 1985 STUDY

Models 11 for both subjects are the 'final' models, not in any definitive sense, such as that no other variable combinations are possible or, indeed, that all possible explanatory variables have been tested. Rather, they are adequate final models given the purpose of this study, to identify some of the most effective and the least effective secondary schools in Zimbabwe, and also that the models include significant explanatory variables and indeed go a long way towards explaining school differences.

Comparison with the final models used in the 1985 study shows that a similar percentage of the total variation in secondary school achievement has been explained by the final equation for Mathematics achievement, but in fact considerably more for English achievement. Whereas 48% of the overall variation in Mathematics achievement (at 'O' level) was explained by the final model in the 1985 study, 44% of the overall variation in Mathematics achievement (at ZJC) was explained by the final model in the current study. Despite the time constraints and the limited variables able to be considered for possible inclusion in the current study, 63% of the total variation in English achievement at ZJC was explained, whereas the much more comprehensive data collection carried out in 1985 culminated in a model for English 'O' level achievement which only explained 38% of the total variation.

TABLE 3.5

Fixed and Random Parameters (Standard Errors) of Final Models for ZJC English and Mathematics

Model	11	11
Response Variables	Mathematics	English
<u>Fixed</u>		
CONS	-1.909 (.3709)	-2.052 (.2844)
GR7M/E	.3841 (.0128)	.6355 (.0160)
M/ETEXT	2.113 (.5728)	1.73 (.4264)
TCHTHIS	.2134 (.087)	.3067 (.0636)
<u>Random</u>		
School (%)	.5696 (25%) (.171)	.2364 (12%) (.0909)
Class (%)	.3001 (14%) (.0482)	.351 (18%) (.0551)
Pupil (%)	1.377 (61%) (.0306)	1.393 (70%) (.0311)
TOTAL	2.2467	1.9804
No. Pupils	4190	4147
No. Classes	138	138
No. Schools	33	33

+Not significant

Another notable difference between the two studies is that significant school level variation in Mathematics achievement was not uncovered in the 1985 study once Grade 7 intake ability was controlled for. Yet, in the current study, nearly a third of the between school variance is left unexplained even with the inclusion of Grade 7 and the two school level variables, textbooks and percentage of trained teachers. The 1985 result was questionable because of the even smaller number of schools in the final sample - 29 - so it is likely that we have uncovered school level differentiation in Mathematics achievement which requires further explanation.

It is also interesting to note that even with the detailed student questionnaires administered in the 1985 study which produced a variety of student background factors able to be controlled for in the final model, 75% of the between student differences remained unexplained in the current study of English achievement, which controlled only for Grade 7 intake, whilst 87% of the between student differences in English achievement remained unexplained in the 1985 study. (The pupil background index variable for English achievement included coefficients for the following variables: sex, ethnic group, father's occupation, father's education, and the presence of electricity at home.) (88% of between student differences in Mathematics achievement remained unexplained in the current study, as opposed to 78% in the 1985 study.)

The appropriateness of the model for English achievement must surely be reflected in the relatively small percentage of class level variance remaining, 36%, considering the fact that no class level variables were included in the current study, but few were even tested, due to the time constraints on data collection. It is unlikely, however, that it would have been possible to include both class and school level variables in the same model, even without the difficulties encountered in ML3. This was overwhelmingly the case in the 1985 study, not surprisingly, due to the high correlations between factors at the two different levels. For Mathematics, as has been noted above, the final model explained less of the total variation in achievement than was the case for the English model, and a higher percentage of class level differences also remain to be explained, 52%.

Finally, as noted in the 1985 study, there seems to be an intractable class level variance, in both subjects, at least in the face of the explanatory variables considered in either study. Comparison of the class level variances, looking across the models 6-11, uncovers very similar statistics, .30 to .31 for Mathematics and .35 to .36 for English. The conclusion of the 1985 study was that this class level variance would remain unexplained unless variables relating to what actually goes on inside the classroom are included in the models.

