INVESTIGATING THE VARIATION IN STUDENT PERFORMANCE IN THE A'LEVEL EXAMINATIONS IN UGANDA: A MULTILEVEL ANALYSIS

Connie V. Nshemereirwe
University of Twente, The Netherlands
c.v.nshemereirwe@utwente.nl

Student performance in the A'Level national examinations in Uganda is the main criterion for selection for higher education, particularly university. About 2000 merit-based scholarships are available annually for the best performing applicants to public universities, but in recent years the majority of the recipients of these scholarships have come from only a handful of the best performing secondary schools in the country university. This reflects a wider issue of the widely differing quality of secondary schools in Uganda, and motivated the current study. In order to investigate the nature of the school effect within the A'Level performance, a multilevel modelling procedure was employed. Covering a period of five years (2005-2010), it was found that up to 30% of the variation in student performance at the end of A'Level could be attributed to the student's A'Level school. Almost one quarter of this school effect was explained by four school characteristics: ownership, boarding status, gender ratio and whether it run the free universal secondary education (USE) programme. Of these, single-sex boarding schools that did not run the USE programme had the highest performance advantage. The performance advantages attributable to the type of school which students attend at A'Level can partly explain why the majority of students enrolled at universities in Uganda come from such a small proportion of secondary schools.

Key words: Multilevel Analysis; School Effects; A'Level Performance; Uganda.

INTRODUCTION

Entry into university in Uganda is determined by a candidate's performance at the end of upper or advanced level (A'Level) of secondary school. Unfortunately, due to a limited number of places at the university level, not all qualified students can be absorbed. Entry into the public universities is particularly competitive because there are about two thousand merit-based state scholarships on offer. In recent years, it has been observed that the majority of these scholarships are taken up by students from only a handful of the best performing schools, and the aim of this study was to investigate the characteristics of schools that can account for these performance differences.

The study proceeded by obtaining the results of all students who sat the A'Level Examinations between the years 2005 and 2009 from the Uganda national examination board (UNEB). Data was available at both individual and school level, and was submitted to a multilevel analysis to separate the sources of variation in performance due to student differences and due to differences between schools. Similar analyses have been performed on student performance at primary school and lower secondary level, but none appears to have been performed at A'Level; the aim of this study was to extend these analyses to the A'Level. Before the results of this analysis are presented, multilevel analysis as a methodology is briefly described, and after the results the paper ends with some general conclusions and recommendations.

PRE-UNIVERSITY EDUCATION

Education in Uganda follows the 7-4-2 system, with seven years of primary school, four years of lower secondary/ Ordinary Level (O'Level), and two years of A'Level, after which students are eligible for university entry. Students sit national examinations at the end of each of these stages, and the selection for the next stage is carried out based on the results in this national examination. National examinations are centrally set by the UNEB, and the same body takes care of administration, security, and release of results.

With the introduction of Universal Primary Education (UPE) in 1997, and Universal Secondary Education (USE) ten years later, there have been concerns that the focus has been much more on increasing numbers entering the system than on the quality of education being given. Even in 2012, for instance, over 30% of primary school children still did not have adequate sitting space; the most affected were those in the first and second year of primary school, where rates are 48% and 40% respectively (Uganda Bureau of Statistics, UBOS, 2012). This is of concern because a recent study found that the two most significant determinants of learning achievement in primary school were that a pupil had their own place to sit and the number of teachers in a school with the mandatory two years of teacher training (Kasirye, 2009). The situation is slightly better in secondary school with an average of 7.5% not having adequate sitting space (all students in A'Level had adequate sitting space). (UBOS, 2012).

Determinants of learning achievement in pre-university education

The achievement levels of primary and lower secondary in Uganda has been measured through both national and international assessments. National assessments include those carried out by the UNEB, such as the annual National Assessment of Progress in Education (NAPE), and international assessments include the one periodically carried out by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ). The SACMEQ was set up in 1991, and currently has fifteen members: Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania (Mainland), Tanzania (Zanzibar), Uganda, Zambia, and Zimbabwe. There have been three cycles of assessment since its inception, and Uganda has participated in the last two: SACMEQ II & SACMEQ III (data collected in 2000 and 2007 respectively). Currently, the SACMEQ confines their assessments of educational achievement to the sixth year of primary school (P.6), while the NAPE carries out assessments at primary three (P.3), P.6 and the second year of secondary school (S.2). Both assessments evaluate achievement in English literacy and numeracy at primary school, but at S.2, the NAPE also evaluates achievement in Biology in addition. A critical difference between the NAPE and the SACMEQ surveys is that SACMEQ also collects and uses SES information in analysis, and extends analysis to more school factors than the NAPE.

