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Is Teacher Education level and Experience impetus for student achievement? Evidence from public secondary schools in Kenya.

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ABSTRACT

This study established whether advanced degrees and years of teaching experience are associated with student science achievement gains in Public Secondary schools in Kenya. In particular, the study differentiated education level into advanced degrees in Science and advanced degrees in any major, and experience into general years of teaching experience and years teaching Science in general and at grade 12. Teaching quality factors drawn from dynamic model of teacher effectiveness were utilized in the model to establish if they mediated the effect of teacher's education level and experience on student achievement. A sample of 610 respondents was sampled consisting of 570 respondents consisting of 450 students and 120 grade 12 Science teachers was selected from 40 public secondary schools in the county. 2-Level Hierarchical linear modelling was used to disentangle variance associated with students nested within classes and teachers nested within four categories of high rank and low rank schools in the County. The study found no variation in teacher qualification, between high and low ranking secondary schools with respect to education level ($X^2=0.324$; $df=2$, $P=0.065$, and experience ($X^2=0.824$, $df=3$, $P=0.066$), but only with a small difference in grade 12 experience between low ranked and high ranked schools ($X^2=0.824$, $df=3$, $P=0.046$). With regards to proportion of variance due to nested data, 20.8% of variance in student achievement was amongst student while the rest was within classrooms (teachers). With regards to teacher experience, teachers with more than two years of grade 12 experience will improve student scores by 1.15 units while those teachers without such experience will improve scores by 0.83. With regards to education level, a teacher with advanced degree chemistry or education will improve student achievement gains by 0.085 units, while that with no advanced degree in any major will result to only 0.067 unit increase in student chemistry achievement. The study, recommends that the teacher service commission of Kenya acknowledges that advanced degrees currently acquired by teachers have significant effect to student and as such, teachers with such degrees and experience should adequately be remunerated.

Keywords:

Teacher qualifications, Hierarchical linear Modelling, Grade 12, Student achievement, Low and high performing schools

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Introduction

Student achievement continue to dominate global education discourse in the wake of massification of education. The post EFA 2015 campaigns have shifted to efficiency and accountability in education systems as the world gears towards the realization of sustainable development goals (Holden, Linnerud, & Banister, 2017). Recent education literature has greatly shifted from the famous Coleman findings (James Samuel Coleman & USA, 1966) that, student social background (SES) matters more in student outcomes than other variables, to the reality that indeed schools and teachers matter too (Hanushek, 2016). The debate on who matters in student achievement has dominated education discourse with many studies indicating that quality teachers, matter to student achievement and that student achievement is the most appropriate indicator of quality education and human capital transfer from teachers to students (Hanushek, 2016). In recent times, some studies have investigated on what teacher attributes matter to student achievement (Darling-Hammond, 2000; Darling-Hammond & Baratz-Snowden, 2007; Hanushek, Kain, & Rivkin, 2004; Hanushek & Rivkin, 2010). A study by Zhang (2008) found out that advanced degrees in the subject major and grade level experience were positively associated to student science achievement gains. However many education experts have criticised the overreliance on teacher qualification as the panacea in student achievements. The key study carried out by Wenglinsky (2002) pointed

that holding an advanced degree in a given major or more years of teaching a given subject will not automatically translate to better scores for students. This is because, qualified teachers can still carry forward ineffective classroom practices from one year to the other. In her arguments, she alludes that, teacher qualifications are simply proxies of knowledge and skills inherent within teachers, which can only be manifested in classrooms through effective teaching practices. Recent studies on teacher quality, have focussed a lot into teacher behaviours, especially at classroom levels (Kraft & Gilmour, 2017; Kyriakides, Creemers, & Antoniou, 2009; Zhang, 2008). A special attention has been paid to the effect interaction of teacher behaviours and teacher qualification on student achievement (Johnson, 2017; Zhang, 2008) and the role of the dynamic model of teacher effectiveness in explaining variation in student scores as a result of teaching quality. Despite the fact that these studies have utilised multilevel modelling to handle nested data, many of them have been conducted in developed nations.

