DIFFERENTIALS IN STUDENT ACADEMIC ACHIEVEMENT: A HIERARCHICAL LINEAR MODELLING OF PRIMARY SCHOOL EFFECTS IN MUMIAS AND KURIA EAST SUB-COUNTIES, KENYA

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University or for any other award

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DEDICATION

I dedicate this thesis to my sons Sifa Alakara and Amani Ejakait who in future, by God's Grace, will probably live to write better theses than their father's.

ABSTRACT

Spurred by the Coleman Report of 1966 on the Equality of Educational Opportunity in the US, the past five decades have seen rapid expansion in academic achievement surveys albeit fraught with mixed findings and interpretation. Utilizing the education production function models, the surveys sought to test whether school or teacher-level variables explained more academic achievement variance than did student-level variables. Within this framework, this study examined the effect of primary school-level variables on student academic achievement in Mumias and Kuria East Sub-Counties. Despite heavy resource allocation to public primary schools under the Free Primary Education policy in terms of financial, human, material and capital inputs, student academic achievement in these schools has remained low compared with that in private primary schools. The study examined the effect of teacher-level variables, non-teacher school-level resource input variables and school-level aggregate variables on student academic achievement in the Kenya Certificate of Primary Education (KCPE) examination. Mumias and Kuria East Sub-Counties were randomly sampled from the top and bottom five percent Sub-Counties on a merit list of KCPE results for 2010-2012 respectively. Using the ex-post-facto research design, stratified random sampling using probability proportion to size was used to draw 1824 Class 8 students in 61 primary schools from target populations of 6120 and 161 respectively. Sixty-one head teachers and 305 teachers of Class 8 were purposively drawn from the sampled schools. Supervisors validated the instruments and the inter-item reliability correlation coefficient was 0.812, 0.793 and 0.778 for the school, teacher, and student questionnaires respectively after piloting in four schools, one public and one private in each of the Sub-Counties. Using Hierarchical Linear Modelling, teacher-level variables explained 1.05% of the 49.29% variance explained in Objective 1. A Likelihood Ratio (LR) test for this value ($\chi^2 = 24, p < .001$) suggested sufficient evidence to reject the null hypothesis that the teacher-level variables in the final Model had no statistically significant effect on student academic achievement. Under Objective 2, the non-teacher school-level resource inputs explained 2.71% of the 58.07% variance explained. A LR test for this value ($\chi^2 = 42, p < .001$) suggested sufficient evidence to reject the null hypothesis that these inputs had no statistically significant effect on student academic achievement in the KCPE examination at α .05. Under Objective 3, other school-level variables explained 49.31% of the 63.67% variance explained. A LR test for this value ($\chi^2 = 122, p < .001$) suggested that there was sufficient evidence to reject the null hypothesis that these variables had no statistically significant effect on students' KCPE scores. The conclusion is that school-level variables accounted for much of the variation in student academic achievement than did student or teacher. It is recommended that strong mentorship programmes for female students be initiated to improve their academic achievement. Day schools should maximally utilize their time while students should be allowed to borrow school and library books and other learning materials for private study during their free time away from school.

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LIST OF ACRONYMS

APHRC	African Populations and Health Research Centre
CCNED	City Council of Nairobi Education Department
SCDoE	Sub-County Director of Education
EFA	Education For All
EPF	Education Production Function
EPP	Expenditure Per Pupil
FPE	Free Primary Education
GER	Gross Enrolment Rate
HLM	Hierarchical Linear Model
IEA	International Association for the Evaluation of Educational Achievement
IQ	Intelligence Quotient
JCA	Joint Correspondence Analysis
KCPE	Kenya Certificate of Primary Education
KNEC	Kenya National Examinations Council
MCA	Multiple Correspondence Analysis
MDGs	Millennium Development Goals
NCST	National Council for Science and Technology
NER	Net Enrolment Rate
OLS	Ordinary Least Squares
PCA	Principal Components Analysis
PPS	Probability Proportion to Size
PTR	Pupil Teacher Ratio

SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SES	Socioeconomic Status
SSA	Sub-Saharan Africa
TIMSS	Third International Mathematics and Science Study
TPR	Textbook Pupil Ratio