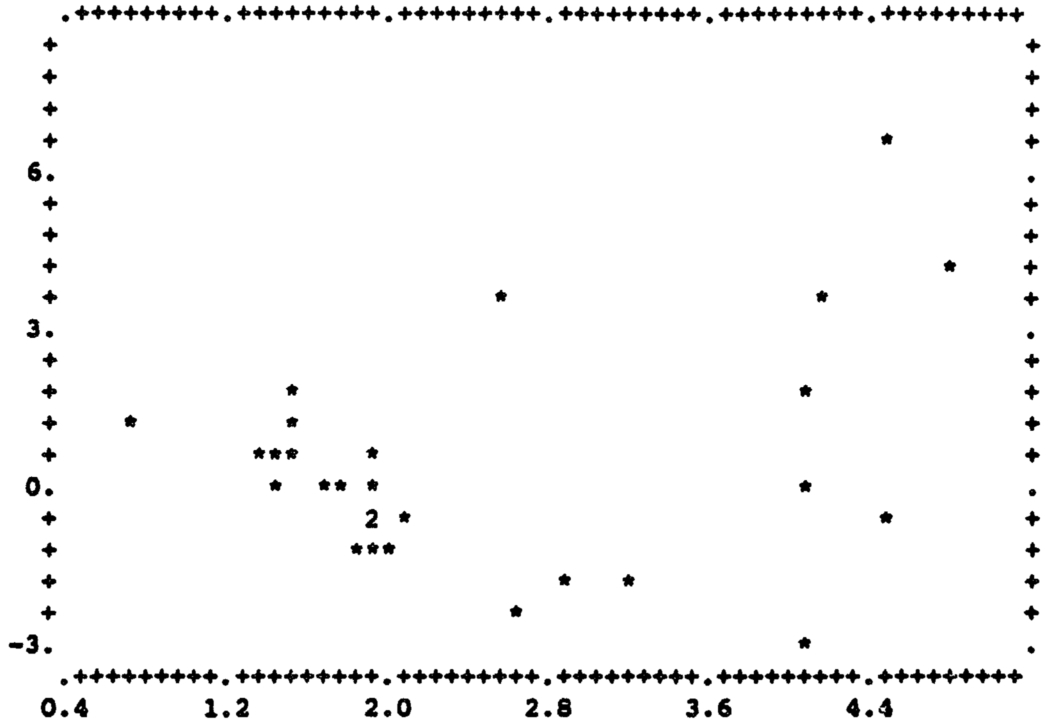
IV. THE MOST AND THE LEAST EFFECTIVE SCHOOLS AND CLASSES IN ZJC MATHEMATICS AND ENGLISH

Having chosen what we feel are the best models describing between school differences in ZJC Mathematics and English achievement, it is now possible to use the random parameters or residuals estimated for each school to detect outliers and to rank the schools in their 'adjusted' performance.

The scatterplots of the standardized school level residuals against the predicted values of the ZJC grades averaged by school enable one to identify any outliers, or exceptional schools, in the final models. Graph 1 is such a scatterplot for Mathematics, and outside the clustering in the middle range of values for the standardized school level residuals, one can see four schools above, say the 3.0 mark, and four schools below, say, the -1.5 mark. Table 4.1 identifies these eight schools and lists their standardized school level residuals as well as their actual and predicted grades on the 1989 ZJC Mathematics. Similarly, for English, Graph 2 depicts the four positive outliers above, say, the 1.5 mark and the three negative outliers from about the -1.5 mark and below. Once more these schools are identified in Table 4.1.