Literature Review:

Since the famous report on Equality to education opportunity by Coleman in 1966, systematic studies have slowly shifted to his findings that student SES mattered most in student achievement to schools and teachers mattered most (Danielson, 2012; Darling-Hammond, 2000; Hanushek, Piopiunik, & Wiederhold, 2014). In defining what exactly mattered in student achievement, Hanushek carried out

value additional assessment of teacher effects on student achievement and found out that teachers with advanced degree in the subject major and more years of teaching experience were positively associated to student achievement gains (Hanushek & Rivkin, 2010). However, this 'blackbox' treatment of teacher qualification has been condemned by value-added studies who have postulated that gains in student achievement are as a result of teacher behaviours while in classrooms, since classrooms are avenues where the 'teacher attributes' interact with student and classroom contextual variables, to result to meaningful and measurable student learning outcome (Darling-Hammond & Baratz-Snowden, 2007; Wenglinsky, 2002). These studies found out no evidence in relationship between teacher experience (as measured by years of actual teaching) and student science achievement gains. Despite the fact that the study involved science teachers, the findings implied that teacher effectiveness was not a preserve of years of teaching experience. However, Rivkin, Hanushek, and Kain (2005), pursued a non-parametric investigation of teacher experience between novice and 'experienced' teachers, and found out that teacher experience effects are evident in the first few years of teaching, with novice teachers performing worse than teachers with more than two years' experience (Rivkin et al., 2005). The duo further observed that previous studies (especially ones that used OLS estimations of teacher effects), had methodological biases that assumed teacher characteristics added themselves linearly in the

estimation model and that teacher quality variance may be as a result of unobserved student differences across the classes which are already nested within different schools. (Rivkin et al., 2005).

Ceteris paribus, recent studies on effects of these advanced degrees have become counter-intuitive. A study by Taylor and Tyler (2012), found out no substantial benefit of advanced degrees on students except a negative influence of those with masters and beyond on 4th grade student mathematics test scores in Texas. The explanation offered by Taylor and Tyler (2012), is that teachers with advanced degrees will always prefer to teach students with high achievement and innate ability. The fact that the effect of advanced degrees on student achievement has offered mixed findings over time does not imply that there are no differential teacher effectiveness between teachers with higher education level and those with low education level. Besides, a teacher cannot be determined to be qualified merely by checking his or her education level, years of experience, or teaching certification (Wenglinsky, 2001), but on how he utilizes the acquired knowledge and skills in improving his or her practices which ultimately will result to value addition in student achievement gains. Previous studies have used teacher's educational level as a proxy of teacher's knowledge of the subject matter and found it to be associated with student gains.

Estimating the impact of teachers' education level on student learning can be subject to errors. This is evident in many studies that have only focused on the level of the degree rather

than the subject of the degree (Goldhaber & Anthony, 2004). This estimation problem may be worse in developing nations which are characterized with inadequate education data (James S Coleman, 1966) and teacher shortages compounded with high teacher turn-overs. In Kenya for example, teachers are trained and certified to teach two subjects in public secondary schools but after some years in the profession, some may end up pursuing advanced degrees in fields different from their subject majors. Despite the fact that the minimum qualification for one to be considered for employment is a Bachelor's degree in Education or Diploma in Education with a minimum a grade C+ in the two teaching subjects (TSC Act, 2012), science teachers may opt acquire post graduate degree in education, science or even business administration (Huang & Moon, 2009). Evidence has alluded that the school system themselves are capable of producing different qualities of teachers(irrespective of one's education level)depending on the quality of students and resources they receive(Rivkin et al., 2005).

Above that, some schools may have enough teaching and learning facilities as well as different qualities of school based supervision(Hanushek & Woessmann, 2010) which ultimately results to variations quality of teachers. The Kenyan TSC commission has also been issuing mixed signals pertaining pegging teacher wages on the level of education. In the currently released performance appraisal guidelines, teacher numeration and promotion is based on teacher performance and not one's

level of education. To make matters worse, teacher study leave with pay have been abolished and only few cases are being considered for teachers pursuing advanced degrees in the subject major or education(Odhiambo, 2005). Effectiveness studies pay a lot of attention to classrooms since they are avenues where teacher attributes and student attributes interact. Therefore, quality teaching is the most important factor at the classroom level and thus teacher effectiveness in the classroom is one of the most significant factors related to student achievement(Blazar, 2016).

Purpose of the study

The purpose of this study was to find out was to establish if teacher qualification were the impetus in student achievement and whether or not, teaching quality mediated the relationship between teacher qualification and student achievement. The study addressed the following research questions:

- (I). Does grade 12 science teachers in low and high performing secondary schools in the county differ in qualification with respect to their education level and experience?
- (ii).What proportion of variance in student achievement is attributed to nesting of students within classes and teachers within different ranks of schools?
- (iii). To what extend does class size and student background variables like age, gender, SES, and grade repetition associated with grade 12 science achievement?

