EXPLORING TEACHER ADDED VALUE INTO LEARNERS READING ACHIEVEMENTS SCORE

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Abstract
Teacher quality characteristics are used to measure the importance of the teacher to learners' academic performance. Studies on this topic have focused on teachers' educational background, years of teaching experience and salaries. While it is clear that certain teachers are more effective than others at improving student achievement, there is considerably less consensus on whether specific, observable teacher characteristics such as qualification or experience produce higher achievement. This study sought to explore the value addition of the teachers on learner's performance scores for reading after controlling for several characteristics of learners, teachers and schools. In the study, the value added by the teacher is termed teacher effect and is measured as a random component representing the differences between the learners' actual score and the predicted score. This difference is assumed to be attributable to teacher after controlling for background variables. The study used the data obtained from Progress in International Reading Literacy Study (PIRLS) of 2011 year cycle. There were 4197 learners matched to 141 teachers. Data sets also contained the background information of teachers, learners and schools. The study used the contemporaneous specification of the value added model (VAM). The results of VAM suggested that the effect of the teacher on students' scores was attributable to between school and within school effect. Further analysis suggested that teacher qualities that influence the students' achievement included level of education, ability to use computer, experience beyond 16 years and the better teaching strategies.

Introduction

Teachers are integral to learners' achievements; however their level of importance is quantitatively difficult to measure. One study observed that the benefit of moving a student from an average teacher to a quality teacher at 85th percentile ranking is comparable to the benefits of 33% reduction in class size, Rockoff (2004), Hanushek (2005). More often teachers are required to account for the learners' performance, however, the amount of contribution of teacher to learners score is not known. Most accountability systems believe that productivity of the teacher depends on his/her credentials often termed quality factors such as experience, qualification, etc. However, there is a lot of variation in teachers' effectiveness, with similar credentials, even within the same school. Studies have noted the importance of teacher quality attributes to learners achievements scores. For instance, Rockoff (2004) found significant results of teacher experience on learners' achievements. However, some studies have found little association between observable teachers' characteristics and learners outcomes.

There is a substantial literature on the relationship between teacher characteristics and student learning. Most prior researchers on this topic such as Hanushek (1971), Hanushek & Rivkin (2010); Jacob & Lefgren (2008); Sass et al. (2014) have focused on teachers' educational background, years of teaching experience and salaries. They observed that while it is clear that certain teachers are more effective than others at increasing student performance, there was considerably less consensus on whether specific, observable teacher characteristics such as education or experience produce higher performance. The study investigated the relationships between learners' performance and teachers' quality characteristics, after controlling for both observable and unobservable teacher characteristics.

Statement of the Problem

While there is a substantial literature on the relationship between general teacher characteristics and student learning, there are no studies in Botswana context to quantify the importance or value of teacher to learners' performance. Studies linking learners' performance with background variables have been focussing on general factors affecting performance, but not focusing on the teacher and their contribution to learners score. Due to the declining outcomes of learners, the policy makers and general stakeholders want researchers to interrogate each component relating to learners performance more closely. This study hence purported to study teacher effect to learners score closely, and investigate how other factors relating to learners performance impact teacher effectiveness in the classroom. Furthermore, there has been an outcry by school to measure value addition of teachers and school to learners' performance. Some practitioners argued that the ranking of schools must reflect how much school has contributed to the learners' performance. Teachers on the other hand are requested to account for learners score. Hence the issue of value addition needs to be addressed to guide both accountability systems and also to provide proper feedback to the schools on learners' measurements. In this study, the value addition methodology was applied in the teacher factors to determine the effectiveness of the teachers.

Purpose of the Study

This study sought to explore the value addition of the teachers on learner's performance scores for reading after controlling for several characteristics of learners, teachers and schools. In the study the value added by the teacher is termed teacher effect and is measured as a random component representing the differences between the learners' actual score and the predicted score. This difference is assumed to be attributable to teacher after controlling for background variables. The study intended to determine the teacher effect on student learning of elementary learners. When children begin school it is expected

that drastic changes take place, it could be in the cognitive, the psychosocial or even the physic, but above all the cognitive and psychosocial are the most important. Therefore, this study sought to measure the cognitive and the psychosocial development that the children develop at school which is hypothetically influenced by their teachers. That would also help to generate better teacher evaluation strategies for the elementary teachers.

Study Objectives

1. To estimate teachers added value to learners scores
2. To determine the correlation between teacher quality characteristics and learners performance
3. To determine the impact of learners and school factors on teachers' quality factor

Literature review

The effect of teacher on students has been studied intensively by many researchers, including Rothstein (2009) who worked on teacher quality in educational production and Sass et al. (2014) who used value added model (VAM) to measure the teacher quality. Studying teacher effects requires a longitudinal data on both students and teachers. The advent of longitudinal databases, for instance the state-wide longitudinal databases in North Carolina and Florida allowed researchers to measure changes in achievement at the individual student level controlling for students and families variables. Students' achievement model is influenced by many factors which include student past achievements, family factors and school-based educational inputs such as resources, pedagogical issues and teachers' variables. Learners' achievements scores had been used to gauge school accountability and measurement of teachers' performance. Teachers and school are given awards based on how their learners have performed. This is done mainly to recognize the teacher effect onto the learners' academic scores.