GRAPH 1

STANDARDIZED SCHOOL LEVEL RESIDUALS (Y)
PLOTTED AGAINST PREDICTED AVERAGE SCHOOL
ZJC RESULTS IN MATHEMATICS (X)



GRAPH 2

**STANDARDIZED SCHOOL LEVEL RESIDUALS (Y)
PLOTTED AGAINST PREDICTED AVERAGE SCHOOL
ZJC RESULTS IN ENGLISH (X)**

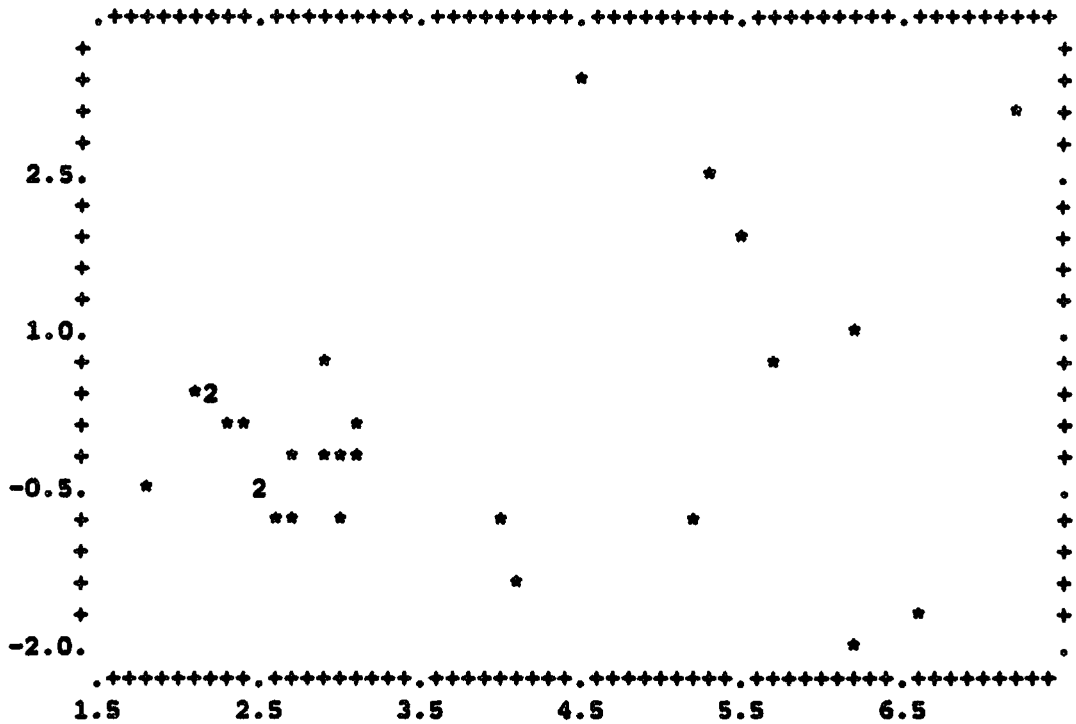


TABLE 4.1
Positive and Negative Outliers: Standardized School Level Residuals, Actual and Predicted Average School Grades by Subject

MATH

	School ID	Stand. Res	Actual ZJCM	Predicted ZJCM
Positive Outliers	2	3.7	3.7	2.6
	15	4.1	6.4	4.8
	19	3.8	5.5	4.2
	21	6.3	6.8	4.4
Negative Outliers	1	-1.7	2.7	3.2
	13	-1.7	2.5	2.9
	16	-3.0	2.9	4.1
	22	-2.4	1.9	2.6

ENGLISH

	School ID	Stand. Res.	Actual ZJCE	Predicted ZJCE
Positive Outliers	1	2.6	6.4	5.3
	2	3.3	5.6	4.5
	15	3.0	8.5	7.2
	24	1.8	6.2	5.5
Negative Outliers	16	-2.1	5.2	6.2
	22	-1.4	3.6	4.1
	23	-1.6	5.9	6.6