(iv). While controlling for student and teacher background variables, do grade 12 chemistry students attain differential levels of achievement gains when taught by teachers with advanced degrees in chemistry/education or by teachers with advanced degrees in any concentration?

(v). While controlling for student and teacher background factors, do grade 12 chemistry students attain differential levels of achievement gains when taught by teachers with more years of teaching Chemistry in any grade or with more years of teaching chemistry in grade 12?

Methodology

The sample for the study constituted of a sample of 610 respondents was sampled consisting of 570 respondents consisting of 450 students and 120 grade 12 Science teachers was selected from 40 public secondary schools in the county. Data was analyzed in line with the specified objectives and research questions. Before data analysis, all necessary investigation of the quality of data were done making sure that there were not omitted variables and that data followed a normal distribution. The teacher variables in the survey included: whether teachers held an advanced in chemistry, number of years of teaching chemistry in in secondary schools and number of years of teaching chemistry in grade 12. The other teachers' background variables that were factored in the study were: teacher ethnicity and teachers participation in teacher professional development (i.e. attending SMASSE and

marking of grade 12 national examination). Individual student control variables included: student prior achievement score in chemistry, student final chemistry score, student gender, student truancy, grade repetition, remedial tuition and a variables measuring student social economic status (SES).

Prior student achievement (commonly referred as MOCK examination) was the grade attained from the school based attainment tests done one year, prior to grade 12 examination. Such kind of examination is normally administered after an intensive revision program by teachers since it is assumed to contribute immensely to student self-belief before the main examination, especially when students perform better in them (Darling-Hammond, 2000).

Analytical Variables:

Student prior achievement and the outcome variable in the study(final grade 12 Chemistry) score were extracted from the K.C.S.E, A to E grading system with a score of grade A, equivalent to 12 points, and an E which is the lowest score, equivalent to 1 point. The scores were standardized to a mean of zero and standard deviation of 1. Dummy variables were created for teacher education level (1= Bachelor degree and above in Science or Education, 0= Bachelor's degree and below in Science). Teacher experience was measured on a continuous scale as the number of years of teaching chemistry in grade 12(CHEM-12) and number of number of years of teaching chemistry at any grade in general (CHEM-GEN). For easy entry into the model, and for proper

interpretation of the findings, total experience was abbreviated as CHEM-GEN (1≤5 years), CHEM-GEN (6≤10 years), and CHEM-GEN (more than 10 years). The teacher control variables included the gender of the teacher abbreviated as (1-Male, 0-Female). Teachers' professional development was measured by two variables: attendance of SMASSE cycle (1-attended and 0-Never attended) and marking national chemistry examination (1- Examiner and 0-Not Examiner).

Teacher ethnicity was captured to cater for variation on student scores between those students taught by a teacher from the same ethnical community and those taught by teachers from the same ethnic community. It's was abbreviated as (1=same ethnic community, 0= different ethnic community). Student control variables included: student age, social economic status, gender, attendance of remedial tuition, grade repetition and level of truancy. Student age at the time of K.C.S.E and was entered in a continuous scale but standardized to the mean of 0 and SD of 1. Gender was abbreviated as (1-male, 0-female), while socioeconomic status (SES) and student level of truancy were also used as controls with each abbreviated as (1=High, 0=Low) were also used as control variables. Tuition implies whether student access private tuition services away from school (1=Yes, 0=No); Repetition implies that student has repeated in the current grade 12 irrespective of how many times (1=Yes). Truancy is a composite variable measuring level of discipline of the student, indicated by the number of times the student comes to school late, frequency of

punishments while in school and number of suspensions per year. Student SES i.e. a composite value for social economic status indicated by parent(guardian) level of education, household income as well as his/her occupation were included in the dataset and were abbreviated as Low (1), and high (0).

Analytical model

2-level Hierarchical linear modelling (HLM) used in the analytical process since it was suitable to disentangle the variance due to clustered nature of data. The data was clustered into two levels: level 1(student level) and level 2(classroom /teacher level).

(i). Level 1- which will encompass student's level factors and science teacher level factors in different classes in selected schools. The student level variables included: student age, gender, SES, prior achievement, attendance of remedial tuition and level of truancy.

(ii). Level 11-variables encompassed classroom factors like teacher qualification and teaching quality. The teacher variables in this level included teacher qualifications, (Education level and experience), and the eight composite variables representing eight elements of the dynamic model of teacher effectiveness. The teacher control variables included teacher ethnicity and participation in teacher professional development. The classroom control variables was class size. According to (Raudenbush & Bryk, 2002), Education data is Hierarchical in structure and hence HLM will reduce aggregation bias of

data, reduce misestimated standard errors and heterogeneity of regression.

