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TEACHER QUALIFICATION AND STUDENT ACHIEVEMENT GAINS IN KISII, KENYA: A MULTILEVEL ANALYSIS

Duke D. Obonyo[1i],
Chen Bin[2],
Ann Muiru[3]
[1]Huanzhong Normal University, China
[2]Central China Normal University, China
[3] Mount Kenya University, Kenya

Abstract:
The study investigated the effects of teacher professional qualifications (measured by teacher educational level and experience) on student science achievement gains in both low and high performing public secondary schools in Kenya. The study utilized highest education level of teachers in general and also in Chemistry as well as experience of teaching chemistry in general and also at an examination grade. Two level Hierarchical linear modelling was used with a Value added approach to analyze data from 2000 grade 12 students and 200 teachers from 60 public secondary schools in Kisii County, Kenya. The study found out that teachers with advanced degrees in Chemistry positively, and significantly predicted student achievement gains than those with advanced degrees in any subject major. With respect to experience, years of teaching at any grade level did not significantly predict student chemistry achievement, while higher grade 12 experience positively and significantly predicted student chemistry gains. Conversely, novice teachers with few years of teaching but with higher grade 12 years of teaching coupled with teacher professional development, positively influenced student achievement gains.

Keywords: teacher qualifications, hierarchical linear modelling, grade 12, student achievement, low and high performing schools

1. Introduction

Student achievement has dominated global education discourse in the recent past as the paradigm shifts to efficiency of education systems and teacher accountability. Many studies on student achievement has focused on factors related to students, teachers and the school (Dossett & Munoz, 2003; Huang & Moon, 2009). Recent education literature

[i] Correspondence: email dukeacademia@yahoo.com

has greatly shifted greatly from the famous Coleman findings (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 what constitutes an effective school and an effective teacher continue to elicit mixed findings, with teacher quality dominating the education discourse. Associating teacher quality to student outcomes has led to an increased demand for high quality teachers, citing evidence that an effective teacher is the most influential factor in student achievement at school (Darling-Hammond, 2000; Darling-Hammond & Baratz-Snowden, 2007; Hanushek, Kain, & Rivkin, 2004; Hanushek & Rivkin, 2010) and that their classrooms are avenues where teacher qualifications (measured by knowledge, skills and dispositions) interact with the prior knowledge and attitudes of students to result to any measurable student outcomes.

2. Literature Review

The impact of teacher characteristics on their effectiveness has been highly studied since the Coleman report of 1966. One such study was carried out by Kane, Rockoff, and Staiger (2008) on the effect of teacher quality on reading and writing scores of grade 2-6 pupils on two school districts in New Jersey. The study found out that increase in teacher quality by one standard deviation, resulted in a 0.11 standard deviation increase in reading and writing test scores while controlling for student background variables. The most recent meta-analysis on the effect of teacher inputs on student outcomes was conducted in the US by Wayne and Youngs (2003), and it involved 21 studies which drew the relationship between students SES, teacher characteristics, student prior scores and their test scores. The study found out that, all the determinant had a positive effect on secondary mathematics scores, with greater impact being observed on teachers with advanced degrees in Mathematics.

In addition to teacher educational level, teacher experience is a topic of potential concern to many policymakers, as experienced teachers are assumed to be associated with good classroom practices and student achievement (Lewin & Stuart, 2003). However, this is not normally the case, as some experienced teachers who may be considered as experts because of their many years of teaching, may remain "experienced non-experts" (Tsui, 2003). Few key studies have been conducted so far that sought to find out the relationship between teacher professional characteristics (measured by teacher education level and years of teaching experience) on student science achievement gains (Dan Goldhaber, 2008; D. D. Goldhaber & Brewer, 2000; Ye, 2000). These studies found out no evidence in the 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 that teachers with more than two years' experience (Rivkin et al., 2005). Ceteris paribus, 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 (D Goldhaber & Anthony, 2004). This estimation problem may be worse in developing nations which are characterized with inadequate education data (Lewin & Little, 2011) and teacher shortages compounded with high teacher turn-overs.