What do we know about these schools that can give us any indication of why they have performed exceptionally well or exceptionally poorly? We shall take the positive outliers for Mathematics and English first. The positive outliers are drawn from three different schooltypes: there are two former Group A schools, one high fee-paying school and three mission schools. Schools number 2 and number 15 were identified as positive outliers for both subjects. Five out of the six schools are boarding schools, and four out of the six are single sex schools, with two of each type. There is a high percentage of trained teachers in all the six schools, between 86 and 92% of the teachers being trained. The teacher pupil ratios at the schools range from 12 to 33 pupils per teacher. The teachers at all the schools have on average at least two years of teaching experience and have been at the schools in question at least two years. Four of the six schools have sufficient textbooks for each child to have her/his own, the remaining two schools have their students sharing between two students. Five of the six schools are at least 90% African, one having only 23% Africans in the student body. School sizes vary from 528 to 929 pupils. Finally, class sizes vary from between 29 pupils to a class up to 40 per class.

Aside from wanting to investigate further the fact that the positive outliers are primarily boarding and single sex schools, there is nothing overwhelmingly indicative of factors likely to set these schools apart from the rest in the sample, particularly as one of the other two significant features has already been controlled for in the final model, namely, the ratio of textbooks to students.

The negative outliers comprise one former Group A school, in fact, curiously enough, the same one which features as a positive outlier for English, school number one, one former Group B (rural) school, one high fee-paying school and two mission schools. School number 22, one of the mission schools, is a negative outlier for both subjects, and school number 16, a high fee-paying school similarly features for both subjects. What characterizes these negative outliers? Two out of the five are boarding schools; five out of the six are coeducational; the percentage of trained teachers in some of them is lower than for the positive outliers, the range being from 67 to 100% trained. The teacher pupil ratios at the schools range from 17 to 30 pupils per teacher. The teachers at all the schools have on average at least four years of teaching experience and have been at the particular schools in question for at least three years. There are fewer textbooks at these schools than for the positive outliers, four out of five of the schools have two students sharing the same textbook between them. The school sizes vary from between 448 pupils and 1419. All are between 90 and 100% African, with the exception of the high fee-paying school which is 32% African. Finally, class sizes vary from between 18 and 40 pupils per class.

Interestingly, the set of negative outlying schools have more teaching experience on average than the positive outliers and their teachers have stayed longer at the particular schools. Otherwise, notable is the lower percentage of trained teachers and the number of textbooks, the latter, of course, having already been controlled for in the final model.

There is not an obvious set of characteristics that differentiates either the positive or the negative outliers from the remaining school population. Given that these outliers emerge from the analysis with several major controls already being exercised, namely, the previous ability of the Form II students, the numbers of textbooks available and the number of years on average that the teaching force has been at the particular school, answers will have to be sought elsewhere as to their performance. It is our hunch that some of these answers can be found in the schools and classrooms themselves.

Finally, two further tables are produced here. Table 4.2 presents the ranking by school level residuals. This ranking represents how much better or worse a particular school has performed after the inclusion of the influences of all the variables entered into the final models. This ranking by school level residuals can be compared with the ranking by actual and predicted scores, presented in Table 4.3. The ranking by the predicted scores is entirely dependent on the fitted variables and therefore does not represent a ranking based on the full variance but only the proportion which is explained by the model. Although this sort of ranking is an improvement on the ranking of raw, unadjusted mean scores, the ranking based on the residual variances is of greater interest, for it is the ranking <u>after</u> adjusting for the explanatory variables, i.e. <u>about</u> the predicted values, and it reflects the total variance.

If one looks only at the top ten schools according to the actual and the school residuals ranking, in Mathematics the top three schools according to the residuals ranking are in fact the top three schools in terms of their actual mean scores, schools 21, 15 and 19. However, going further down the list, other schools which are earmarked as being particularly effective on the school residuals ranking don't even appear on the ranking by actual mean scores, e.g. schools 2, 25, 38, 10, 28 and 40. A similar case prevails for English achievement. Of the top four schools on the residuals ranking, three appear at the top of the ranking by actual ZJC English scores. However, schools 25, 10, 27, and 45 don't even appear on the ranking by actual scores, yet it can be assumed that they are more effective than some of the other schools lower down on the residuals ranking which happen to appear high up on the ranking by actual scores. For instance, school 23 is seventh on the ranking by actual ZJC English scores, yet is next to the bottom on the school residuals ranking. This illustrates how misleading it is to rank schools by achievement that is not adjusted for differences in intake. Some of the most 'effective' schools will never be uncovered.