CHAPTER ONE

INTRODUCTION

1.1 Background

The report by Coleman et al. (1966) is classic, and one of the earliest and widely quoted documents on the effect of school factors and family socioeconomic background on student academic achievement. The report had at the time, one of what was considered a controversial finding, but which has since sparked sustained research on factors associated with achievement. It argued that for the USA, out-of-school variables such as family background and neighbourhood characteristics accounted for the observed achievement differences between students. Building on this, researchers have found varied results with probably four main strands of findings seeming to come out. The first has argued that teacher variables, attributes, and quality have larger effect on student academic achievement than any other factors. For instance, one widely published researcher in education and on student academic achievement, Stephen Heyneman, has argued in several publications that the effect of school and teacher quality explained large positive academic achievement than did the students' socio-economic background (Heyneman, 1976a, 1976b, 1979, 1997; Heyneman & Loxley, 1982, 1983). Other researchers finding that student achievement is largely driven by teacher variables and quality are Sanders and Rivers (1996); Wright, Horn, and Sanders (1997); Alvidrez and Weinstein (1999); Darling-Hammond (1999); Laczko-Kerr and Berliner (2002); (Wenglinsky, 2002); Nye, Konstantopoulos, and Hedges (2004); (Rivkin, Hanushek, and Kain (2005); Caprara, Barbaranelli, Steca, and Malone (2006); Neild (2009) and Konstantopoulos and Chung (2011). Other than Heyneman's work from Uganda in the 70s, all the other studies listed that explore the effect of teacher variables on student academic achievement were not carried out in Africa. Again, almost all the listed studies did not model the effect of teacher-based variables on student achievement between public and private primary schools as well as between a top and low performing Sub-County/ region. This study modelled three teacher-level variables. These were teacher's age in years (t22a), number of in-service courses attended by the subject teacher in their respective subjects (t214), and the number of formal written tests in the teacher's subject (t227).

The second strand has argued that non-teacher school resource inputs such as Expenditure Per Pupil (EPP) have large effects on student achievement (Hedges, Laine, & Greenwald, 1994a, 1994b; Shimada, 2010). Eric Hanushek, a renowned Economics of Education scholar and researcher has however argued against findings suggesting that teacher or school resource inputs significantly explain a large portion of student academic achievement. His numerous publications have reported a lack of significant positive relationship between school-level variables and student achievement (Hanushek, 1971, 1979, 1981, 1986, 1989a, 1989b, 1991; Hanushek, 1994; Hanushek, 1997; Hanushek, 2001; Hanushek, 2003; Hanushek & Luque, 2003; Hanushek & Rivkin, 2009). However, Hedges, Laine, and Greenwald (1994a, 1994b) faulted these conclusions by Hanushek and insisted that teacher and school-level variables significantly affected student academic achievement. But Hanushek has insisted that there was no compelling evidence to suggest that this was the case (Hanushek, 2001; Hanushek & Luque, 2003). All the listed studies were not carried out in Africa and Kenya hence did not model non-teacher school resource inputs on student achievement scores in the KCPE examination. This study estimated the effect of four non-teacher school-level input variables on student academic achievement in Mumias and Kuria East Sub-Counties. These were: Whether a school had piped water (h31e), whether a school had electricity (h31f), whether a school had a typewriter (h31i), and whether a school had a feeding programme (h32).

The third strand has argued that school characteristics such as Pupil Teacher Ratio (PTR), Textbook Pupil Ratio (TPR) class size, school type, and teaching-learning processes have larger significant positive effects on student achievement than any other factors (Carbonaro & Elizabeth, 2010; Deutsch, 2003; Ejakait, Mutisya, Ezeh, Oketch, & Ngware, 2011; Hanushek & Rivkin, 2009; Hungi & Postlethwaite, 2009; Nye, Hedges, & Konstantopoulos, 1999; Nye, Hedges, & Konstantopoulos, 2002).

Of the listed studies, the one of Ejakait et al. (2011) is the only one that was done in Africa and Kenya in particular. Although it disaggregated the school variable into public and private, the study did not control for other school level variables such as teaching and learning materials, PTR, staffing norms and quality and class sizes among other variables. It is therefore possible that the effect of this finding is over-stated. This study seeks to fill those gaps by modelling the effect of school level variables on student academic achievement. This study modelled the effect of eight school-level variables on student academic in Mumias and Kuria East Sub-County. These were Sub-county (h16), boarding status at class 8 (h24a), mean parental contribution 0-10 scale (h218z), mean community school participation 0-10 scale (h227z), mean teacher years since first employment (h49a), number of female teachers (h432), number of graduate teachers (h487), and students disallowed from borrowing library books to take home (h5122).