At primary school level, both assessments highlight the special challenge of over age children, who tend to perform at lower levels than their younger classmates (UNEB, 2011(a), Byamugisha & Ssenabulya, 2005). The SACMEQ further highlights the importance of the amount of homework given, corrected and explained as an important student level variable, with standardised β as large as 0.1 for both reading and mathematics (effects $\geq |0.10|$ are considered important in the usual context of educational research). The largest effects on pupil achievement, however, were at school level, and school factors were able to account for a much larger percentage of between school variation than of within schools (Hungi, 2011). School resources (such as classrooms and chalkboards) and school location (rural vs urban) had some of the largest effects; for instance, a standardised regression coefficient of 0.18 was estimated for reading in both cases. Private schools also performed better than public schools. This is likely linked to the fact that most public primary schools also run the UPE programme; UPE schools are characterised by overcrowding and a larger than average percentage of over-age children. For this reason, they tend to perform at lower levels on average than non-UPE schools. Zuze and Leibrbrandt (2011) also found that while socioeconomic status (SES) acted at student level to a significant degree, it was also of major importance at school level. They carried out a multilevel analysis that revealed that SES had a significant slope on performance, and that this slope was steeper in schools with higher average SES. This meant that the effect of SES advantaged the wealthier students the most. These researchers also found that teacher had a significant but negative slope on student achievement, indicating that heavy teaching workload had the worst effect on the performance of pupils of lower SES.

Achievement at O'Level has been measured through the NAPE, and on the whole, students in urban schools did better than those in rural schools (except for Biology where they were comparable), and there were also significant regional differences. Further, the best performing schools at this level were public schools that did not run the Universal Secondary Education (USE) programme, followed by the private schools that also did not run the USE, and then finally both government and private schools running USE. Gender differences were most pronounced in Mathematics and Biology with boys performing significantly better than girls, while girls performed slightly better than boys in English literacy, but not to a significant level. In 2011, more than 50% of students at S.2 were found to be over-age (i.e. older than

14-15 years), and as was the case for over-age primary school children, over-age S.2 students performed worse than their younger counterparts (UNEB 2011(b))

The determinants of achievement at A'Level have not been reported on (to the author's knowledge), so the specific focus of this paper was to investigate whether the student and school level effects on student achievement observed at primary and lower secondary level continue through to A'Level. The particular variables that will be investigated in this study at student level are gender and age, and the school level variables are school ownership (private/public), school type (boarding/non-boarding), whether a school runs the USE programme (USE status) and whether a school is single-sex/coeducational.

Research Question

The question that guided the research reported here was the following:

To what extent do school level variables explain the variation in student performance in the A'Level national examinations in Uganda?

This question was broken down into three sub-questions:

- *what is the school effect in the A'Level performance of all students who sit the A'Level national examinations?*
- *what characteristics of students' former secondary schools explain the school effect at A'Level?*
- *do the age and gender differences in performance found at lower levels of schooling in Uganda persist to A'Level?*

METHODOLOGY

Multilevel analysis

The aim of this research study was to find out the extent to which various characteristics of A'Level schools explained the variation within their entry grades. It has become common practice in educational research involving group level effects on measures at individual level to use a multilevel approach. Multilevel analysis pays attention to the fact that the students in the sample form part of a "nested" structure. What this means is that when students attend the same school, their performance will depend partly on their own ability, but also on factors related to the school, such as the school size, its location, teacher qualifications, school facilities and so on. In order to illustrate the extent to which mean school performance varies in Uganda, the mean A'Level performance of a random sample of 31schools in 2009 is plotted in Figure 1. A'Level performance in Uganda is scored using letter grades A, B, C, D, E, O and F, with A being the highest and F being the lowest. The mean performance of the 31 schools is plotted by translating the letter grades to numbers (A = 6, B = 5, C = 4, D = 3, E = 2, O = 1, F = 0), and the differences in mean performance are plain to see. The number of candidates from each of the schools in the random sample ranges from just 12 to over 200, and, the best performing school has an school average of almost 4 or letter grade C, (N =144, sd = 1.00), while the worst performing school of comparable size comes in at just over 1, or letter grade O (N = 113, sd = 0.85).