Table 4.2
Ranking of Schools by School Level Residuals: English and Mathematics*

	ENGLISH			MATH		
Rank	School ID	School Type	Residual	School ID	School Type	Residual
1	15	HF	.87	21	M	1.93
2	2	A	.81	15	HF	1.28
3	1	A	.69	19	M	1.16
4	24	M	.48	2	A	.91
5	21	M	.27	25	DC	.59
6	19	M	.21	24	M	.52
7	25	DC	.17	38	DC	.45
8	10	B(r)	.16	10	B(r)	.33
9	27	DC	.16	28	DC	.26
10	45	DC	.11	40	DC	.26
11	46	DC	.02	27	DC	.19
12	39	DC	.01	39	DC	.14
13	36	DC	.00	41	DC	.01
14	33	DC	-.06	36	DC	.00
15	40	DC	-.07	45	DC	-.02
16	48	DC	-.07	48	DC	-.04
17	28	DC	-.10	20	M	-.06
18	38	DC	-.15	30	DC	-.19
19	41	DC	-.15	23	M	-.19
20	42	DC	-.16	33	DC	-.26
21	13	B(r)	-.19	42	DC	-.26
22	14	B(r)	-.20	13	B(r)	-.37
23	20	M	-.22	14	B(r)	-.38
24	32	DC	-.28	46	DC	-.38
25	30	DC	-.35	32	DC	-.43
26	22	M	-.37	1	A	-.46
27	23	M	-.45	22	M	-.66
28	16	HF	-.63	16	HF	-.98

* The four Group B (urban) schools and one Group A (urban) school are not included in these rankings due to the limitations of ML3. Schools having >255 students were excluded from the residuals calculations and there was insufficient time to compose a sub-sample from these schools in order to have them included.

Table 4.3
Ranking of Schools by Actual and Predicted SJC Grades:
English and Mathematics (Rankings)

School ID	School Type	ENGLISH Predicted Score	ENGLISH Actual Score	MATH Predicted Score	MATH Actual Score
1)		5.34 (8)	6.41 (3)	3.17 (10)	2.69 (9)
2)	GpA	4.51 (10)	5.60 (8)	2.59 (13)	3.68 (7)
3)		5.65 (6)	5.99 (6)	3.89 (8)	2.35 (11)
5)		3.09 (17)	2.96 (17)	2.17 (14)	1.79 (20)
6)	GpB(u)	2.62 (24)	3.30 (13)	1.86 (23)	1.75 (22)
7)		3.22 (14)	3.05 (16)	2.00 (16)	1.97 (15)
8)		4.05 (12)	2.89 (19)	3.23 (9)	1.85 (18)
10)		2.93 (20)	3.16 (15)	1.51 (28)	1.90 (16)
13)	GpB(r)	3.97 (13)	3.76 (11)	2.89 (11)	2.51 (10)
14)		3.00 (18)	2.72 (22)	1.97 (17)	1.53 (29)
15)	HF	7.17 (1)	8.53 (1)	4.78 (1)	6.36 (2)
16)		6.17 (4)	5.20 (9)	4.08 (5)	2.92 (8)
19)		5.73 (5)	6.05 (5)	4.16 (4)	5.54 (3)
20)		5.16 (9)	4.67 (10)	4.06 (6)	4.03 (6)
21)	Mission	6.23 (3)	6.65 (2)	4.45 (3)	6.75 (1)
22)		4.11 (11)	3.58 (12)	2.62 (12)	1.87 (17)
23)		6.65 (2)	5.95 (7)	4.48 (2)	4.24 (5)
24)		5.49 (7)	6.16 (4)	4.04 (7)	4.64 (4)
25)		2.08 (32)	2.39 (27)	1.49 (29)	2.25 (13)
27)		2.18 (31)	2.51 (24)	1.33 (32)	1.56 (28)
28)		2.97 (19)	2.79 (20)	1.94 (20)	2.29 (12)
30)		2.66 (23)	1.73 (32)	2.09 (15)	1.78 (21)
32)		2.56 (25)	2.05 (31)	1.92 (21)	1.36 (33)
33)		3.09 (16)	2.92 (18)	1.94 (19)	1.61 (26)
36)	D.C.	3.12 (15)	3.22 (14)	1.95 (18)	1.98 (14)
38)		1.75 (33)	1.36 (33)	0.73 (33)	1.45 (30)
39)		2.31 (29)	2.31 (28)	1.55 (27)	1.73 (23)
40)		2.91 (21)	2.73 (21)	1.41 (31)	1.82 (19)
41)		2.49 (27)	2.21 (30)	1.67 (26)	1.68 (25)
42)		2.52 (26)	2.23 (29)	1.92 (22)	1.57 (27)
45)		2.25 (30)	2.44 (26)	1.43 (30)	1.39 (31)
46)		2.44 (28)	2.45 (25)	1.84 (24)	1.37 (32)
48)		2.68 (22)	2.57 (23)	1.75 (25)	1.69 (24)