The fourth argues alongside the findings of the Coleman Report (Coleman et al., 1966) that student input measures, usually proxied by socio-economic measures of the student, affect student performance more than school factors. It has been argued that these divergence and varying results probably stem from choice of data analysis techniques and the difficulty of controlling for other relevant achievement inputs due to conceptual and data limitations (Hanushek, 1997; Raudenbush & Willms, 1995; Rivkin et al., 2005). As a result, Hierarchical Linear Modelling (HLM) is now gaining lots of traction as one way of trying to achieve convergence in modelling student academic achievement when variables of interest are at different hierarchical units of analysis (Rabe-Hesketh & Skrondal, 2012; Raudenbush & Bryk, 2002).

This study modelled student-level variables as control variables for the study's three objectives. These were student sex (s21), student's age in years (s22a), student's years in current school (s23a), the number of times student spoke English in the 7 days preceding the interview (s27), student's wealth index (s313x), number of siblings (s36c), looking after younger relatives (s314a), looking after elderly relatives (s314b), cooking (s314d), House cleaning (s314e), fetching water (s314h), chopping fire wood (s314i), gardening/working in a vegetable garden (s314l), taking care of livestock (s314m), mother has some primary education (s332), mother has completed primary education (s333), mother has some secondary education (s334), mother has completed post-secondary training (s336), father has completed primary education (s353), father has completed post-secondary training (s356), number of times student has repeated classes (s58x), and student keeps negative company (s61x)

For Kenya, existing research evidence suggests that inadequate primary school resource inputs have an adverse effect on student academic achievement. The quality of schooling has and continues to be a major area of concern with results from the Southern and Eastern Africa Consortium for Measuring Education Quality (SACMEQ) III showing that one in every five pupils did not have all the three basic learning materials needed for effective participation in classroom activities (Southern and Eastern Africa Consortium for Measuring Education Quality, 2011). In the light of FPE which annually allocates finances for the purchase of text books, a worrying finding from the study suggested that at least four in every five pupils did not have sole use of mathematics textbooks and that most of the pupils without these mathematics textbooks were in public schools (Southern and Eastern Africa Consortium for Measuring Education Quality, 2011). Evidence from a longitudinal study in Nairobi's informal settlements suggested that while 65% of school-going children were enrolled in public schools in 2003 and about 66% in 2004, these figures had dropped to 56.7% in 2007, with the enrolment in informal private schools rising to 43.3% in 2007 from 34.4% in 2003, largely due to quality of education concerns in public primary schools (Oketch, Mutisya, Ngware, & Ezeh, 2010; Oketch, Mutisya, Ngware, Ezeh, & Epari, 2010).

Improving the quality of education is a top priority of Kenya's Education and training sectors as espoused in policy documents guiding the implementation of the education sector's strategic focus. These policy documents are: (a) The Sessional Paper No.1 of 2005 on a Policy Framework for Education, Training and Research: Meeting the Challenges of Education, Training and Research in Kenya in the 21st Century, (b) The Kenya Education Sector Support Programme (KESSP) 2005-2010 and (c) The Sessional Paper No.14 of 2012 on Reforming Education and Training Sectors in Kenya.

The documents' strategic focus is to meet EFA targets and Millennium Development Goals (MDGs) on education by improving access and the quality of education and training to all Kenyans (Ministry of Education, 2005a, 2005b; Ministry of Education & Ministry of Higher Education Science and Technolgy, 2012). In particular reference to quality education, the Sessional Paper No. 1 of 2005 notes that "…in order to meet the demands for the 21st century, our [Kenya] education and training programmes must be of the highest quality to compete favourably with the international standards…" (Republic of Kenya, 2005, p. 22). The Kenya Education Sector Report for 2008 acknowledges that issues around school and education quality are a major challenge towards meeting the targets of EFA and MDGs by 2015 (Republic of Kenya, 2008). The Sessional Paper No.14 of 2012 seeks to reform education in line with the Constitution and Vision 2030 and ensure access, equity and quality across all levels of Basic Education by 2020 (Ministry of Education & Ministry of Higher Education Science and Technolgy, 2012). By studying the effect of school-level variables on academic achievement at primary school level, this research seeks to contribute to the pursuit of EFA's goal 6 on improving the quality of education (The EFA Global Monitoring Report Team, 2004).

There has been a persistently wide gap in primary school academic achievement when scores between public and private schools or between top tier sub-counties and those at the bottom of the academic performance index are compared. Available evidence suggests that for the period between 2006 and 2013, private primary schools posted higher mean scores and produced the top individual-student scores in KCPE compared with government-aided primary schools (often called public) (Muindi & Ngirachu, 2010b; Oduor, 2014; The Kenya National Examinations Council, 2007, 2008, 2009;

Toili, 2013). This however masks the fact that there are some top performing government-aided primary schools just as there are low performing private primary schools. It is therefore not a general conclusion that all private primary schools are on top of the KCPE performance index table. The empirical gap that seeks attention is to identify possible school-level variables that are driving these differentials in academic achievement and which could be the focus of policy calibration to narrow this achievement gap.