Measurement of teacher productivity in both education and in accountability systems is often based largely on estimates from panel data where individual' teacher effects are interpreted as teacher value added through cumulative achievement model developed by Boardman and Murname (1979) and Todd and Wolpin (2003). Both authors assume that learner education achievement score is a production function based on teachers, schools, learners and classroom observed and unobserved factors. The cumulative achievement model developed by Boardman and Murname (1979) and Todd and Wolpin (2003) includes entire histories of individual, family, school based educational inputs. The individual specific heterogeneity are modelled by a composite factor representing time –invariant characteristics an individual is endowed with at birth such as innate ability or pre-service education. The school-based educational input includes both school-level inputs such as the quality of principals and other administrative staff within a school, classroom-level inputs in classroom. The classroom-level inputs include peer characteristics, time-varying teacher characteristics such as experience, non-teacher classroom-level inputs such as books, computers, etc.

The time-invariant teacher characteristics include innate ability and pre-service education. The time-variant teacher characteristics can be captured by a set of teacher such age, experience, use of technology, in-service training and ability to implement curriculum.

In the contemporaneous specification of VAM Sass et al. (2014) the prior student and school-based inputs is assumed to decline geometrically with time leaving the few observed and unobserved factors in the model. However, Sass et al. (2014) rejected the null hypothesis that the prior inputs have no effect on current achievements in the model with no unobserved time invariant individual specific

effects. In the model with unobserved teachers' effects, learners' effects and schools fixed effects fitted, the prior inputs were found to be insignificant.

There had been a strong belief that teachers' quality traits are important for learners' academic success. However literature on this subject showed varying and inconsistent conclusions. Some studies such as Rockoff (2003) and Hanushek (2005) found insignificant relationships between teachers' quality factors and learners' academic achievements, while other studies have found significant relationships

Rockoff (2003) noted that with data in which learners were matched to their teachers, it was possible to correctly divide the learners' performance into a series of fixed effects for learners, teachers, classroom and schools. The learners' academic score could be explained in terms of how much each entity contributed to the production of the score. The studies have advised that relying on only measurable characteristics of teachers, learners and school brought about inconsistent estimates of the effect of teacher characteristics on learners academic performance. The individual specific heterogeneity must be controlled to get an accurate and reliable estimate of teacher value addition. The individual specific heterogeneity was measured as unobserved factor termed fixed effects in the model for Harris and Sass (2007). Rockoff (2003) further noted that teacher fixed effects were significant predictors of learners' scores. The teacher experience were also found to be significant only before a certain experience level cut off after that the teacher experience was found to be insignificant.

Sass et al. (2014) used teacher fixed effects to measure value added effect of the teacher. They measured teacher added value as a random phenomenon representing time-invariant characteristics an individual is endowed with at birth such as innate ability and pre service education. These fixed effects are used to represent variations in the teachers and are said to be correlated with teacher, learners and school measurable characteristics. The fixed effects are used to measure teacher productivity and teachers are ranked based on their value added.

Hanushek (2005) found insignificant results on the analysis of learners' performance and teacher quality factors; teachers' qualification and teachers' experience. The inconsistency of the results was puzzling considering that most schools pay more for teachers with graduate degrees and more experience. Hanushek (2005) concluded that while teacher quality might be important, the variation in teacher quality was driven by characteristics that are difficult or impossible to measure.

There is a consensus in education literature that teacher quality is not only driven by observable/measurable teachers' characteristics but there is also the existence of some unobservable factor, termed fixed effects or random effects, Sass et al. (2014)

Methodology

Data Description

A secondary data analysis on Progress in International Reading & Literacy Study (PIRLS) of the 2011 year cycle was conducted. The primary PIRLS data had been collected from many schools across the country on students' performance, teacher's attributes and parent's attributes. This was a comparative study and focused on comparatives with other countries participating in the study. This therefore meant that the data yielded was underutilised but enough to conduct secondary analysis of issues that may still be current and could not be addressed by the primary analysis of the 2011 data. The secondary analysis focused mainly on students and teachers data. Each student in the sample was matched to the teacher. There were 141 teachers and 4197 students in the sample. In the data sets, both

student and teacher information were linked to specific classrooms. The secondary analysis was backed by corroborative literature review.

Variables used in the Study

The study analysed the learners achievements score as a function of teachers' quality factors, factors representing school characteristics and factors representing learners' background variables. The study also investigated the impact of school; learners and teachers characteristics on the factors termed teacher's quality factors. Most variables used are categorical in nature. Some of the factors were constructs or indices manifested by several statements which were highly correlated.

1. Teacher's quality factors:

   - Years of Experience,
   - Highest level of education completed,
   - Language specialization,
   - Collaboration ability with other teachers,
   - Ability to use Computer in teaching
   - Pedagogy (methods of teaching)

2. School characteristics used:
   - Teacher level of Satisfaction
   - Teachers Understanding of Curriculum
   - Teachers Degree of implementing Curriculum
   - Parental Involvement in School activity
   - Class room Size
   - Library usage
   - Computer availability
   - Homework Policy
3. Learners factors considered were:
   - Demographics,
   - Home possessions,
   - Bullying tendencies,
   - Parental support,
   - Perceptions on their ability to read,
   - Perceptions about their reading teacher

Conceptual frameworks

Value Added Model

The analysis of teacher quality was based on the Value Added Model (VAM) as first formulated by Boardman and Murnane (1979) and Todd and Wolpin (2003). VAM is an education production function for learners' achievement scores. It assumes that the learners' achievement score is a function of additive factors of; prior school inputs, learners/family prior inputs, classroom-level inputs, teacher, learners, and school characteristics, innate ability of learner and teacher the idiosyncratic error. The full model requires repeated observations.