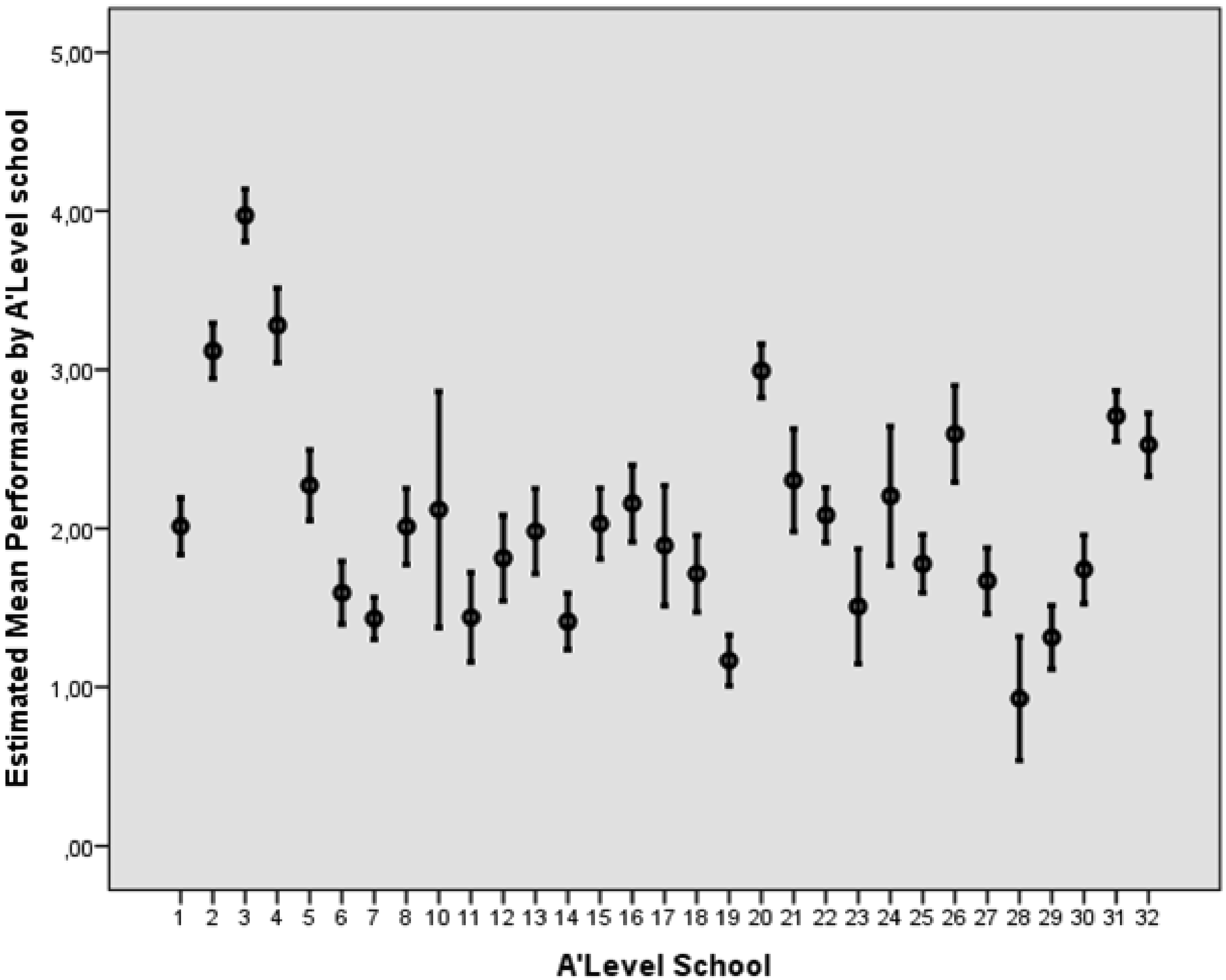

Fig 1: ±1 SE error bars of estimated mean performance of a random sample of schools in the 2009 A'Level examinations