With these concerns, some policy planning and investment questions are bound to be asked: Why would public primary schools continue to post low academic results compared with those posted by private primary schools despite heavy resource allocations under the FPE policy? Does this scenario suggest that heavy resource allocation alone may not be sufficient for good academic performance? In Kenya's context, what school-level factors can be targeted to improve school and education quality? This study seeks to contribute to this effort.

1.2 Statement of the Problem

Despite heavy resource allocation to public primary schools under the FPE policy in terms of financial, human, material and capital inputs, student academic achievement in these schools has remained low compared with that in private primary schools. Available statistics show that since 2006, public schools have comparatively posted a lower performance in KCPE compared with private schools. For instance in 2006, only 24 (17.4%) out of 138 pupils in the top 100 positions came from public schools (The Kenya National Examinations Council, 2007, 2008, 2009). In 2009, four private schools had a mean score of 400 and above while the best public primary school had

389. In the same year, 87 candidates out of the top 100 positions came from private schools (Muindi & Ngirachu, 2010a). Of the 121 pupils in the top 100 positions in 2010, only 26 (21%) were from public schools.

This pattern persisted into 2011 where only 10 of the top 50 schools were public and in 2012, the top ten schools nationally were private (Toili, 2013). All top 10 positions in the 2013 exam were taken by students from private primary schools (Oduor, 2014). Analysts and commentators suggest that this trend is indicative of the downside of free learning (Nation Reporter, 2012).

To understand and isolate the variables driving this observed academic achievement gap between schools at student, teacher and school levels, this study fitted Hierarchical Linear Models (HLM) with students (level 1) nested within teachers (level 2) nested within schools (level 3). The HLM has methodological advantages over ordinary least squares regression models which run into aggregation and disaggregation biases when they encounter hierarchical datasets. Hierarchical Linear Modelling is adept at relating variables at one level of analysis e.g. the students, to another level of analysis e.g. the teachers or classrooms and to yet another level of analysis e.g. the school. This HLM model therefore helped fill the analytical gaps and shortcomings that have bedevilled attempts at modelling student academic achievement, which often, is a product of variables at different units of analysis.

1.3 Purpose of the Study

The purpose of this study was to examine differentials in student academic achievement using a hierarchical linear modelling of primary school effects in Mumias and Kuria East Sub-Counties.

1.4 Objectives of the Study

The study set out to:

i) Examine the relationship between teacher-level variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties;

ii) Establish the relationship between non-teacher school-level resource inputs and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties;

iii) Determine the relationship between school-level characteristics and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties.

1.5 Hypotheses

The study tested the following null hypotheses for statistically significant relationships between school-level variables and student academic achievement in KCPE:

$H_0 1$: There was no statistically significant relationship between teacher-level variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties;

$H_0 2$: There was no statistically significant relationship between non-teacher school-level resource inputs and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties;

$H_0 3$: There was no statistically significant relationship between school-level characteristics and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties.

1.6 Significance of the Study

Much of academic learning for students at basic levels of education takes place in learning institutions such as schools. It is believed that if such institutions are of high quality, then the learning experiences of students will be enriched and the schooling outcomes will be more fulfilling and of high quality. With significant differences in academic achievement between students in public and private primary schools, this study examined the influence of school-level variables on such academic achievement. Another motivating factor for this study was informed by research gaps in student achievement literature in developing countries, and especially after the implementation of free primary education policies in several countries in Sub-Saharan Africa (SSA). Few studies that have attempted to look at student achievement in Sub-Saharan Africa (SSA) and Kenya have often omitted private schools from their samples. Results from such studies have often therefore addressed schooling outcomes in public schools only. Because of these methodological and data limitations, most previous studies on primary school achievement in Kenya have either glossed over the issue or have given one-sided results. This study sought to fill these methodological and data gaps by modelling the effect of this public-private school dichotomy involving five subject areas and a rich pool of variables at school level adjusting for individual pupil characteristics, family and socio-economic status. Examination/test scores are often one of the variables used to judge school/education quality, school effectiveness and may even be used to determine resource allocation (Lee & Barro, 2001). Finally, this study also hoped to contribute to literature and discourse on student academic achievement in primary schools in Kenya.