Different models can be specified as special case of the cumulative model depending on the relaxation of some assumptions. Due to lack of longitudinal data, the restricted VAM was used in this study. The model is a restrictive version assumes that learners current achievements depend on; learners characteristics, school based inputs and individual fixed endowment (innate ability, pre-education learning), as in Sass et al. (2014).

Teacher Fixed Effects

Teachers Fixed effects are unobserved qualities of a teacher which affect the teachers ability to influence learners performance when the effects of learners characteristics, school, characteristics and teachers observable qualities have been controlled. The fixed effects of teacher would suggest that statistically significant differences in the learners' performance are caused mainly by persistent differences in their teachers. Even after controlling for the observable teacher credentials such as experience, advanced degrees, ability to employ pedagogical factors, there are difference in learners' performance attributable to teachers. They are measured as random component in the value added model.

In the gain score model specification of VAM (Cowen & Winters, 2013), the teachers fixed effects represents teacher-specific component to student test score outcome. It measures the differences between the students' actual scores and the predicted test scores, i.e. differences are attributable to the teacher. In Sass et al. (2014) teachers fixed effects represents the unobserved teachers ability which is not accounted for by the teachers qualities in the model. In the contemporaneous specification of VAM Sass et al. (2014) teacher fixed effects represents unobserved teacher qualities that are not accounted by the teachers qualities in the model. It represents the value added measure of teacher effectiveness in the class. A fixed effect identifies the important of a teacher. This is also interpreted the same in Rockoff (2003). In this study, we can only be able to estimate teacher fixed effect but this is entangled with classroom effect because the teachers have not been observed in multiple classes. Teachers were observed in one classroom so teacher effect cannot be separated from classroom effects.

Results

Estimates of the Impact of Teacher Characteristics on Students Reading Achievement Using the Valued Added Model

Figure 1: 95% CI for Estimates of the Effects of Teacher quality factors on Learners Reading Performance
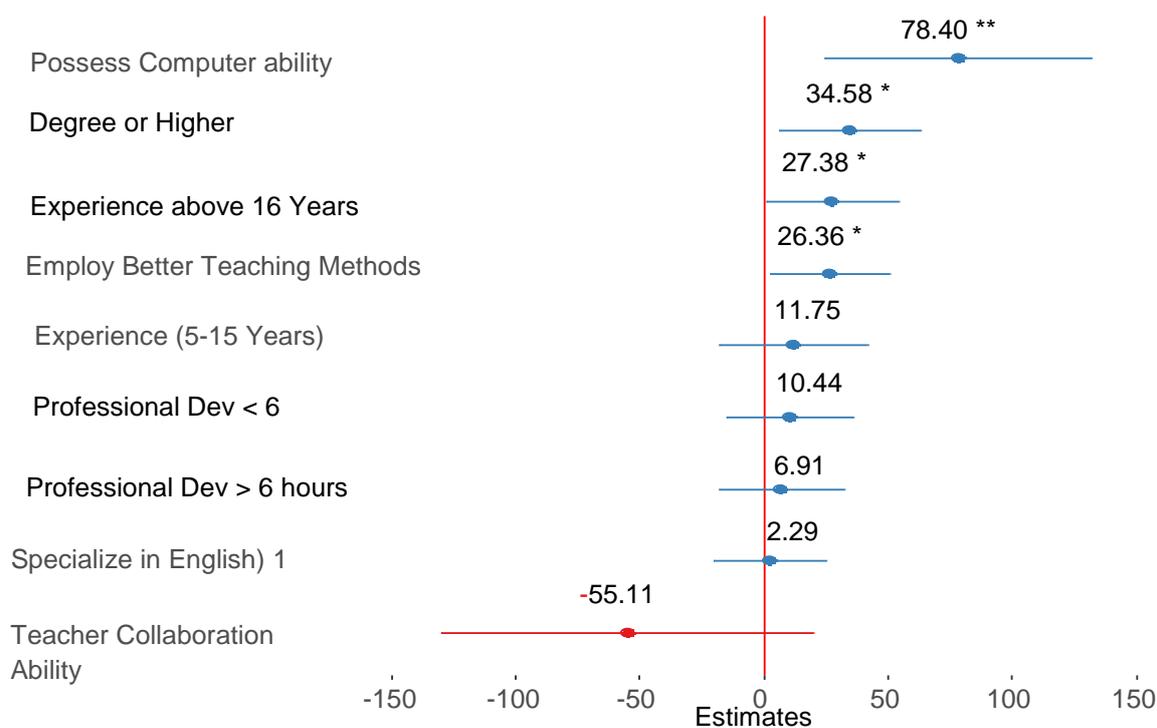
The value added model was applied to the data using only variables concerned with the teachers' quality characteristics such as Teachers' years of Experience, Degree or Higher, Language Specialization, Teacher Collaboration Ability, Teacher Possession of Computer Skills, Teachers Own Perceptions, teacher major area of study, teacher length of professional Development and Teaching Methods. Only four (4) variables were significant in explaining students' achievements in reading. These variables are Teachers' years of experience, Degree or higher and Teaching Methods explored by the teacher and Teacher Possess of Computer ability.