To investigate these school level effects on individual student performance, a measure of the "within-school variance" (the extent to which students within a given school differ on their individual performance) is compared to a measure of "between-school variance" (the extent to which schools differ in their mean performance). This measure is represented by the "Intra-class coefficient" (ICC), which is given by:

$$\text{ICC} = \frac{\text{between school variance}}{\text{within school variance} + \text{between school variance}}$$

Values of the ICC range from 0 to 1, with values very close to zero indicating very little similarity between individuals who attend the same school, and that the nested structure of the data does not affect the estimation of regression coefficients at student level. Values as low as 0.1 (or 10%), however, may indicate enough variation between mean school performance as to be worth exploring. Using ordinary regression analysis in such a case (which ignores the nested structure) results in stronger associations within the data than really exist in the population due to the covariance between the performance of students in the same school.

Predicting the Student Score

In ordinary regression analysis, the outcome variable is predicted by some variables according to a regression equation with an intercept, a regression coefficient (or the slope) and an error term, and these parameters are assumed to be fixed for all values of the explanatory variable. However, if the students for whom the scores are being predicted are grouped within schools, it is possible, as has already been explained, that due to factors unique to that school, the relationship between a predictor variable and an outcome variable may be different from school to school. Take a predictor variable like age. Based on the data of a given school, the predicted average performance of 12-year olds in one school may be higher than the predicted average performance of 12-year olds in another school due to different conditions in that school. This would lead to school specific intercepts and slopes, which may also be different from those estimated for all 12-year olds over the entire population of schools. Multilevel analysis is a procedure that allows the relationship between the explanatory and outcome variables to vary from school to school, so that rather than the resulting regression equation having a fixed intercept and slope for all students, it can have a random intercept, and even a random slope. Put differently, the intercept (and even the slope) in such a regression equation, being random, would each have its own regression equation, complete with predictor variables and error term. This idea can be better seen in the multilevel regression equation predicting student scores (1) below:

$$Y_{ij} = \beta_{0j} + \beta_{1j}(x_{ij}) + r_{ij} \qquad (1)$$

Where

Y_{ij}= the A-Level score of an individual student ***i*** in a given school ***j***

β_{0j} = the random (or school-specific) intercept

x_{ij} = the value of a predictor variable x for student ***i*** in school ***j***

β_{1j} = the regression coefficient/slope (may be fixed or random) for the predictor variable x

r_{ij} = the residual of the performance of student ***i*** around the mean performance of school ***j*** (the variance of the error term r_{ij}, say σ^2, is known as the "within-school" variance)

Note: all residuals are assumed to be normally distributed with a mean of zero, and be mutually independent; additionally, these residuals are assumed to have the same variances for all groups.

Estimating the Random Intercept, $\boldsymbol{\beta_{0j}}$

The random intercept, β_{0j}, in equation (1) is then predicted by the following regression equation:

$$\beta_{0j} = \gamma_{00} + \mu_{0j} \qquad (2)$$

Where

γ_{00} = grand mean intercept (mean of all school-specific intercepts)

μ_{0j}= residual of school-specific intercepts around the grand mean intercept (the variance of μ_{0j}, say τ_0^2, is known as "between-school" variance)

In multilevel modelling, the intercept is estimated as random because the differences between the mean school performance may be predicted by school level variables such as school size or the average social economic status of students within a school. The effect of these factors can be estimated by adding them as predictor variables to equation (2) and have:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(z_{1j}) + \mu_{0j} \qquad (3)$$

Where

γ_{00} = grand mean intercept

z_{1j} = the value of a school-level predictor variable z for school ***j***

γ_{01} = the regression coefficient/slope for the school-level predictor variable z