Model Specification.

Unconditional model

The first unconditional (null) model, i.e. one way random effects analysis of variance was done without the predictors as to ascertain random variation between groups and random variation within groups. Each student’s end year K.C.S.E chemistry score was modelled as a function of classroom/ teacher’s mean score and a random error at student level (model 1a). Each teacher/classroom’s mean score (model 1b) was modelled as a function of the school mean score and a random error at the classroom/ teacher level. The two models were combined to give rise to a mixed effect model (model 1c) as shown as shown below.

$$(Y_{ij}) = \beta_{0j} + r_{ij} \dots\dots\dots (1a)$$

$$\beta_{0j} = \gamma_{00} + u_{0j} \dots\dots\dots (1b)$$

$$Y_{ij} = \gamma_{00} + u_{0j} + r_{ij} \dots\dots\dots (1c)$$

Where Y_{ij} is the standardized grade 12 chemistry score for student i taught by teacher j , while β_{0j} is the intercept representing classroom average score for teacher j and γ_{00} is the average grade 12 chemistry gain scores for chemistry teachers in the school. Further, r_{ij} and u_{0j} are the random effect terms at student and teacher level models, respectively. Model 1c is the mixed equation model presumably with both fixed and random effects. The purpose of this unconditional model was to partition the variance between student level and teacher level and ultimately determine the need for further multilevel modelling.

Level-1 conditional model

The level-1 conditional model for predicting student chemistry gain score due to student prior achievement and student level factors was carried out in two stages: The first stage incorporated student prior achievement score to the model minus other student predictors as shown below.

$$Y_{ij} = \beta_{0j} + \beta_{1j} (\text{Prior Achievement})_{ij} + r_{ij} \dots (2)$$

Where β_{0j} is the intercept of the model while β_{1j} is the effects of student prior achievement and r_{ij} is the random effect for student i nested in teacher j . Student prior score and other continuous variables were standardized. Later, other student predictors were added to the hierarchical model (model 3) to estimate the actual variance associated with student level variables.

$$Y_{ij} = \beta_{0j} + \beta_{1j} (\text{Prior Achievement})_{ij} + \beta_{2j} (\text{Female})_{ij} + \beta_{3j} (\text{Tuition})_{ij} + \beta_{4j} (\text{Repetition})_{ij} + \beta_{5j} (\text{Age})_{ij} + \beta_{6j} (\text{SES})_{ij} + \beta_{7j} (\text{Truancy})_{ij} + r_{ij} \dots (3)$$

Where, Y_{ij} refers to student KCSE chemistry Score, β_{0j} is the intercept while β_{1j} through β_{7j} are the slopes of seven respective level-1 control variables. The term r_{ij} is the random effect for student i nested in teacher j . The level 1 parameters, (β_{0j} & β_{1j}) were estimated indirectly through level 2 and their effects are indicated by γ (Luke, 2004).

Level-2 conditional model

The level-2 conditional model was formulated to predict level-1 coefficients using teacher related independent variables. Attention was paid to the key parameters of interest i.e. educational level and teaching experience with model 5 using

teachers' years of teaching chemistry in general and highest education level in general while model 6 used years of teaching chemistry in grade 12 and highest education level in Chemistry.

$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{Above degree in Sci/Edu})_j + \gamma_{02} (\text{General experience})_j + u_{0j} \dots \dots \dots (5)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11} (\text{Above degree in Sci/Edu})_j$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21} (\text{Above degree in Sci/Edu})_j$$

Where γ_{00} represents the average chemistry gain scores for teachers in a class, γ_{01} is the mean achievement gain difference between those students taught by teachers who hold advanced degrees in Chemistry or Education, and those who do not hold such advanced education qualifications, while γ_{02} is the effect of teachers' general chemistry teaching experience on average student chemistry achievement gain. β_{1j} is the coefficient for student prior chemistry score which is predicted by average prior student chemistry achievement gain slope (γ_{10}) and the interaction effect of the teacher's highest education level (γ_{11}). The same coefficient estimation procedure is carried out for coefficients β_{2j} (Female), β_{3j} (Tuition), β_{4j} (Repetition), β_{5j} (Age), β_{6j} (SES), and β_{7j} (Truancy). Substituting equation (4) and (5), we get the following single equation that predicts student chemistry score using student and teacher control variables as predictors while carefully taking into account teachers highest education level in any discipline as well as general years of teaching chemistry in high school thus giving rise to a mixed effects model (model 5b) with fixed effect portions (containing

γ terms as constants) and random effect portions (containing u and r terms as variables) as shown below.