The model with teacher quality factors fitted established that the variation in teacher fixed effects or teacher heterogeneity can be decomposed into the within school variability and within school variability. Between school variability is influenced by heterogeneity between schools, which is attributed by differences in school and teacher characteristics while the within variability is influenced mainly by characteristics relating to students. It is therefore important to study the impact of the teacher qualities on students' performance in connection with school, teacher and students characteristics. The within variability constitutes 67.7% of the total variability while between schools constitutes 32.3% of the total variability. The log likelihood ratio test failed to reject the existence of individual teacher fixed effects in the model (F ratio (P-value 0.0001)). This suggests that the teacher fixed effects or heterogeneity are important in explaining the students score outcomes.

In Figure 1 above, the teacher quality factors were plotted against their estimated effects coefficient on the reading scores. The horizontal lines in the graph signify the 95% confidence interval (CI) on each estimate. The vertical line at zero is used to show whether the variable is significant or not. Any factor whose confidence interval (CI) touches the line is insignificant.

Only four (4) variables were significant in explaining students' achievements in reading. These variables are Teachers' years of experience, Degree or higher, teachers' possession of computer skills and Teaching Methods explored by the teacher.The fitted teacher quality factors accounted for 10.4% of variation while unobserved teacher heterogeneity explains 27.8%. The significance of teacher quality factors such as experience, education and methods of teaching in the model with fixed effect or teacher heterogeneity suggest that not only these quality factors are important; there are also some unobservable characteristics of a teacher that drive differences in students' performances. The studies on teacher quality factors have noted that teachers' heterogeneity is influenced by teachers' innate ability and pre-service education. These unobserved factors accounted for 27.8% variation in reading scores in this study. Teachers' heterogeneity is said to be influenced by teachers' innate ability and pre-service education because the variation still existed after all quality factors have being considered.

The teachers' propensity to collaborate with other teachers became insignificant in the model. With a negative coefficient, the interpretation suggests that teachers may have not been honest about their collaboration effort with other teachers within the school. If the teacher interacts with others on issues concerning to students work, the positive correlation is expected with students performance. In the next section, the effect of teacher qualities and fixed effect was studied controlling for the teacher demographics, student level factors and school specific factors.

The effect of Teachers Characteristics on Teachers Quality

Adjusting for teachers' demographics in the model with teacher fixed effects showed that the effects of each quality traits on students' performance change in magnitude but the significance of each variable remains qualitatively the same with the model with no teachers' demographic characteristics discussed above. Only teachers' gender has been used at this stage to determine significance of teachers' demographics on the quality of the teacher to impact on students' performance. Teachers' age was correlated with teachers experience and hence not included in the model. A slight difference especially on the effect of years of experience suggests that male teachers and female teachers use their experience differently in teaching students.

Figure 2: 95% CI for Estimates of the Effects of Teacher quality factors on Learners Reading Performance Controlling for Teacher Sex
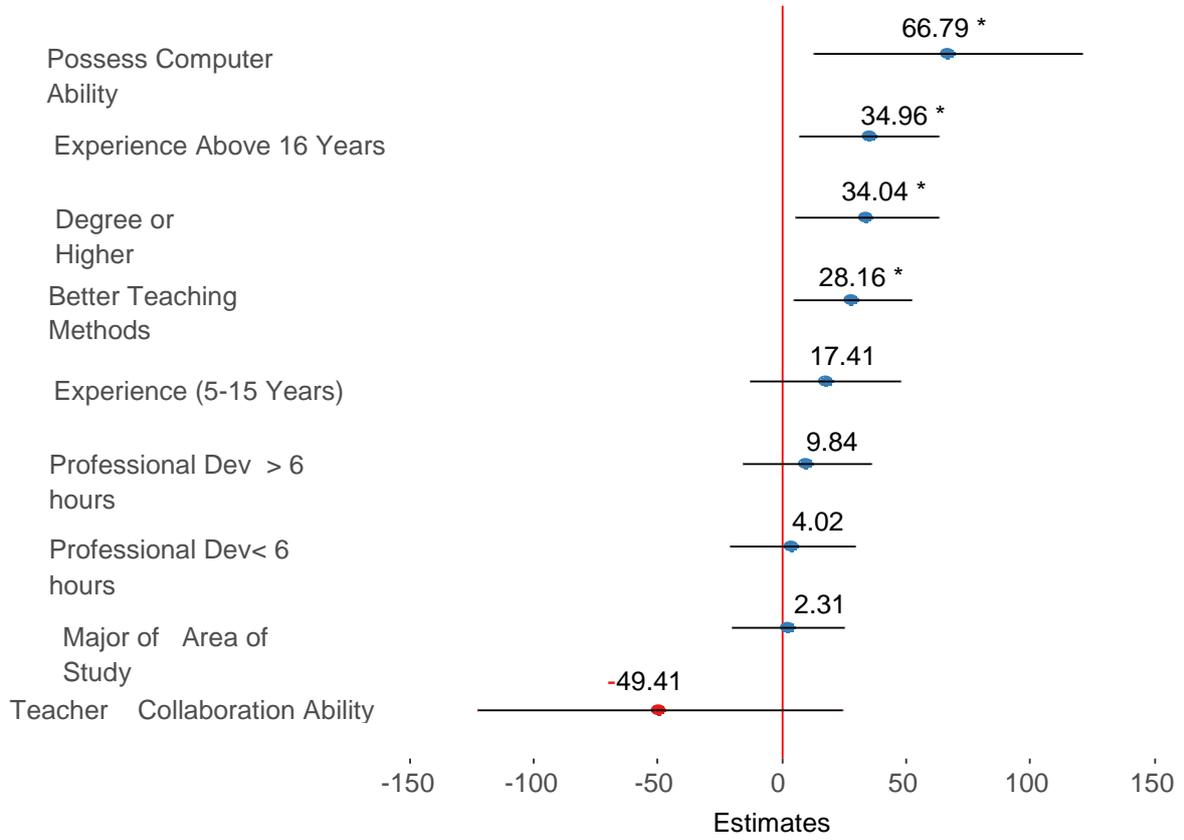
The effect of School Characteristics on Teachers Quality