μ_{0j} = residual of school-specific intercepts around the grand mean intercept

Estimating the Random Slope, β_{1j}

In more complex models, it is also possible to have school-specific slopes for a given predictor variable. Such a predictor variable would necessarily be a group-level variable moderating the slope of a student level variable. Take an example of the effect of Social Economic Status (SES) on student performance. In a school with better teaching resources (a school level variable), the difference in the performance of between students with high and low SES may be less pronounced (have a flatter slope) than in a school with poor teaching resources; in this way, it is possible to have school specific slopes for the extent to which SES is responsible for a student's performance. The regression equation for the random slope would then look like this:

$$\beta_{1j} = \gamma_{10} + \gamma_{11} w_{1j} + \mu_{1j}, \tag{4}$$

where

γ_{10} = the mean slope of the student level variable within the whole sample,

w_{1j} = a school level predictor of the slope,

γ_{11} = the regression coefficient for the school level variable w, and

μ_{1j}= residual of school-specific slopes around the mean slope (the variance of μ_{1j} is denoted by τ_1^2, and the covariance between slope and intercept residuals, cov (μ_{01j}, μ_{1j}), is denoted by τ_{01}^2).

This is only a basic overview of multilevel regression analysis, but depending on the research questions being investigated, even more complex models can be built. For a more in-depth understanding of multilevel analysis, see Snijders and Bosker (2012); Kreeft and De Leeuw (1998); Enders and Tofighi, (2007); and Zuze and Leibbrandt (2011)

The Data

Data for this study was obtained from Uganda national examination board (UNEB). This was of all students country-wide who attempted the national examinations over the period 2005-2010. The outcome variable in this study was the student score averaged over the scores of the subjects taken at A-Level; this was preferred to the total score since some students choose three subjects, and some choose four subjects at A'Level. To calculate this average score, the letter scores were translated to numbers as follows: A-6; B-5; C-4; D-3; E-2; O-1; F-0. Table 1 shows the sample sizes and the average performance for students sitting the A'Level examinations in the years 2005-2009.

Table 1: Sampled students and their mean scores

Examination year	Number of Students	Number of Unique Schools	Mean score (S.D)
2005	70,548	862	2.25 (1.282)
2006	70,574	900	2.10 (1.210)
2007	84,930	996	2.04 (1.254)
2008	88,377	1,069	2.08 (1.255)
2009	96,633	1,164	2.25 (1.348)
2005 - 2009	411,062	1,164	2.15 (1.277)

RESULTS

Question 1: What is the school effect in the A'Level performance of all students who sit the A'Level national examinations?

In order to answer this question, it was necessary to fit the unconditional or so-called "empty" or unconditional model (a model without any predictor variables in it) to the data and then calculate the ICC. The results of fitting the unconditional model are reported in Table 2, and show that the unconditional school effect in the A'Level student performance is estimated at 30%. The reported intercepts represent the estimated grand mean performance of students, and at 1.93, that of the A'Level population is almost equivalent to a letter grade of *E*.

Table 2: Estimated mean intercept and ICC for A'Level performance

Parameter	Parameter estimate
Intercept γ_{00}	1.93*** [a]
<u>Random Effects</u>	
Within-School Variance, σ^2	1.02***
Between-School Variance, τ_0^2	0.43***
Intra Class Correlation (ICC) $[(\sigma^2)/(\sigma^2 + \tau^2)]$	0.30
Deviance[b]	1,134,989

[a] A'Level letter grades have been transformed to a scale between 0-6, with 0 being the lowest.
[b] Deviance is a measure of how well a model fits the data compared to random noise. In this case, the -2 Restricted Log Likelihood is reported, and the fit of further proposed models will be evaluated based upon the significance (chi-square tested) of the reduction in this value.
*** $p< 0.001$; ** $p< 0.01$; * $p< 0.05$.

Question 2: What characteristics of students' former secondary schools explain the school effect at A'Level?