Kenya utilizes 8.4.4 education system (8 years in primary, 4 years in secondary and 4 years in University) and grades in secondary schools are classified into Forms; with the lowest one being Form One, and the examination grade being Form Four(commonly known as grade 12). Different schools are registered with different number of streams per class (Form) with high quality schools (in most cases National Schools) having more streams, low teacher pupil ratio and higher quality peer group than the sub-county schools (Glennerster, Kremer, Mbiti, & Takavarasha, 2011; Makori & Onderi, 2014). The idea that novice teachers have a negative effect on student achievement is widely accepted. Indeed, research finds that teachers with 0 to 1 year of experience have a strong negative effect on student achievement, regardless of their educational level (Darling-Hammond, et al., 2005). Buddin (2010) also confirms that students taught by teachers with the most advanced degrees in the subject area and more years of teaching experiences achieved higher test scores than students taught by novice teachers.

Research suggests that teachers who have more teaching experience in a certain subject greatly impact on student achievement scores in that subject than those who do not, but this need to be estimated while controlling for teacher and student background factors (Ingersoll, 2001). In both general and grade level experience, many teachers exhibit greatest productivity gains after post-novice levels, after which their performance tends to level off implying that the impact of experience is strongest during the first few years of teaching; after that, marginal returns begins to diminish (C. T. Clotfelter, Ladd, & Vigdor, 2007; Sharkey & Goldhaber, 2008). 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 (Darling-Hammond, 2000; Hanushek & Rivkin, 2012; Sharkey & Goldhaber, 2008). As compared to education level, many studies have shown that teacher's completion of an undergraduate degree is closely associated with higher student achievement (Wenglinsky, 2000). However recent studies on effects of these advanced degrees have become counter-intuitive (C. Clotfelter, Ladd, Vigdor, & Wheeler, 2006; Hanushek, 2011; Rice, 2010; Rivkin et al., 2005). Some studies found 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 (C. Clotfelter et al., 2006; Hanushek et al., 2004; Rice, 2010; Rivkin et al., 2005). The explanation offered by Clotfelter (2006), is that teachers with advanced degrees will always prefer to teach students with high entry behaviors, achievement and innate ability.

Therefore, there was need for this study to establish the combined effect these two teacher qualification indicators, namely teacher's education level and experience on student science achievement, at grade 12 while controlling for both student and teacher background factors.

2. Data and Methods

This study sought to find the effect of teacher professional qualification measured by Educational level and experience on student achievement gains. Using teachers' years of service since employment as a proxy of teachers experience may subject the findings to errors. Therefore, teacher's highest education level was designed to include: highest educational level in any major and highest educational level in the teaching subject (Chemistry), while teachers experience was designed to include teachers general years of experience in any teaching subject and experience in chemistry.

The following questions were addressed by the study:

1. Is there any variation in the distribution of chemistry teachers with respect to education level and experience between low and high performing public secondary schools in the two counties? How does this variation contribute to differential achievement levels amongst students across the schools?
2. What proportion of variance in grade 12 student chemistry score is attributed to class size and student background factors like age, gender and social economic status?
3. Do grade 12 chemistry students attain high levels of achievement gains when taught by teachers with advanced degrees in chemistry or advanced degrees in any concentration while controlling for their background factors?
4. 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?

The outcome variable in the study was student Chemistry score in the Kenya Certificate of Secondary Examination (ranked using 1-12 points scale with an E representing 1 point and an A being the excellent grade representing 12 points). A sample of 60 public secondary schools was drawn from the Kisii County through cluster sampling while 200 teachers were selected through purposive sampling. 2000 grade 12 students from each school were proportionately and randomly sampled.

2.1 Description of Variables

The study utilized student and teacher level variables while the outcome variable was student chemistry scores in grade 12 national examination commonly known as KCSE.

2.1.1 Outcome Variable

To test the research question, student achievement scores in chemistry which served as the outcome variable, assumed a continuous scale of 1-12 points derived from the A, B, C, D, and E grading system in the K.C.S.E examination. Grade A is equivalent to 12 score points, while grade E is equivalent to 1 scores points. Prior student achievement was factored into the model to account for the non-biased estimates of teacher effects on student score. Prior student achievement (commonly referred as MOCK examination) was the grade attained from the school based attainment tests done three months prior to grade 12 examination.