V. SUMMARY AND CONCLUSION

This school survey and multi-level analysis were undertaken as part of a larger joint Ministry of Education and Culture-World Bank study of the education sector in Zimbabwe. The study had two purposes. First, it was designed to contribute to a policy dialogue on how to improve student achievement in secondary schools by identifying factors that explain variation in Form II exam scores. Second, it was designed to identify a sample of schools that were outliers in terms of student achievement on national exams, i.e. they performed better or worse than what would be expected given students' prior academic achievement and certain basic school resource inputs such as textbooks and teachers.[8/] This guided the selection of a sample of schools for site visits to gather additional information on high and low performing schools (such as school management and expenditures) that may explain the differences in achievement.

The development and implementation of the survey instruments and the analysis of the data were completed within a very short period of time (only three months) which provided information rapidly for the sector study. However, the time constraint limited the range of data collected; multicollinearity among the measured variables further reduced the number of variables included in the statistical models to assess their influence on student achievement. These limitations notwithstanding, the study produced several noteworthy findings and identified areas for further research.

The results of the sample survey showed, first, that students in high-fee paying (trust) schools, former group A (elite government) schools, and mission schools have higher levels of English and Maths achievement than students in government groups B (less well-endowed government) schools and those in district council schools. Second, a substantial share of the variation in student achievement among students was attributable to the school

---

[8/] A school is considered an outlier if the standardized residual is two or more standard deviations from the mean of 0.

the student attended and that failure to control for the selection of students into schools on the basis of prior academic achievement results in an overestimate of the variation in achievement attributable to the school. Third, the results of the multivariate analysis showed that student achievement is higher when schools have a greater availability of textbooks, a larger proportion of trained teachers and teachers who have taught at that school for a longer period of time. The availability of textbooks and the length of teacher tenure at a particular school together accounted for 50 percent and 72 percent of the variation attributable to the school in Math and English, respectively, after accounting for the variation due to the academic intake of the students. This suggests that raising the proportion of trained teachers and, more importantly, improving the provision of textbooks and providing incentives for teachers to remain in the same schools for a reasonable period of time are promising investment options to boost student achievement.