Four of the school characteristics that have been found to partly explain variation in student performance at lower levels of education were investigated in this analysis: school ownership; whether a school is boarding or non-boarding; whether a school runs the USE programme or not; and whether a school an all-boys, an all-girls or a coeducational school. Hypotheses to test the effects of these school characteristics were developed in line with effects found at lower levels of education as follows:

- *Students at private schools perform better, on average, than those from public and community schools.*
- *Students at boarding schools perform better, on average, than those from non-boarding schools.*
- *Students from schools that do <u>not</u> run the Universal Secondary Education (USE) programme perform better, on average, than those at schools that run the USE programme.*
- *Students in single sex schools perform better, on average, than students from co-educational schools.*

The result of testing these hypotheses is summarised in the second column of Table 3. The intercept represents the mean performance of a private, non-boarding all-girls' school, and all effects are estimated as over and above that.

Table 3: The effects of school and student level variables on student performance at A'Level

Parameter	Parameter estimate	
	Only School Effects	**School Effects + student**
Intercept , γ_{00}	1.60	1.53***
Fixed Effects		
School Ownership		
Community Schools	0.13	0.13
Public Schools	0.11	0.10
Private Schools	0.00 [b]	0[b]
Boarding Status		
Boarding Schools	0.40***	0.38***
Day Schools	-0.11*	-0.11*
Partly boarding schools	0.00	0[b]
USE Status		
Non-USE schools	0.48	0.44***
USE schools	0.00 [b]	0[b]
Co-educational Status		
All-Boys	0.31 ***	0.26*
All-Girls	0.23*	0.29**
Co-educational	0.00 [b]	0[b]
Student Gender		
Female		-0.17***
Male		0[b]
Student Age		
17-year olds		0.50***
18-year olds		0.39***
19-year olds		0.23***
20-year olds		0.10***
21-year olds		0.05***
22-23 year olds		0[b]
Random Effects		
Within-School Variance, σ^2		1.01
Between-School Variance, τ_0^2	0.33***	0.31***
Total explained student level variance		1%
Total explained school level variance	23%	28%
Deviance [b]	264***	6,079***

[a] A'Level letter grades have been transformed to a scale between 0-6, with 0 being the lowest
[b] this parameter is set to zero, and the effects of the other school variables estimated relative to it.
[c] Deviance is a measure of how well a model fits the data and is, in this case, as compared to the unconditional model. A significant positive value (chi-square tested) indicates better fit.
*** $p< 0.001$; ** $p< 0.01$; * $p< 0.05$.

Contrary to what has been found at primary and lower secondary school level, there are no significant differences in mean A'Level performance when schools are categorised by ownership (public, private or community). However, the predicted mean performance of all-boys and all-girls schools is higher than that of coeducational schools, with all-boys schools performing the best (effect size of 0.31). Additionally, going to a boarding school instead of a day school results in a higher predicted average score of about half a letter grade at the time they sit their A'Levels (0.40, $p<0.001$ for boarding schools and -0.11, $p<0.001$ for day schools, both relative to partly boarding schools). Attending a non-USE school instead of a non-USE resulted in a similar effect (0.47 $p<0.001$). Finally, fitting this model to the data led to a significant improvement in fit over the unconditional model (deviance = 294, $p<0.001$), and also resulted in the explanation of almost 25% of school level variance.

Question 3: Performance differences due to gender and age found at lower levels of education retain their direction at A'Level.

Having estimated the contribution of the four school characteristics to explaining mean school performance, attention now turns to the effect of student level variables in explaining both student and school level variation in student A'Level performance. National and international studies at lower levels of education in Uganda show that gender and age are significant predictors of performance. However, given that the gender differences are small and variable at primary school and O'Level, it is likely that these have disappeared by A'Level; however, age differences probably persist, so the hypothesis tested here was:

There is no significant difference in performance between boys and girls, but increasing age is associated with poorer performance.