$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{Educational level})_j + \gamma_{02} (\text{General experience})_j + \gamma_{10} (\text{Prior achievement})_{ij} + \gamma_{11} ((\text{Educational level})_j * (\text{Prior achievement})_{ij}) + \gamma_{20} (\text{Female})_{ij} + \gamma_{21} (\text{Educational level})_j * (\text{Female})_{ij} + u_{0j} + r_{ij} \dots \dots \dots (5b)$$

To separate the variance due to above a degree in Chemistry or education from highest level of education in any Chemistry or education as well as the variance as a result of years of teaching chemistry in grade 12 from that of general years of teaching chemistry in secondary schools, model 6 was formulated as shown below.

$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{Education level})_j + \gamma_{02} (\text{Grade 12 experience})_j + u_{0j} \dots \dots \dots (6)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11} (\text{Education level})_j + \gamma_{12} (\text{Grade 12 experience})_j + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21} (\text{Education level})_j + \gamma_{22} (\text{Grade 12 experience})_j + u_{2j}$$

The subscript j in the equation for level 1 implies that the model will be estimated j times, ones for each j groups, with each j group having a different Chemistry score (β_{0j}); and that the effect of individual student characteristics like gender or SES on the student score (β_{0j}) will differ from teacher to teacher. The prefix γ_{00} , represents the predicted average score for a particular student nested within a particular teacher. The prefix γ_{01} is the mean KCSE Chemistry Score difference between students taught by a teacher who holds an advanced degree in chemistry or education and those whose teachers do not hold an advanced degree

in chemistry or education; γ_{02} is the effect of teachers' experience on KCSE Chemistry Score, γ_{10} represent intercepts associated with the slope of the model 6 predictor variables. The terms γ_{11} , γ_{21} represent slopes that are associated with teacher education level and experience, respectively, in predicting student Chemistry Score. The error term u_{0j} is the

random effect associated with the Chemistry Scores.

Results of the Analysis.

A descriptive analysis was further conducted on students' and teacher background variables, class contextual variables as well as teacher qualifications and the results are shown in table 6 below.

Table 1: Descriptive statistics for teachers and student

| <i>Variables</i> | <i>M</i> | <i>SD</i> | <i>Min</i> | <i>Max</i> |
|---|----------|-----------|------------|------------|
| Teacher variables | | | | |
| Contract teacher(diploma/degree graduate, 1=yes) | .274 | .436 | 0 | 1.000 |
| Above Degree level in Science/Education (1=yes) | .277 | .455 | 0 | 1.000 |
| Chemistry experience in general (1≤5 years) | .121 | .323 | 0 | 1.000 |
| Chemistry experience in general (6≤10 years) | .253 | .432 | 0 | 1.000 |
| Chemistry experience in general (more than 10) | .183 | .387 | 0 | 1.000 |
| Chemistry teaching experience at grade 12 | .978 | .234 | 0 | 1.000 |
| Attended Professional development, (1=Yes) | .454 | .452 | 0 | 1.000 |
| Teacher as grade 12 examiner (1=yes) | .483 | .534 | 0 | 1.000 |
| Gender of the teacher | .435 | .345 | 0 | 1.000 |
| Teacher from County's ethnic group (1=yes) | .456 | .489 | 0 | 1.000 |
| Average teaching workload (Lessons per week) | .635 | .398 | 0 | 1.000 |
| Percentage of OVC | .217 | .310 | 0 | 1.000 |
| Class size | .391 | 5.54 | 0 | 1.000 |
| Student Variables | | | | |
| Female(1=yes) | .524 | .496 | 0 | 1.000 |
| Student age(1=yes; if more than 18 years) | .198 | .399 | 0 | 1.000 |
| Student average SES(1=high) | .575 | .495 | 0 | 1.000 |
| Remedial classes/tuition(1=yes) | .342 | .352 | 0 | 1.000 |
| Repetition once (1=yes) | .376 | .456 | 0 | 1.000 |
| Truancy | 6.635 | 3.365 | 0 | 1.000 |
| Student Prior achievement | 5.635 | 2.513 | 4.233 | 6.353 |
| Student Final KCSE score(1-12 grade points) | 5.876 | 3.243 | 4.345 | .5637 |

Teacher experience in grade 12 Chemistry, Student age, prior achievement, age at testing, class size and student final chemistry score are standardized to the mean of 0 and SD of 1

Distribution of teachers across High ranked and Low Ranked schools.