The analysis of school rankings shows that rankings based on raw results of achievement tests aggregated at the school level are misleading. Some of the most effective schools will never be detected if the prior academic achievement of students is not taken into account. After controlling statistically for prior academic achievement and for basic resource inputs (textbooks and teacher tenure), some district council schools are more effective than what would be expected given their base level of resources and some high fee and mission schools are less effective than what would be predicted given their resource base. Additionally, the interesting finding that there were more experienced teachers in the set of less effective schools as compared with the more effective schools suggests that newly trained recruits have much to offer and that longer experience may erode teacher effectiveness. This is a common finding in developed countries. Typically the learning curve among teachers is steeper and levels of effort are higher during the beginning years of teaching. Research into these and other characteristics of the newly trained teachers in Zimbabwe should be conducted in order to assist policy makers in the development of strategies directed at maintaining high levels of teacher effectiveness.

The outlier analysis pointed to the need for further research to identify which aspects of boarding and single-sex education explain the high levels of high academic achievement found in these schools. Although boarding schools are a high-cost alternative to day schools and cannot be a standard, it seems important to investigate if boarding schools have certain characteristics, other than boarding, that can be replicated in non-boarding schools. For example, it may be that students are assigned more homework because they have fewer demands on their time outside school. Boarding schools also allocate certain periods of the day for study sessions which students are required to attend and during which they receive assistance from a resident teacher. Perhaps these study sessions contribute to higher levels of achievement.

Equally, investigating which factors explain the comparative advantage of boys over girls in Mathematics and the advantage associated with single-sex schools could also identify strategies that improve school effectiveness. In particular, observational studies would be helpful in determining if teaching practices contribute to the disadvantage of girls in Maths and of students at coeducational schcols, more generally.

REFERENCES

Burstein, Leigh, "The Analysis of Multilevel Data in Educational Research and Evaluation", in Review of Research in Education, 8, American Educational Research Association, 1980a.

Burstein, Leigh, "The Role of Levels of Analysis in the Specification of Education Effects", in Robert Dreeben & J. Thomas, The Analysis of Educational Productivity, Volume I: Issues in Microanalysis, Ballinger, Cambridge Ma. 1980b.

Goldstein, Harvey, Multilevel Models in Educational and Social Research, Charles Griffin & Co., Ltd., London, 1987.

Lockheed, M., L. Nyagura and A. Riddell, Draft. "School Type Effects on Mathematics and English Achievement in Secondary Schools in Zimbabwe." Washington, D.C.: World Bank, Population and Human Resources Department, Education and Employment Division,. 1991

Rasbash, J., Prosser, R., and Goldstein, H., L 2 Software for Two-level Analysis, Users Guide and ML 3 Software for Three-level Analysis, Supplement (October 1989) mimeo, Institute of Education, University of London, 1987.

Riddell Abby, Rubin, "An Alternative Approach to the Study of School Effectiveness in Third World Countries", in Comparative Education Review, Volume 33, No. 4, November 1989.

Riddell, Abby Rubin, "School Effectiveness in Secondary Education in Zimbabwe: A Multilevel Analysis", unpublished Ph.d dissertation, Institute of Education, University of London, 1988.

APPENDIX 1

List of Variables

Student Level

SCHOOLID	Name of School
CLASSID	Class (Stream)
PUPILID	Pupil's ID
ZJCE	ZJC English grade
ZJCM	ZJC Math grade
GR7E	Grade 7 English grade
GR7M	Grade 7 Math grade
SEX	Sex of pupil
AGE	Age of pupiil

Class Level

ETCH	Form II English teacher
MTCH	Form II Math teacher
EQUAL	Form II English teacher's qualifications
MQUAL	Form II Math teacher's qualifications
EXPER	Form II English teacher's yrs. exper.
MEXPER	Form II Math teacher's yrs. experience
CLSIZE	Class size

School Level

TCHQUAL1	% Band 1 trained teachers
TCHQUAL2	% Band 2 trained teachers
TCHQUAL3	% Band 3 underqualified teachers
TCHQUAL4	% Band 4 untrained teachers
TCHEXPER	Teachers' average yrs. teach. exper.
TCHTHIS	Teachers' average yrs. this school
ETEXT	Ratio of English books to students
MTEXT	Ratio of Math books to students
BOARD	Day or boarding school
SIZE	School size
TPR	School size divided by teachers in post
PERCTAF	% Total enrolment African