1.7 Assumptions of the Study

The study made the following assumptions:

i) That the KCPE candidates for the year 2014 were old and knowledgeable enough to give data on their individual family background and asset ownership that was used to determine their socio-economic status (SES).

ii) That the sampled candidates would put in honest work in their KCPE examination devoid of cheating and that they would receive their full results.

iii) That school level data on staffing, enrolment, resources and curriculum implementation collected from individual schools would be authentic.

1.8 The Scope of the Study

As mentioned, the study involved the KCPE candidates in 2014 in public and private primary schools in Mumias and Kuria East Sub-Counties. Any other students in primary schools or any other learning institution were therefore outside the scope of the study. The outcome variable was student academic achievement as measured by KCPE examination results for the year 2014. Any other measures of student achievement such as in co-curricular activities were outside the scope of this study. For logistical and professional reasons, the study did not involve learners with special educational needs as these would require professionally trained personnel to administer questionnaires. Their examinations and the conditions of sitting such examinations were also different from those for students without special learning requirements.

1.9 Limitations of the Study

The study was limited in the following ways:

i) While family background and household data such as asset ownership are best collected from heads of households, for logistical reasons, this study collected such data from students who were members of such households. Some of these students may have been limited in what they knew about their family background such as careers and educational attainment levels of their parents or guardians. To ameliorate this, the study used plain and non-technical language in phrasing the questionnaire items and explained each item during questionnaire administration.

ii) This study did not measure the intelligence quotient (IQ) of the students before they took their KCPE exams as this was a highly technical measure that the researcher was not experienced in. The students' IQ scores may be one of the predictors and drivers of variations in academic achievement. The researcher collected many control variables at student, teacher and school levels that helped explain variations in student academic achievement between students.

iii) Mumias and Kuria East Sub-Counties did not have sufficient number of private primary schools to permit comparative analysis at Level-3 (school-level) with public schools between the two Sub-Counties. At least 20 groups are required at each of the higher levels of nesting.

1.10 The Theoretical Framework

The study used the Education Production Function (EPF) which has its foundations in the Coleman Report of (1966) and as espoused by Hanushek (1971, 1979, 1986, 1997, 2003). The Report was the product of a study into the distribution of educational resources within the United States of America (US) by race in order to ascertain which of the various inputs into the educational process were most important in determining the achievement of students. The Report is best known for what was thought to be controversial in its findings and conclusions then. It argued that for the USA, out-of-school variables such as family background and neighbourhood characteristics accounted for the observed achievement differentials between students.

Studies of the EPF nature (sometimes also called "input-output" analysis) examine the relationship among the different inputs into and outcomes of the educational processes. The studies are systematic, quantitative investigations, sometimes requiring econometric analysis to separate the various factors influencing student performance (Hanushek, 1979). Since these factors are often at different units of analysis, multilevel models such as HLM have gained statistical acceptance in modelling such data for such studies.

The typical EPF model is suited for straight cases such as how much capital and labour to employ in producing a certain output. Often, knowledge of the production function and the pricing of each of the inputs allow a straight forward answer e.g. of the least cost set of inputs (Hanushek, 1986). But in education, the output of the educational processes such as student academic achievement is directly related to a series of inputs.

Some of these inputs such as the characteristics of schools, teachers (professional training, experience etc.), curricula, pupil teacher ratios, expenditure per pupil, etc. can be controlled by the policy making process while other inputs such as those of households, parental education background, socio-economic status of the student, inputs by friends and the individual student attributes may not be controlled (Hanushek, 1989b, 1997). Also, while achievements may be measured at discrete points in time, the educational process is cumulative with inputs having occurred at some time in the past but whose effects can be seen in the students' current levels of achievement (Hanushek, 2003). Caldas (1993) has labelled student input variables as input factors and school input variables as process factors. Lamdin (1996) has argued that in education, the input-output approach is appropriate since there is no universally accepted single output measure. The education process may be characterized by multiple outputs. Also, the implicit assumption of an optimizing producer allocating inputs may not be tenable in the case of education. Test scores that measure cognitive performance are general. This study followed Lamdin (1996) in specifying student, teacher and school variables as inputs and student academic achievement as one of the outputs. Two and three Hierarchical Linear Models were used for analysis since the outcome variable was at student level and the students were nested within teachers who were in turn nested within schools.

1.11 The Conceptual Framework

Student academic achievement at any point is a cumulative function of school-level factors, family background and SES, individual student characteristics, peer group effects as well as community-level factors. This study sought to clarify the linkages between school-level factors and student academic achievement. But since these school level factors were not the only explanatory factors in student academic achievement, the study controlled for individual student characteristics, family background and SES, parental involvement, peer group influence and community level effects. Figure 1 presents the conceptualization of the interaction of variables in the study.