This study revealed that High ranked schools had few number of teachers with 3 year Diploma

in science (18%), but high number of 4 year Bachelor's degree teachers (55%). In comparison, low ranked secondary schools had 28% of the teachers with a 3-year diploma in

science and 50% of teachers with 4-year Bachelor's degree in sciences. High performing schools had 27% of teachers holding over a master in Chemistry or Education while low performing had 22% of teachers holding over a master and above in Science or Education as shown in table 2 below.

However as per the Chi- Square results, there was no difference in educational level of teachers between high and low ranked secondary schools, ($X^2=0.324$, $df=2$, $P=0.065$). This findings concur with those of Odhiambo (2005) who found out that Secondary schools are not allocated teachers based on their performance, but through curriculum based establishments, following the teacher pupil ratios. The same was observed with regards to

teacher experience. A 2-Level HLM was run with student prior achievement in grade 12 as a dependent variable and with teacher's years of grade 12 experience (1 for over five years and 0 for less than five years) as independent variable while controlling for student SES, age and gender. The findings from the 2-level model indicated that there was no significant difference ($p=.084$) in scores between students that were assigned to teachers with over fives experience at grade 12 and those with less than five years' experience hence presenting grounds to reject the hypothesis of teaching sorting between low and high performing schools which called for further investigation on the variance in student science achievement gains across various schools in the county.

Table 2: Distribution of teachers between High and Low Ranked Secondary schools

| Education level of teachers | % of teachers based on education level | |
|---------------------------------------|--|--------------------|
| | High ranked schools | Low ranked schools |
| 3 years Diploma in Sciences | 18 | 28 |
| Bachelor's Degree in Sciences | 55 | 50 |
| Above degree in Sciences or Education | 27 | 22 |

Proportion of Variance between Teachers and Students.

Having established that there was no sorting in the distribution of teachers between low and high performing secondary schools, it was imperative to establish if the variance in student grade 12 chemistry achievement gains existed within and between classrooms (teachers) which will then be the basis for further multilevel investigation. To estimate the proportion of variance in student

scores attributed to nesting of data between level-1 and Level-2, an unconditional model (One way Anova) was run as explained in chapter three. From the unconditional model, between groups variance was 0.207, whereas within group (residual) variance was 0.788 and all variance components were statistically significant ($P= < 0.001$ for the classroom and students). This was followed by calculating the Interclass correlation coefficient (ICC) which

then will indicate the clustering effect between level 1 and level 2 of the data using the formula below.

$$ICC = \tau^2 / (\sigma^2 + \tau^2) = 0.207 / (0.207 + 0.788) = 0.208$$

Whereby τ^2 represents between classroom variance, and σ^2 represents the within-classroom variance. The sum of σ^2 and τ^2 , indicates the sum of between classroom variance and within classroom variance. From the unconditional model, the ICC was 0.208 which implied that nearly 20.8% of variance amongst student in chemistry achievement gains, occurred within classrooms (teachers). An addition of student prior achievement scores into the model (now model 2), reduced the total variability in student achievement score gains by 51% from .995 to .493 which accounted for variance associated with the other teacher and student predictors not included in the model. The model fitness was tested using Log likelihood ratio test (LRT) and the LRT ($\Delta\chi^2_{df=1} = 1,134.3$, $p < .001$) results indicated a better model fit.

Proportion of Variance Attributed to student and class contextual variables

The table 3 below shows the effects of student and teacher contextual variables on student achievement.

Discussion of the Results.

The effect of teacher and student covariates on grade 12 chemistry gains were approximated by model three and four (table 3). To specifically answer question two, model three was run bearing only student background variables (age, gender, average SES, Repetition, and Truancy). No interaction and random effect analysis was

done, since the aim of this objective was to find out the effect of student background variables on student science achievement gains. Student SES ($p < .01$) and truancy ($p < .01$) were statistically significant but negatively associated with student grade 12 chemistry gains. Student participation in remedial/tuition ($p < .01$), was significant and positively associated with student chemistry gains. Repetition ($p > .001$), student gender ($p > .05$), and age ($p > .001$) were found to be insignificant. In terms of effect size, student prior achievement in chemistry MOCK tests, recorded the largest positive effect size (.643) followed by student attendance of remedial teaching/tuition (.345). Student SES and truancy recorded a negative effect with the later recording the highest (-.244).