Figure 3: 95% CI for Estimates of the Effects of Teacher quality factors on Learners Reading Performance Controlling for School Characteristics
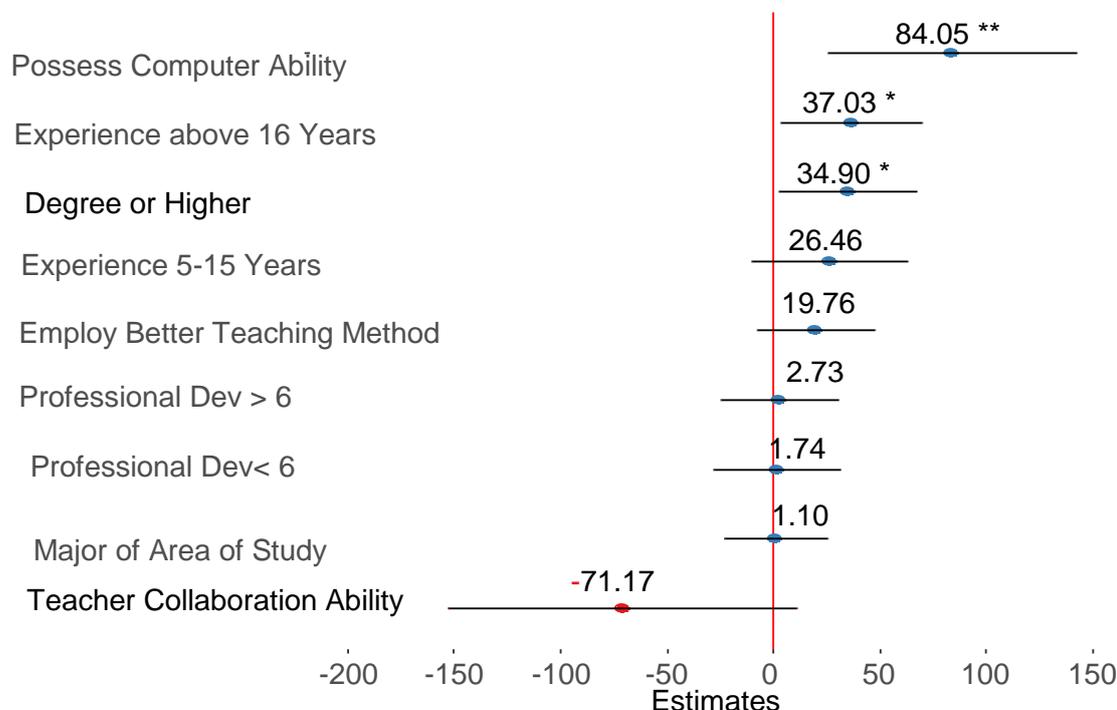

Figure 3 above presents the estimates of the impact of teacher quality characteristics on students' achievements from models with differing controls for teacher job satisfaction in school, teachers' understanding and implementing of the curricular, parental support, safety in school, students behavior, school resources, class sizes etc. The inclusion of the school factors altered the effects estimates of the quality factors, the factors changed in the magnitude of the effect when school factors were included compared to the values obtained from the same factors when the schools factors were not controlled for. Further, the factor on "Employ Better Teaching Methods" become insignificant when school factors was controlled. The change in significance of the teachers' quality variables suggests the importance of school factors on teachers' quality factors. There was a correlation between the school factors and the teaching methods. The insignificant of the factor representing teaching methods suggested that school environment affect the teaching methods. Schools with better teaching environment would compensate for the effect of better teaching methods compared to school which employ better teaching method but operating on unhealthy teaching environment. Since the model included a factor on teacher effect to control for unmeasured aspects of teachers' quality in a model with school factors controlled, significant change in the effects estimates of teacher quality factors imply that the teacher effect is useful to controls for any unobserved teacher quality that might correlate with school factors that affects teachers' effectiveness in class. Sass et al. (2014) suggested that this scenario may occur due to correlation between teacher qualities with the school characteristics due to non-random assignment of teachers to schools. This implies that a quality of teacher is enhanced by a quality characteristic of the schools.