APPENDIX 2
School Coding

School ID	School Type
1-4	Former Group A
5-8	Former Group B Urban
9-14	Former Group B Rural
15-18	High Fee-paying
19-24	Mission
25-48	District Council

PRE Working Paper Series

	Title	Author	Date	Contact for paper
WPS689	Do Tax Policies Stimulate Investment in Physical and Research and Development Capital?	Anwar Shah John Baffes	May 1991	A. Bhalla 37699
WPS690	The Terms-of-Trade Effects from the Elimination of State Trading in Soviet-Hungarian Trade	Gabor Oblath David Tarr	May 1991	J. Smith 37350
WPS691	Can Debt-Reduction Policies Restore Investment and Economic Growth in Highly Indebted Countries? A Macroeconomic Framework Applied to Argentina	Jacques Morisset	May 1991	S. King-Watson 31047
WPS692	Health Financing in the Poor Countries: Cost Recovery or Cost Reduction?	J. Brunet-Jailly	May 1991	O. Nadora 31091
WPS693	Report on Adjustment Lending II: Lessons for Eastern Europe	Vittorio Corbo	May 1991	A. Oropesa 39075
WPS694	Labor Markets in an Era of Adjustment: An Overview	Susan Horton Ravi Kanbur Dipak Mazumdar	May 1991	M. Schreier 36432
WPS695	Long Term Prospects in Eastern Europe: The Role of External Finance in an Era of Change	Ishac Diwan Fernando Saldanha	June 1991	S. King-Watson 33730
WPS696	Macroeconomics of Public Sector Deficits: The Case of Chile	Jorge Marshall Klaus Schmidt-Hebbel	June 1991	S. Jonnakuty 39074
WPS697	Volatility Reversal from Interest Rates to the Real Exchange Rate: Financial Liberalization in Chile, 1975-82	Paul D. McNelis Klaus Schmidt-Hebbel	June 1991	S. Jonnakuty 39074
WPS698	Tax Policy Options to Promote Private Capital Formation in Pakistan	Andrew Feltenstein Anwar Shah	June 1991	A. Bhalla 37699
WPS699	Regulation and Deregulation in Industrial Countries: Some Lessons for LDCs	Ralph Bradburd David R. Ross	June 1991	E. Madrona 37496
WPS700	Trade Liberalization and the Transition to a Market Economy	Oleh Havrylyshyn David Tarr	June 1991	N. Castillo 37961
WPS701	Education and Adjustment: A Review of the Literature	Andrew Noss	June 1991	C. Cristobal 33640

PRE Working Paper Series

	Title	Author	Date	Contact for paper
WPS702	Should Price Reform Proceed Gradually or in a "Big Bang?"	Sweder van Wijnbergen	June 1991	M. Stroude 38831
WPS703	The Political Economy of Fiscal Policy and Inflation in Developing Countries: An Empirical Analysis	Sebastian Edwards Guido Tabellini	June 1991	A. Bhalla 37699
WPS704	Costs and Finance of Higher Education in Pakistan	Rosemary Bellew Joseph DeStefano	June 1991	C. Cristobal 33640
WPS705	What Causes Differences in Achievement in Zimbabwe's Secondary Schools?	Abby Rubin Riddell Levi Martin Nyagura	June 1991	C. Cristobal 33640
WPS706	Successful Nutrition Programs in Africa: What Makes Them Work?	Eileen Kennedy	June 1991	O. Nadora 31091
WPS707	Population, Health, and Nutrition: Fiscal 1990 Sector Review	Population, Health, and Nutrition Division, Population and Human Resources Department	June 1991	O. Nadora 31091
WPS708	Nongovernmental Organizations and Health Delivery in Sub-Saharan Africa	Jocelyn DeJong	June 1991	O. Nadora 31091