2.1.2 Teacher Predictor Variables

The model utilized policy linked teacher predictor variables i.e. teacher education level and working experience. Teacher Education level was designed into two categories: highest education level attained in general (Diploma, degree, Master and Ph. D) and highest education level in Chemistry (diploma, degree and master). Dummy variables were created for each education level so as to give accurate variance associated with each in the student score. In line with the objectives of the study, teachers experience was designed into general years of teaching Chemistry (EXP-CHEM), and years of teaching Chemistry subject in grade 12 (EXP-120). In addition, other teacher variables were included in the model like teacher's ethnic group, teacher's participation in the SMASSE program of teacher professional development, and teacher marking of National Grade 12 Chemistry examination. A variable of whether a teacher was a T.S.C or Board of Governors (BOG) employee was also included to account for variance associated with high quality but unqualified teachers.

2.1.3 Control Variables

The teacher control teacher 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- Marking and 0-Not marking). Student control variables included: 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) as well as student level of truancy (1=High, 2=Low) were also used as control variables. Tuition implies whether student access private tuition services away from school (1=Yes); Repetition implies that student has repeated in the current grade 12 irrespective of how many times (1=Yes). Truancy is a composite variable indicated by the number of times the student comes to school late, frequency of punishments and suspensions per year. Student SES was a composite value for social economic status measured by parental level of education, household income as occupation. It was abbreviated as Low (1), and high (0).

2.2 Analytical Strategy

The study employed 2L HLM where student variables were incorporated in level 1 while teacher variables were incorporated in level 2. HLM analysis was carried out in the SAS software using the PROC MIXED procedure. Conditional models were used to predict student achievement scores using level 1 and 2 variables. Since the students were non-randomly selected into classrooms and classes non-randomly assigned to the students, the 2level HLM was used to explain the variance that is associated with such nested data (Raudenbush & Bryk, 2002).

2.3 Unconditional (null) Models

One way random effects ANOVA was done without the predictors to ascertain teacher-teacher variance on student score (*shown in model 1a, 1b, and 1c below).*

Score (Yij) = β0j+ rij …………………………………… (1a)

β0j = γ00 + u0j………………………………………… (1b)

Yij =γ00+ u0j+ rij……………………………………… (1c)

Where Yij is the standardized grade 12 chemistry score for student *i* taught by teacher *j*, while β0j is *the intercept representing classroom average* score for teacher j and γ00 is the average grade 12 chemistry gain scores for teachers. Further, rij and u0j 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.

2.4 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.

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

Where β_{0j} is the intercept of the model while $\beta_{1j,}$ 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.

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

2.5 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.

$\beta_{0}j = \gamma_{00} + \gamma_{01}$ (Highest education general) j + γ_{02} (General experience) j + u_{0j}……………....... (5)
$\beta_{1}j = \gamma_{10} + \gamma_{11}$ (Highest education general) $_{j}$
$\beta_{2}j = \gamma_{20} + \gamma_{21}$ (Highest education general) $_{j}$
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 any discipline, 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. B_{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.

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

To separate the variance due to highest level of education in Chemistry from highest level of education in any discipline 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.

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (Highest chemistry education)$_{j}$ + γ_{02} (Grade 12 experience)$_{j}$ + u_{0j}…………..(6)
$\beta_{1j} = \gamma_{10} + \gamma_{11}$ (Highest chemistry education)$_{j}$ + γ_{12} (Grade 12 experience)j + u_{1j}
$\beta_{2j} = \gamma_{20} + \gamma_{21}$ (Grade 12 experience)$_{j+}$ γ_{22} (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 $\gamma 00$, 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 and those whose teachers do not hold an advanced degree in chemistry; 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 Score.

3. Results

Table 1: Descriptive statistics for teachers and students

Variables	M	SD	Min	Max
Teacher variables				
Contract teacher(diploma/degree graduate, 1=yes)	.274	.436	0	1.000
3 year Diploma Education in Chemistry (1=yes)	.276	.442	0	1.000
4 year BED degree in Chemistry (1=yes)	.286	.534	0	1.000
Above Degree level in Chemistry (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 SMASSE chemistry TPD (1=Yes)	.454	.452	0	1.000
Teacher marks grade 12 Chemistry exam(1=yes)	.483	.534	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
Repetition at least once(1=yes)	.265	.113	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	.5.637

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.