The effect of Students Characteristics on Teachers Quality

Figure 4: 95% CI for Estimates of the Effects of Teacher quality factors on Learners Reading Performance Controlling for Learners Characteristics
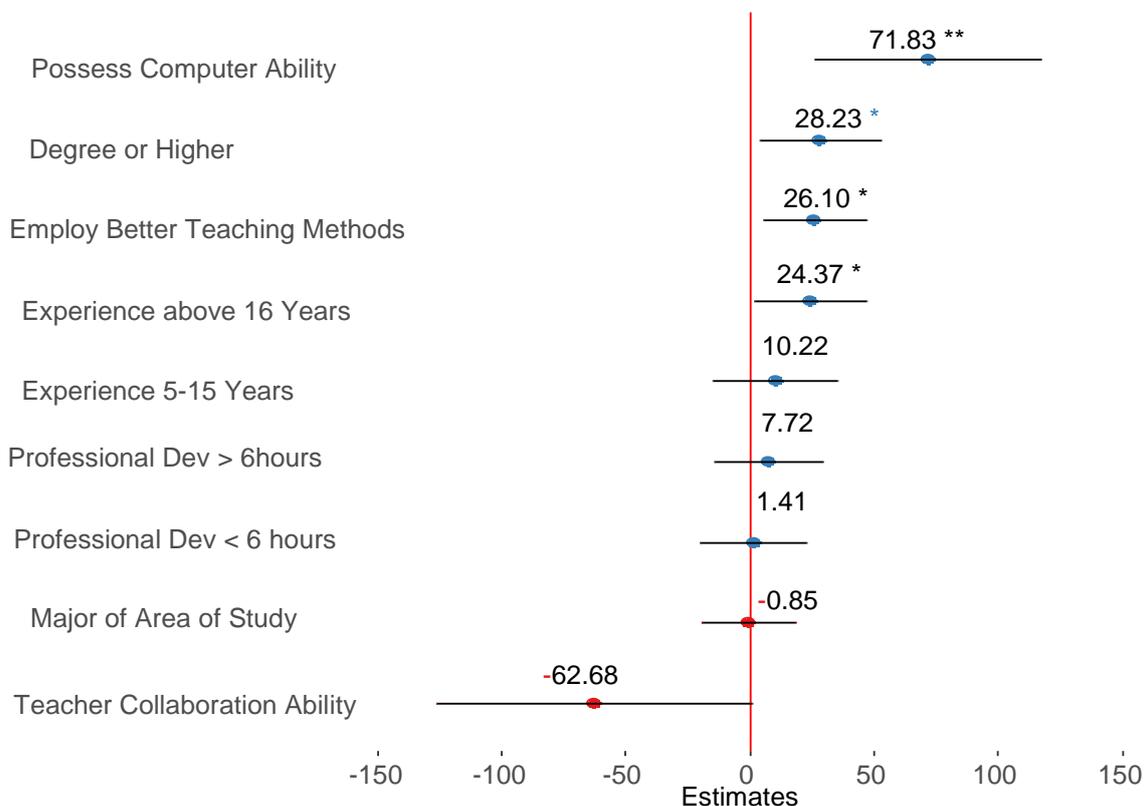

Figure 4 above presents the estimates of the Value-Added Model for the impact of teachers' quality on students' achievements taking into account students factors and teachers fixed effects. The students factors used in this analysis are gender, amount of home possessions, frequency of bullying at school, parental support and students perceptions about reading lesions. When students' factor is considered in the model, four (4) teacher quality factors remained significant; Teacher possesses computer ability, Degree or higher, Experience beyond 16 years and Employ better teaching methods. These factors were also significant in the first model when only teacher quality factors were fitted. The results were not surprising as the model included also the teacher fixed effect which controls for heterogeneity between teachers which might be correlated with students' behaviors and demographics factors. If teacher fixed effect parameter had not been included we expected the estimates on teacher quality factors to change significantly. This is an indication that the variation within teachers was significant in determining the learners reading achievements.

Teacher Added Value

The impact of teachers experience vanished when students' covariates were included in the model with teachers fixed effects. Since students were not randomly assigned to teachers the results suggests that there was a correlation between teachers' unobserved characteristics and students covariates.

In this analysis the teacher fixed effect was measured as a random factor representing the added value of the teacher to the learners reading score. Similar approach was used by Sass et al. (2014). They further urged that teacher fixed effects showed unobserved teachers qualities which an individual teacher is endowed with at birth such as innate ability and pre service education.

The value added by the teacher to learners reading score has been displayed in a caterpillar plots as shown in figure 5 below.