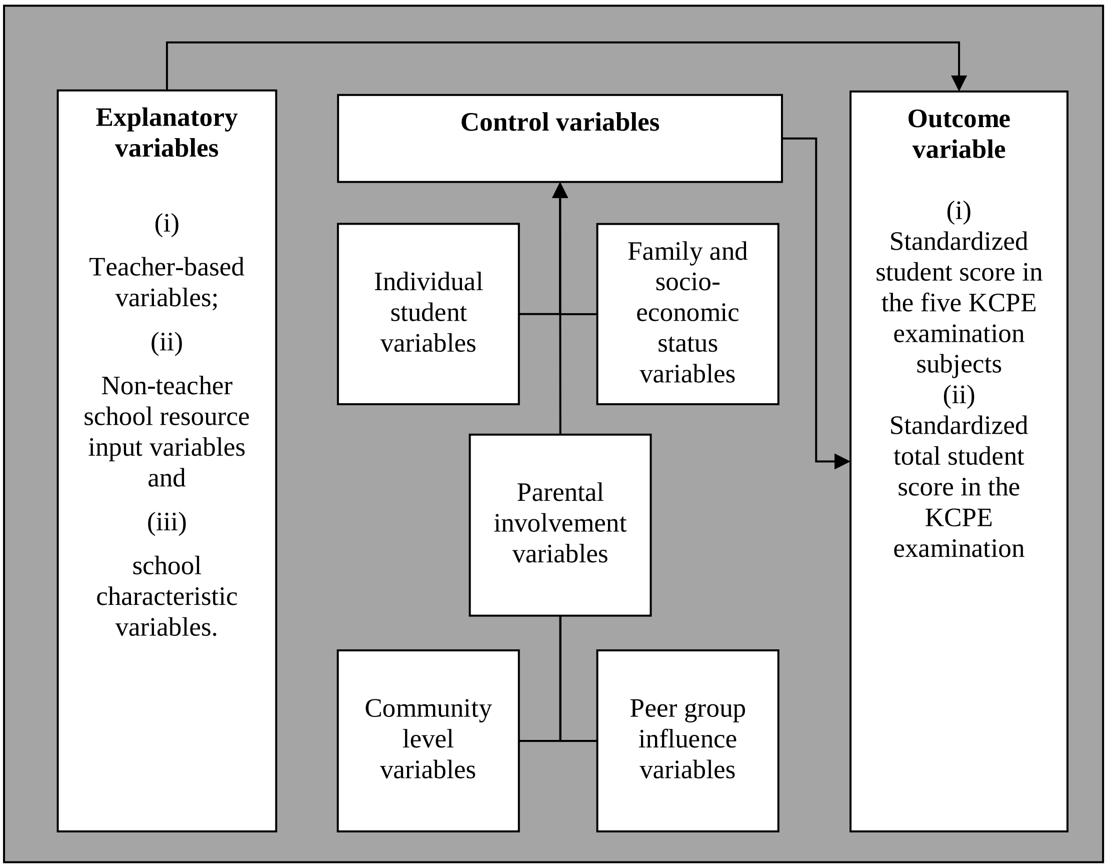

Figure 1.1. Researcher's Conceptual Framework Showing the Linkages Between Variables.

For Objective 1, individual student scores in the five KCPE subject areas were the outcome variables measured on the interval scale. For Objectives 2 and 3, the outcome variable was a summation of these five scores. For ease of interpretation, these KCPE scores were transformed to standard scores with $\bar{x} = 0$, $S = 1$, and $s^2 = 1$. Controlling for individual student variables, family and socio-economic status variables, parental involvement variables, community level variables and peer group influence variables, the conceptual framework modelled the effect of teacher-based variables on the individual five KCPE scores in Objective 1. Using the same control variables, the effects of non-teacher school resource input variables and school characteristic variables on students' individual total KCPE score were modelled in Objectives 2 and 3 respectively.