3.1 Distribution of Teachers across Schools with Respect to Education Level and Experience

A Chi- Square test of independence was carried out to find out if there was teacher quality variation with respect to teachers' highest education level in Chemistry and years of teaching experience between low and high performing public secondary schools in the county. High performing schools had few number of teachers with 3 year Diploma (18%) but high number of 4 year degree teachers (65%) as compared to low performing schools (28%, 3-year diploma and 45% 4-year degree teachers) but in general there was no difference in educational level of teachers between high and low performing secondary schools, (X^2=0.324, df=2, P=0.065). With regards to the teaching experience, high performing schools had many teachers (43%) with over ten years of experience in mixed grades and in grade 12, as compared with low performing schools which had only 12% of teachers with over 10 years of teaching chemistry in mixed grade and in grade 12. The study therefore found no difference in teacher qualification between high and low performing schools with respect to grade 12 teaching experience *(X^2=0.324, df=2,* P=0.0567), and general mixed grade teaching of chemistry (X^2=0.824, df=3, P=0.016).

Since both low performing schools and high performing schools have many classes (streams) per grade, there could have been a possible confounding factor of teacher sorting where high quality teachers may have been allocated to high performing students in a given stream or those from high SES or with low levels of truancy and therefore the study proceeded to test the hypothesis that students were not sorted amongst teachers. In doing so, the sample of students was split into two: those taught by teachers with more than five years of grade 12 experience and those whose teachers had five and below years of grade 12 teaching 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.

3.2 The effect of grouping on student chemistry achievement gains

Unconditional models were run without student background variables (see model 1c and table 2), so as to depict what exact proportion of variance in student scores can be attributed to between teachers and within students themselves. The model 1 showed a 78% between students within class variance, and 22% between teachers (classroom) within school variance in final grade 12 chemistry score gains. All variance components were statistically significant (P=< 0.001 for the classroom and students). 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 ($\Delta\chi df=1^2$ =1,134.3, p<.001) results indicated a better model fit.

Table 2 below illustrates what proportional of variance in grade 12 chemistry is attributed to nesting of students within teachers and teachers within different classrooms.

Table 2: The variance components and coefficients of the unconditional models and student achievement score for 2000 students and 200 chemistry teachers within 60 public secondary schools in two counties

Model	Unconditional model	Student prior achievement	
	(1c)	(2)	
	Coefficient estimates		
Intercept	.003*	-.004	
Student level			
Chemistry prior achievement		.676***	
	Variance components		
% of total variance			
Teacher (*τπ00/ τπ00+σ2)*	.207 (21%)	.073	15%
Student Variance *(σ2/ τπ00+σ2)*	.788 (79%)	.420	85%
Total	.995	.493	
	Model fit statistics		
-2Log likelihood	3967.1	3026.7	

p<.10;*p<.05;**p<.01;***p<.001

3.3 Effect of Teacher and Student Covariates on Chemistry Achievement Gains (controlling for class variables and student background factors)

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).

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. The aspect of teachers hailing from the same county as the school had a significant but negative association with chemistry gains. 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) while student SES and truancy recorded a negative effect with the later recording the highest (-.244). Model three revealed better fitness ($\Delta\chi df=5^2=54.9$, p<.001), than model two due to the additional of the five student background variables.

Model four introduced two classroom contextual variables of class size and percentage of orphans and vulnerable children (OVC) to the variables that were entered in model three. While controlling for other student background characteristics, class size was insignificant (p>.05) with a negative effect size of -.011, while percentage of OVC children in the class was significant (p<.01) with a negative effect size of -.082. However model four was statistically insignificant as compared with model three ($\Delta\chi df=4^2=12.4$, p=.145).

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

Model	**Student covariate (3)**	**Contextual variables (4)**	**Teaching years & experience (5)**	**Grade 12 years and experience (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
3 year Diploma Educational level (1=yes)			.112*	
4 year BED /B.sc degree level(1=yes)			.102	
Above degree level in any major(1=yes)			.018	
Above degree level in Chemistry(1=yes)				.096*
General experience in Chem (1≤5 years)			.092	
General experience in Chem (6≤10 years)			.118	
General experience in Chem (more than 10)			.076	
Years of experience at grade 12(1≤2)				.-.037
Years of experience at grade 12(above 2)				.343***
Teacher workload (Lessons per week)			-.012	-.011
Attended SMASSE Chemistry TPD (1=Yes			.068*	.021*
Teacher marks grade 12 Chemistry exam			.026*	.039
Teacher from County 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
Repetition at least once(1=yes)	.003	.003	.002	.003
Percentage of the total Variance				
Teacher level *($\tau\pi00/\tau\pi00+\sigma2$)*	.075(16%)	.065(14%)	.054 (12%)	.048(11%)
Student level *($\sigma2/\ \tau\pi00+\sigma2$)*	.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<.10; ***p<.001.