Figure 5: 95% CI of Estimates of Teacher Added Value on Learners Achievement

The figure shows the mean added value of each teacher and the horizontal line are the 95% CI of each mean. In the graph, teachers ID are in the x- axis and the y-axis is the estimated mean of added value. The teachers were ranked by the mean added value, the teacher at the bottom had lower mean score compared the teacher at the top. A negative mean added value suggest that such a teacher had a negative impact on the learners scores and positive value suggests such a teacher improves learners performance. This shows that some teachers are more effective than others in influencing learners score. The estimated mean value added of teachers ranges from a value around -87 to a value around 145.
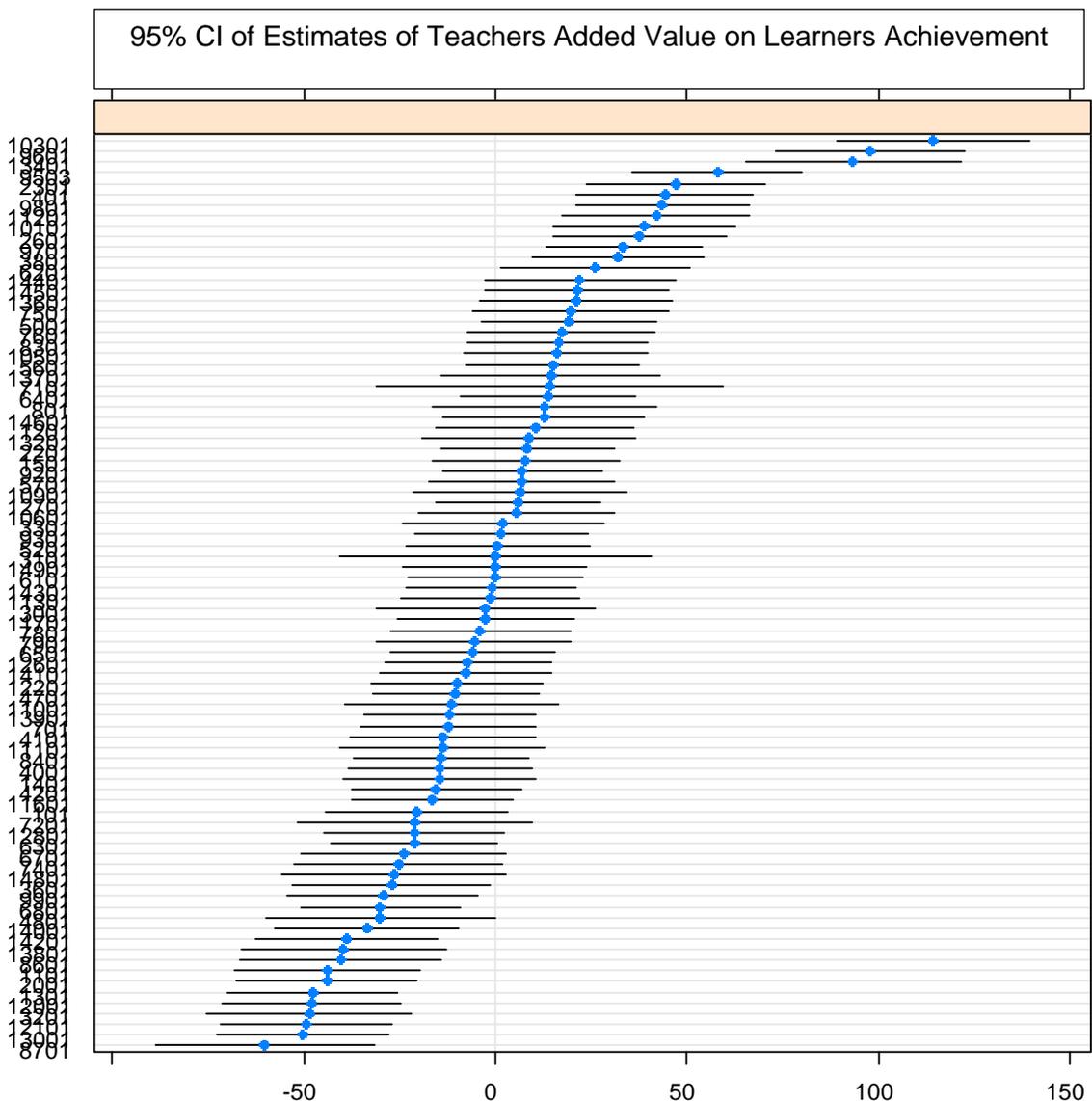
It can be noted from Table 1 below that a teacher who falls within 50% percentile ranking would decrease learner score by -8.20 points on average. Simply means that 50% of the teachers were ineffective in improving performance of the learners. Actually a teacher at 58% percentile had a negative added value of -0.86 points to the learner.

Table 1: Percentile Rank of Mean Added Value

Percentile Rank	10%	20%	30%	40%	50 %	60 %	70%	80%	90%	100%
Value Added	-54.64	-38.71	-24.51	-16.89	-8.2	0.55	14.46	32.36	66.88	153.63

The study shows that teachers ranked higher in the distribution of teacher effects or added value, reflect high levels of the significant quality attributes; experience, qualification, computer ability and frequent use of better strategies classroom teaching. This shows that teacher's added value is correlated with teacher significant quality factors. There is however a lot of heterogeneity in teachers which was strongly associated with learners performance but accounted by observable quality traits.