Students are expected to sit their A'Level examinations around the age of 18. In the current study, the majority of students who sat their A'Level examinations between 2005 and 2009 was aged between 17 and 23 (96%), so analysis was restricted to that age range. Further, more boys than girls took the A'Level examinations during the five years in the analysis (60% compared 40%), with girls being younger on average (65% of girls was aged 19 and below compared to only 38% of boys). Age and gender effects were added to the multilevel model already containing school level variables in order to estimate their additional effect. The results are reported in the third column of Table 3, and since this model now includes the student level variables, the within-school variance, σ^2, was also reported. The intercept of 1.53 refers to the estimated A'Level performance of a 22 or 23-year old male student in a coeducational, privately owned, part-boarding school that runs the USE programme. With this as a baseline, the predicted performance of female students enrolled in coeducational schools is lower than that of male students (effect size = -0.17). However, going to a girls-only school slightly reverses this effect (effect size = 0.29), bringing it closer to the performance of boys in all-boys schools, who differ by 0.29 of a letter grade from their counterparts enrolled in mixed schools. The performance differences due to age are such that seventeen year-olds perform half a grade better on average than twenty-three-year olds, and together, student gender and age explain 1% of the variance between students within the same school. However, these student level variables explain more school level variance (5%) than student level variance, which may be an indication that schools differ significantly on mean age of students, and that this is an additional school level predictor of mean school performance. This model also fits a lot better than the one with only school level predictors (deviance = 6,079, $p<0.001$).

CONCLUSIONS AND RECOMMENDATIONS

Educational achievement at both primary and lower secondary school varies not only because of differences in cognitive ability, but also as a result of other differences between students and differences between the schools they attend. Student level factors include gender, age and home environment, whereas school level factors include school resources and teacher workload. The quality of schools also appears to differ as a result of school characteristics like ownership, boarding status and whether or not the school runs the government free education programmes universal primary education (UPE) and universal secondary education (USE). A good amount of research has been carried out to investigate how these different factors act at primary and lower secondary level, but not so much at the advanced level (A'Level) of secondary school. This is of particular importance since performance at A'Level plays a very big role in a student's admission to university, and yet it has been observed that the majority of students enrolled at the universities come from a small proportion of schools in the country. This dominance is even more apparent within the students who receive the highly competitive government merit-based grants to study at public universities. The current study was carried out in an effort to close this knowledge gap about student and school effects in A'Level educational achievement.

The study relied on a multilevel analysis of the results of A'Level students sitting the national examinations in Uganda between 2005 and 2009, and revealed that the average school effect on student A'Level performance was up to 30%. Unlike the case at lower educational levels, however, this effect had little to do with school ownership, as there were no significant differences in mean school performance between public, private and community schools. On the other hand, attending a coeducational school over an all-girls or all-boys school resulted in a small but significant performance disadvantage, with students enrolled at coeducational schools performing about a quarter of a letter grade lower than those at single-sex schools on average. Within the single-sex schools, students at boys' schools performed at a slightly higher level than students in girls’ schools. The largest school effects were associated with the Boarding and USE status of A’Level schools. Students at boarding schools performed almost half a grade higher than those in day schools, with those attending a non-USE school registering a similar performance advantage those enrolled at USE schools. Together, these school characteristics explained almost quarter of the estimated school effect in A’Level performance. The addition of student age and gender to the multilevel model led to the explanation of an additional 5% of variation at school level, but only 1% of variation at student level. The fact that student level variables accounted for more school level variation than student level variation in performance points to the possibility that schools differ on mean student age, and that this is in turn predicts school mean performance. Further, as was the case at lower levels of schooling, over age student generally performed at lower levels than younger students but differences due to gender were minimal. Female students enrolled in coeducational schools performed at slightly lower levels than male students, but if they were enrolled at an all-girls school, then they performed better than males students in coeducational schools, and at similar levels to male students at all-boys schools.

The main motivation for the current study was to find out whether the trends in student performance observed at primary and lower secondary school persisted to A’Level, and it was found that overall they did. This then could partly account for the large number of students enrolled at universities in Uganda being from only a small number of schools. The quality of A’Level school varies to such an extent that up to 30% of student performance can be explained by differences between schools. Further, the over age students who make it as far as A’Level still continue to perform at lower levels than their peers, so they do not recover from their delayed progress. This research is only a small insight into the effects at work in the achievement at A’Level. The main recommendation coming out of this research is towards suggestions for further research. In particular, the effects of student variables like socioeconomic status, as well as more school level variables like resources and teacher qualifications, need to be investigated as well in order to deepen an understanding of the factors at play in A’Level performance. This would be important input for more targeted interventions towards improving school quality.

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