4. Discussions

This paper geared towards finding out the implication of student background factors, classroom contextual variables and teacher variables on student achievement.

4.1 Teacher Quality Distribution among Low and High Performing Schools

Many studies from developing countries have revealed great disparities in teacher quality distribution among low and high performing schools (Nishimura & Yamano, 2013), between rural and urban schools (Lewin & Stuart, 2003), among high SES and low SES students and minority or black students (Malecki, Demaray, Elliott, & Nolten, 2000). Evidence has it that such tracking of students with teachers implicates a lot on achievement (Hanushek & Woessmann, 2009) as well as other student outcomes like drop out and truancy. However, this study established no significant variation in vital teacher quality variables between low and high performing schools. Lewin and Stuart (2003) established that high performing schools in Kenya, especially national schools have majority teachers holding advanced degrees in the subject area with over five years teaching experience in the same. He justified this phenomena to be as a result of high teacher motivation and incentive structure in such schools which reduces teacher mobility and turn over. He however did not find any evidence to attribute teachers' education level to student performance in such schools.

4.2 Importance of Student Background and Contextual Variables

In the unconditional model (model one), student background variables attributed 79% of variance in student achievement. The addition of prior achievement variable to the model drastically reduced the variance and improved its fitness with consistent large effect sizes in the rest of the models implying that student MOCK scores contributed greatly to student final grade 12 chemistry scores. This finding is supported by those of Croninger, Rice, Rathbun, and Nishio (2007). The addition of the rest of the student background variables in model indicated that age of students had a small, negative and insignificant effect (-0.012) on student grade 12 chemistry gains. This is in contrast with studies on elementary mathematics where age has been reported to have a negative and significant effect on student reading scores (Hill & Weiss, 2005).This can be interpreted to mean that overage students perform 0.012 standard deviations below their peers who are not overage (i.e. those who are 18 years or younger at the time of testing). Despite the gender disparity in science achievement in the country, the effect of gender on student chemistry achievement was small, negative and insignificant grade repetition irrespective of how many times seemed to have a small effect on final scores. The coefficients of those repeating grade 12 once or twice were not significant from those not repeating at all suggesting that grade repetition does not positively improve student scores. This concurs with other studies both locally and globally (Ejakait, Mutisya, Ezeh, Oketch, & Ngware, 2011; Hungi & Thuku, 2010). Lastly, student truancy had a negative influence on student scores with an average of 0.2 standard deviations from those who do not exhibit truancy. These findings concur with Balfanz and Byrnes (2012), and Gottfried (2009) who found out that unexplained absenteeism reduced student achievement and increased student propensity of dropping out. Lastly, student SES had a negative and significant effect on student grade 12 scores. However, the effect size declined slightly with model 5 and 6 where education level and grade level experience were factored into the model. This could possibly imply that experienced teacher practices reduces effect sizes of SES on student achievement(Wenglinsky, 2000). Class contextual factors like class size in contrast had a small negative and insignificant effect on student achievement. However, the negative effect varnishes in model six with teachers holding grade level experience. This is in contrast with earlier findings that small classes are good for student learning (Hill & Weiss, 2005). This inclusion of class size acts as control at classroom level enabling accurate interpretation of differences in variance components. It is clear and evident that student SES and percentage of OVC students in a class significantly influences student achievement especially in low cadre secondary schools in Kenya against the backdrop of free day secondary education policy framework.

4.3 Teacher Characteristics and Student Grade 12 Achievement Gains

Teacher professional characteristics (in model 5 and 6) were the key variables of interest in the study. For a long time now, studies on teacher quality especially in developing countries have limited themselves to key teacher quality variables of teacher's education level, teacher licensure and certification, teacher experience and attendance of teacher professional development. Few studies have been done in developing countries especially due to unavailability of accurate datasets and the structure of teacher management in many countries. In Kenya for example, data on teacher's educational level is only available in the teacher service commission (TSC), while general years of teaching and grade level experience is available through teacher surveys in schools. Many teachers may not accurately recall how many years they have taught at grade level and how many years they have taught chemistry in general due to high internal teacher turnover, and subject sharing policies.