Model five and six (table 3 above), were the models of interest to this study. In terms of education level, model five used highest education level in any other major other than science and education, while model six precisely used highest education level in science (Chemistry) or education. In terms of experience, model five used teaching experience in chemistry in any grade while model six used grade 12 Science teaching experience. Both model five and six included teacher background variables of teaching workload, teacher ethnicity, attendance of teacher professional development (SMASSE), teacher being an examiner of grade 12 Chemistry examination as well as class contextual and student background variables. No teacher practices (teaching quality) were included in model five and six and no interaction

Table 3. Variance components and coefficients of teacher characteristics, student background variables and classroom contextual covariates

| Model | Student covariate | Contextual variables | Teaching years & experience | Grade 12 and experience |
|---|-------------------|----------------------|-----------------------------|-------------------------|
| | (3) | (4) | (5) | (6) |
| Intercept | .178*** | .169** | .067 | .058 |
| Classroom (teacher)level | | | | |
| Percentage of OVC students | | -.082 | -.032 | -.014 |
| Class size(1=more than 45) | | -.011 | -.026 | .004 |
| Above degree level in other major (1=yes) | | | .018 | |
| Above degree level in Science/Edu(1=yes) | | | | .096* |
| General experience in Science (1≤5 years) | | | .092 | |
| General experience in Science (6≤10 years) | | | .118 | |
| General experience in Science (≥10 years) | | | .076 | |
| Grade 12 years of experience (1≤2 years) | | | | -.037 |
| Grade 12 years of experience (≥ 2 years) | | | | .343*** |
| Teacher workload (Lessons per week) | | | -.012 | -.011 |
| Attended SMASSE-TPD (1=Yes) | | | .068* | .021* |
| Teacher examines grade 12 Chemistry exam | | | .026* | .039 |
| Teacher-student same ethnic group (1=yes) | | | .009 | .011 |
| Student Variables | | | | |
| Student prior achievement(1-12 points) | .643*** | .640*** | .638*** | .640*** |
| Female(1=yes) | .038* | -.043* | -.039* | -.037 |
| Overage(1=yes; if more than 18 years) | -.013 | -.012 | -.012 | -.011 |
| Truancy | -.234* | -.326* | -.232* | -.221 |
| Student average SES(1=high) | -.086* | -.088* | -.091* | -.092 |
| Remedial classes/tuition(1=yes) | .345** | .332** | .312** | .303** |
| Repetition once (1=yes) | .006 | .007 | .008 | .008 |
| Percentage of the total Variance | | | | |
| Teacher level ($\pi\pi00/\pi\pi00+\sigma2$) | .075(16%) | .065(14%) | .054 (12%) | .048(11%) |
| Student level ($\sigma2/\pi\pi00+\sigma2$) | .396(84%) | .397 (86%) | .397 (88%) | .396 (89%) |
| Total | .471 | .462 | .451 | .442 |
| -2Log likelihood | 3020.7 | 3016.6 | 3010.3 | 3001.8 |

Model (5) uses general years of teaching chemistry at any grade in secondary school while model (6) uses grade 12 chemistry teaching experience. OVC Orphans and vulnerable children. SMASSE strengthening mathematics and science in secondary education. # $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

effect was tested. Model five and six were geared towards addressing objective three and four of the study. To investigate the random effect suitable for the data, a series of random effect analysis were carried out holding constant student, teacher and class contextual variables constant. All student-level variables and teacher-level predictor variables were included

in model (as explained in 4.4 above). From model five, teachers who hold a three-year diploma positively and significantly contributed to student chemistry score gain with an effect size of .112, whereas those with a four year degree qualification and those with beyond a bachelor's degree qualification in any major positively but insignificantly contributed to student scores with an effect size of .112 and .102 respectively. Notably, only the effect size for teachers who hold a three year diploma in Chemistry from a diploma teacher training college (DTC) was significant implying an existence of quality difference between university graduate teachers and DTC teachers. This findings are supported by those of Kathumbi (2013), who found out that Diploma teachers from DTC were more effective than their graduate counterparts from universities.

With regard to general experience from model five, Students taught by teachers with $1 \leq 5$ years performed lower (.092) than those student taught by teachers with ($6 \leq 10$ years). However student taught by teachers with over 10 years of experience performed lower than those taught by teachers with 6-10 years. Student taught by teachers who held above a degree level in any major had an effect size of 0.018 on student scores. It was evident that highest education level had a positive but insignificant effect on student scores concurring with the findings (Wenglinsky, 2002). The implication of teachers' highest education level being insignificant could possibly imply that teacher education level are either mediated or moderated by teacher practices for them to have a significant effect on

student achievement gains. However, teacher education level and experience can be moderated by teacher professional development and/or managing of teacher's workload. However, the implication of number of lessons per week had a negative impact on student achievement (-0.012) with the effect higher with teachers with general experience than those with grade level experience. This model was less fit than model four ($\Delta\chi^2_{df=6^2}=11.4, p=.072$).