Discussion and Conclusion

The importance of teacher in students' scores was measured by teacher fixed effects which is an unobserved phenomenon representing the worth of a teacher to students school outcomes. The results pointed out that teacher fixed effect controls a significant amount of teachers' quality which is not observed by quality traits of teacher such as education, experience, teaching methods etc. Hanushek in a series of paper starting with Hanushek (1971), Hanushek (1986) and recently Hanushek et al. (2005) used fixed effects in analysis of students' achievement scores. He used dummy variables representing student classroom to measure teachers' fixed effect. His argument was that if classroom effect is significant in students' scores when each class is represented by one teacher, it means that the differences in students' scores is explainable by the teacher hence there exist teacher fixed effect. Teachers' level of experience was measured by the number of years the teacher was teaching and it was only significant at 10% level. Rockoff (2003) found that a year of experience was statistically significant in reading subject. However, in many studies found that it is not significant. The truth is that marginal effect of experience declines quickly and any gain from experience is apparent only in the first few years of teaching. In this study the plot of mean achievements of reading against years of teaching is a flat curve indicating that the mean performance is relatively the same for all levels of experience as shown in Figure 6 below.

Fig 6 :Mean Performance against Years of Experience
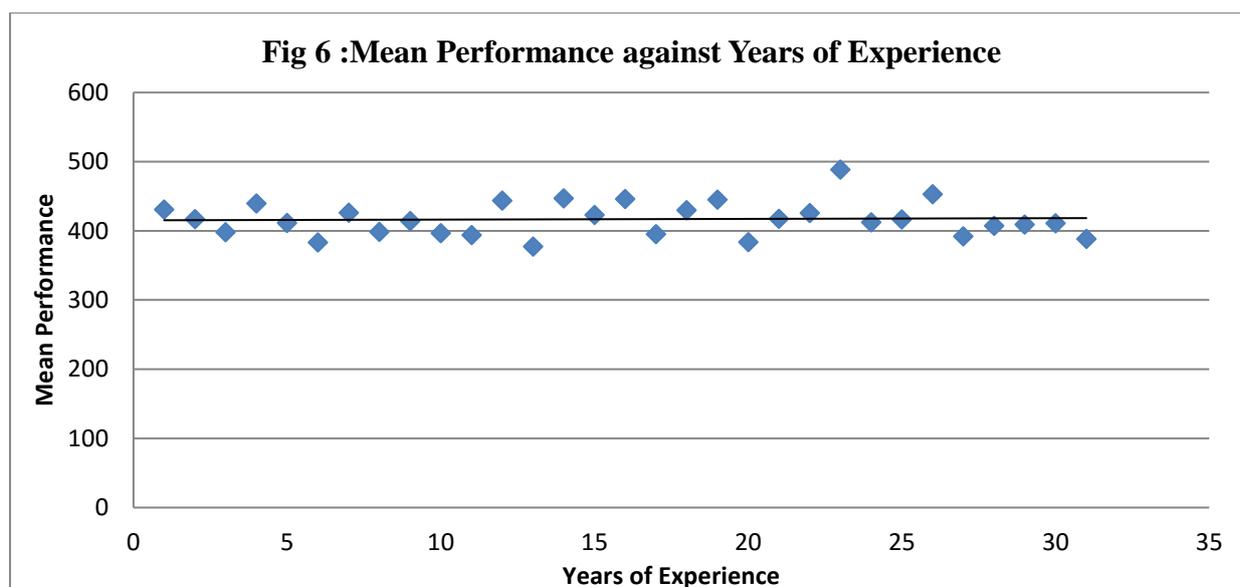
However, it is evident that teacher's level of experience is influenced by both school factors and students' factors controlling for teachers fixed effect. The insight that can be deduced from this assertion is that teacher level of experience has a limitation in students' achievements. In schools where resources are scarce and students attitudes are poor teachers' experience would not help students to perform better.

In all fitted models, educational achievement of the teacher is resistant to changes in the exogenous factors of the students and teacher. Teacher educational status remains significant in the model with fixed effect. The inference made here is that the teachers' level of education is not affected by both students and school characteristics. In Sass et al. (2014) teachers' advanced degree remains unchanged in the model with fixed effect and concluded that teachers' fixed effect was able to control for unobserved teacher quality that might be correlated with students and school characteristics. However, in the model without teachers effect, teacher level of education remains significant but with a smaller coefficient. Therefore, the same conclusion as in Sass et al. (2014) was reached. Jacob & Lefgren, (2007) also found a significant relationship between teacher's level of qualification and students performance but warned that the relationship was not causal because there were many factors involved.

In conclusion the study reveals that the most important characteristics of a good and effective teacher are; Years of Experience, Level of Education Completed, Teaching Methods used and Ability to use Computer to prepare.

These factors accounted for 11.9% difference in learners' achievements when school and learners' characteristics are controlled. Even after taking into account teachers quality factors there existed heterogeneity in the teachers which accounted for 19.29% of differences in performance when learners and school factors are controlled. The study postulated that the difference is influenced by the innate ability of the teacher and the pre-services education. The results suggest that among teachers with similar characteristics experience, education, computer literacy, etc., their influence to learners' performance would strongly depend upon their interest to the field of teaching, degree of sacrifice they have to teaching, etc. Therefore it may be necessary for the accountability systems to develop a competency based test to admit the teachers to college of education that check other aspects of teacher before they start their teaching carrier.

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