During lesson sharing in schools, teachers can either teach vertically (the same students from grade 9 to 12), horizontally (stationed at certain grades) or randomly allocated grades based on TPR of the school. In this study, only teachers who taught the sampled students at grade 11 and grade 12 participated in the study. Both model five and six could not factor teacher background variables like age and gender of teachers since age could be endogenous with experience while gender could have led to biased conclusions due to prior inclusive findings(Hoffmann & Oreopoulos, 2009; Nishimura & Yamano, 2013). However, participation in teacher professional development (SMASSE), and marking of grade 12 national examination were factored in as moderators of teachers' experience and education level.

Teachers' ethnicity had a small positive effect of .009 and .011 for model 5 and 6 respectively, sadly supporting the decentralized policy of teacher staffing in Kenya which encourages employment of teachers in their country of origin. The main difference between model five and model six is that model five utilized highest education level in any major as well as years of teaching experience in any grade while model six strictly utilized highest education level in the subject major (chemistry) and chemistry teaching experience in grade 12. Model five answered questions three while model four answered question four. 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 concurring with the findings of Gathumbi, Mungai, and Hintze (2013). Having advanced degrees in any subject major had a small insignificant effect to student chemistry gains concurring with the findings of Wenglinsky (2002) on the possibility of mediation effects of variables like teacher behaviors or practices. Still in model five, the study had apportioned years of teaching chemistry into three with one to less than five years of teaching chemistry in any grade recording a positive but insignificant effect, six to ten years recording a positive and significant effect of .118 while over 10 years of experience had a small positive effect of .076.

Literature on education production function indicate that novice teachers with less than five years of teaching experience, negatively influence student achievement (D Goldhaber & Anthony, 2004), but this was not the case in this study. This is possibly because many Kenyan teachers accumulate prior experiences as contract teachers before they get employed by the government. Teaching workloads had a negative and significant effect on student achievement with an effect size of -.012 and -.011 for model five and six respectively. The effect size diminished with teachers with grade level experience possibly implying that experienced teachers at grade level can improve student scores irrespective of their heavy teaching workloads. Of all variables of interest in model 5, only teachers with three year diploma in chemistry was statistically significant and model fitness was slightly mirrored in the likelihood ratio test ($\Delta\chi df=5^2=10.4$, $p=.055$).

4.4 Differential Achievement Gains for Teachers with Advanced Degree in Subject Major and Grade Level Experience

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 (D 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 participation of teachers in professional development famously known as SMASSE, positively and significantly affected scores 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 ($\Delta\chi_{df=5}{}^{2}=23.6$, $p<.001$) 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 (Hanushek, 2011). 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 (3x.343=1.029) higher than those taught by beginning or novice teachers.

4.5 Implications to Education Research and Policies in Developing Nations

Advanced degrees and experience have dominated education policy making as parameters of teacher management and accountability, but caution must also be exercised in accounting a teacher's years of teaching experience as well as grade level experience. This is because general years of experience, may not account for the years of teaching before formal employment by the government, and at the same time grade level experience maybe a subset of (endogenous to) the years of teaching. Besides that, teaching experience without breaks (like study leaves) is different from experience with breaks. In this study, experience implied, "teacher experience without any form of disruption or break". Using any form of experience anyhow, will result to biased estimates which may imply that experience is significant, when it's not and vice versa (Huang & Moon, 2009). By doing so will help in unbiased interpretation of variance in student scores accounted for by teacher qualifications while controlling or holding constant other background variables (Cochran-Smith, 2001).

5. Conclusions and Limitations

This study apart from utilizing multilevel modelling technique, focused on differential effects of two types of education level and teaching experience. Since many developing nations like Kenya do not subject teachers to licensure tests, the teaching fraternity is flooded with teachers with all manner of qualifications. Due to lack of much documented evidence from developing nations, this study used highest education level in any major in model five and highest education level in Chemistry in model six so as to obtain differential effects of the two on student achievement. The difference in effect size between the two levels of experience was .078 with the highest education level in subject major (Chemistry) having the highest effect size.

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 so as to 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 outcomes (D Goldhaber & Anthony, 2004).

Lastly, since grade level experiential effects can be cumulative (Coleman & USA, 1966; Huang & Moon, 2009), policy makers should adjust their policies which reward experiences at grade level together with any other form of subject major teacher development. This study had few limitations: it focused on one subject and one grade only. While key variables of policy interest were utilized, there is a possibility some variables that registered insignificant effect on student outcomes required moderation or mediation to register significant effects.

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