1.12 Operational Definition of Terms

Academic Achievement	Academic achievement or (academic) performance is the extent to which a student, teacher or institution has achieved their short or long-term educational goals. Academic achievement is commonly measured through examinations or continuous assessments and for this study, such achievement was measured through the Kenya Certificate of Primary Education examination raw scores in five subjects areas of English, Kiswahili, Mathematics Science and Social and Religious Studies transformed to normal standard scores with $\bar{x}$=0, S=1, and S^2=1.
Community-Level Effects	Support to schools in a bid to improve academic standards.
Family Background	Variables covering family details such as educational levels of parents and the student's siblings
Family Socio-Economic Status	Determined from household asset ownership using Multiple Correspondence Analysis (MCA) and categorized into three SES quintiles (High, Middle, Low)

Hierarchical Linear Model	Hierarchical Linear Modelling (HLM) is a complex form of ordinary least squares (OLS) regression that is used to analyse variance in the outcome variables when the predictor variables are at varying hierarchical levels. For example, students in a classroom share variance according to their common teacher and common classroom. Prior to the development of HLM, hierarchical data were commonly assessed using fixed parameter simple linear regression techniques; however, these techniques were insufficient for such analyses due to their neglect of the shared variance. An algorithm to facilitate covariance component estimation for unbalanced data was introduced in the early 1980s. This development allowed for widespread application of HLM to multilevel data analysis and following this advancement in statistical theory, HLM's popularity flourished.
Parental Involvement	Involvement at school or at home in the academic matters of students
Peer Group Effects	Factors such as use of leisure time, drug and substance use, and academic performance of the peers and friends of sampled students.
Private School	A school which is not established or maintained out of public funds

Public School	A school established and maintained out of public funds
School effects	Variables or factors at school level that may affect student academic achievement. These include teacher-based variables such as sex, age, teaching experience, educational attainment, professional training and syllabus coverage among others. Non-teacher school resource input variables include whether or not the school has a library, staff room, store room, piped water, electricity, sports field, telephone, radio, computer, garden, school feeding programme and fees and, levies charged. School characteristic variables include type of school, sponsorship, year of establishment (school age), number of teachers, pupil teacher ratio, textbook pupil ratio, parental and community involvement in school life and number of quality assurance visits, support and inspection among others.
School Quality	The success with which a school achieves learners' cognitive development as the major explicit objective of all education systems as well as promoting equity, values, attitudes of responsible citizenship and in nurturing creative and emotional development of the learners (United Nations Educational Scientific and Cultural Organization, 2004)

Student Characteristics	Individual student variables such as sex, age and use of leisure time and involvement in drug and substance use

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of related literature on the relationship between school-level variables and student academic achievement. These variables were categorized into (a) teacher-level variables; (b) non-teacher school-level resource inputs and (c) school-level characteristic variables. The review proceeded along this structure and begun with an overview of the literature on student academic achievement which was the outcome variable.

2.2. An Overview of Literature on Student Academic Achievement

Despite the large body of existing literature on the effect of school factors on achievement, the results remain variable largely because of choice of data analysis techniques and the difficulty of controlling for other relevant achievement inputs due to conceptual and data limitations (Rivkin et al., 2005).

Hanushek (1997) reviewed close to 400 studies on student achievement and argued that after accounting for family inputs, this large body of literature did not present compelling or consistent results that suggest a relationship between student performance and school resources.

2.3 Concerns About School Quality and Education Outcomes

Existing research evidence suggests that the quality of schooling has and continues to be a major area of concern for many countries. The problem however appears more acute in developing countries. Fuller (1985) reviewed major findings from 1970-1985 on school quality in developing countries and presented very worrying trends. Some of the findings suggested school quality made a substantial difference in developing countries even after controlling for the effects of the child's pre-school background and economic context. Despite these findings, little progress had been made in improving such quality among the poorest developing nations since 1970 (Fuller, 1985). Some of the 72 empirical studies reviewed by Fuller suggested that the inputs consistently influencing achievement were the instructional processes such as textbooks, writing materials, and teacher quality. Some studies have also found a relationship between school quality and earnings in the labour market with earnings of white male workers in the United States of America (USA) depending significantly on which high school they had attended (Betts, 1995).

The World Declaration on Education for All recommended that dealing with poor quality of education would call for improving the delivery of education while making it universally available and more relevant (Executive Secretariat of the World Conference on Education for All, 1990). It also recognized that expanding access alone would not be sufficient and that emphasis needed to be placed on assuring an increase in children’s cognitive development by improving the quality of their education (Executive Secretariat of the World Conference on Education for All, 1990).

The Dakar framework for action on EFA by 2015 also noted that quality was central to education and there was need to have it satisfy basic learning needs and enrich the lives of learners and their overall experience (World Education Forum Drafting Committee, 2000). The declaration advised that efforts to expand enrolment should ideally be accompanied with attempts to improve educational quality to attract children to school, maintain them there and guarantee meaningful learning outcomes. Specifically, EFA's goal six targets at;

> Improving all aspects of the quality of education and ensuring excellence of all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills (World Education Forum Drafting Committee, 2000, p. 8).