Model 6 was critical to this study. Unlike model five, it used highest education level in Science and highest experience in an examination class (grade 12). Teachers with grade 12 experience of 1-2 years (grade level novice teachers) negatively and insignificantly influenced student scores (-0.037) while those with over 2 years grade 12 experience positively and significantly ($p < .001$) influenced student scores (0.343). This evidently implied that teachers with advanced degree in science as well as more years of grade level experience positively and significantly influences student achievement. Interestingly the bulk of variance in student achievement was among students (89%) while within teacher variance reduced to 12% while the intra-class correlations coefficient (ICC) reduced to 0.1178 representing about 11.78% variance in grouping as compared to 20.8% variance due to grouping in the unconditional model. This findings concur with those of Huang and Moon (2009), who despite having carried the study in a developing nation and using 3-level HLM in studying effects of teacher grade level experience, found similar findings. However, as per Wenglinsky (2002), in multilevel modelling, there can be a possibility of

interaction within a level or across a level. Some teacher variables could have insignificantly affected student scores due to lack of mediation or moderation and in line with Wenglinsky (2002), this study sought to explore the mediation-moderation effect of teacher practices on student achievement gains in the next and last section of the study.

Findings and Conclusions:

Some studies have alluded on the possibility of education level and teaching experience not directly influencing student achievement (Wenglinsky, 2002) and as such the final multilevel model (model 6) factored in the highest education level in chemistry and the teaching experience at grade 12. The results indicated that teacher's advanced degrees in chemistry were a statistically significant predictor of student science achievement. Teachers with above a bachelor's degree in chemistry were .096 standard deviations higher in student gains than those teachers without. However the relationship between teachers with less than two years of grade 12 experience and student achievement was negative and statistically insignificant (-.037) implying that novice teachers even with grade 12 level experience contributes .04 standard deviations less in student gains than their counterparts with more years of experience at grade level. These findings are in line with (Goldhaber & Anthony, 2004).

When grade level seasoned teachers (those with above two years' experience at grade 12) were factored into the model, the results were

positive (effect size .34) and significant ($p < .001$). The attendance of teacher professional development famously known as SMASSE was positive and significant in model five (.068) and in model six (.021) while marking of national examination was positive and significant at model five (.026) but not at model six (.039). In model five, novice teachers who mark grade 12 examination gain skills which improve their effectiveness in student examination preparation. However, the effect size may have varnished in model six due to endogeneity with grade level experience or absence of moderation effect. The fitness of model 6 was the best amongst all ($\Delta\chi^2_{df=5} = 23.6$, $p < .001$) with warping 89% of variance in student gains still observed amongst students (Collemna, 1997) while between teacher variance reducing to 11% thus raising questions on what exactly in teachers matters in student gains (Krishnan, 2005). From model four it's evident that traditional teacher quality variables of highest education level attained and number of years' of teacher experience have no significant effect on student science gains in both low and high performing schools in developing countries. However, the findings in model six imply that it's the type of teacher experience that matters to student achievement in developing nations and not just years of teaching experience.

Teacher effects on student scores for a teacher with over ten years' of experience (model five) were in line with the principle of diminishing marginal returns of teacher experience. If teacher effects were accumulative (Coleman, et.

1966; Sanders and Rivers, 1996), and effect change remains uniform across the subsequent grade 12 classes, then grade 12 students taught by teachers with at least two years' experience at grade 12 for three years in arrow may score one SD ($3 \times .343 = 1.029$) higher than those taught by beginning or novice teachers. This findings should not be interpreted to mean teachers with advanced degrees in the subject major are more effective that those without, but should inform policy makers on policy adjustments factor in this advanced degrees in general teacher developments. In terms of teacher experience, novice teachers with less than two years grade level experience (model six) were found to register a negative and significant effect on student scores (-.037) while those teachers with grade level experience of over two years registered a positive and significant effect on student scores (.343). This findings may not be interpreted to mean teachers with high grade level experience automatically register higher gains in student scores due to the nonlinear effects of teaching experience on student outcome (Goldhaber & Anthony, 2004).

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