Mid-way the timeframe for achieving these goals, the EFA global monitoring report for 2008 noted that key conclusions from international and regional student assessments pointed to low learning outcomes in many countries and that achievement levels were lower in developing than in developed countries. The report further noted that school level factors, family background and socio-economic status affect student learning and achievement (The EFA Global Monitoring Report Team, 2007).

Cross-country studies in SSA under the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) suggest that there were declines in student academic scores (of up to 4%) between SACMEQ I (1995/96) and SACMEQ II (2000/01) for Mauritius, Zanzibar, Namibia, Zambia, and Malawi, although this was statistically significant only for Malawi, Namibia and Zambia (The EFA Global Monitoring Report Team, 2004). The SACMEQ carries out research in 15 countries in Southern and Eastern Africa (Angola, Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe [Tanzania and Zanzibar are one country]). Since its inception in 1995, SACMEQ has completed three research projects, SACMEQ I (1995-1998) SACMEQ II (1999-2004) and SACMEQ III (2007-2009). By November 2013, data for SACMEQ IV had already been collected in 12 countries and data entry and management was underway (Southern and Eastern Africa Consortium for Measuring Education Quality, 2012, 2014).

Odhiambo (2008) argues that Kenya's problem with education quality does not lie with the teachers but with management practices and other government policies which need to be changed. These concerns on the quality of education in schools suggest that there is still a lot that needs to be done by governments, schools, households, researchers and other actors.

2.4 Modelling Student Academic Achievement

There are certainly many peer reviewed publications on student academic achievement since this has been a topic of interest to many researchers and policy analysts since the 60s. The differentiating mark between these publications continues to be the analytical strategy chosen by the authors. Most of the studies employed Ordinary Least Regression (OLS) regression techniques in analyzing the data. One limitation with such techniques is that they are not sensitive to the hierarchical nature of the data. Hierarchical Linear Modelling involves relating variables at one level of analysis e.g. the students, to another level of analysis e.g. the teachers or classrooms and to yet another level of analysis e.g. the school (Rabe-Hesketh & Skrondal, 2012). Studies using OLS tend to either aggregate student data to the school level or to disaggregate school data to the student level. The first approach can introduce aggregation biases into the models, the second approach can seriously underestimate standard errors, and both approaches can miss important information about the nature of the school effects (Bryk & Raudenbush, 1992; Rabe-Hesketh & Skrondal, 2012; Wenglinsky, 2002).

A second limitation with OLS techniques is their failure to take measurement error into account. These techniques assume that the variables in the models are perfectly measured by the observed data. More often, the operationalization of most variables is subject to substantial error, both because the operationalization does not correspond perfectly to the model (e.g. parents' income as a proxy for socioeconomic status) and because data collection procedures are error-prone (Raudenbush & Bryk, 2002). Failing to take measurement error into account can lead to biased estimates of model coefficients (Goldstein, 1995; Wenglinsky, 2002).

A third limitation with OLS techniques is that they are not adept at measuring interrelationships among independent variables. School effects often involve a multi-step process, in which one school characteristic influences another that may, in turn, influence the outcome of interest. While it is possible to run a series of models that regress each independent variable on the others, such models tend to be cumbersome and lack precision in measuring the overall fit of the series of models (Raudenbush & Bryk, 2002). Because of these difficulties, school effects research often neglects the indirect effects of various school characteristics (Hardin & Hilbe, 2012; Wenglinsky, 2002).

The researcher's data structure is nested (also called hierarchical or multilevel) because such data naturally divide into groups that have something in common such as students attending the same school or patients treated by the same doctor with the different doctors themselves working at the same hospital (Rabe-Hesketh & Skrondal, 2012). With this structure of the data, the most appropriate analysis strategy is to use Hierarchical Linear Modelling (HLM) or sometimes also called Generalized Linear Mixed Models (GLMM). The models are "mixed" in order to allow for fixed and random effects, and are "generalized" because they are appropriate for continuous Gaussian responses as well as binary, count, and other types of limited dependent variables (Bryk & Raudenbush, 1992; Rabe-Hesketh & Skrondal, 2012; Raudenbush & Bryk, 2002). Following this specification, the researcher proposes to fit a three-level hierarchical linear model with students (level 1) nested within teachers (level 2) nested within schools (level 3) (Bryk & Raudenbush, 1992; Hungi & Thuku, 2010; Nye et al., 2004; Rabe-Hesketh & Skrondal, 2012; Raudenbush & Bryk, 2002; Shimada, 2010).

2.4.1 The Relationship Between Teacher-based Variables and Student Academic Achievement

Stephen Heyneman is one of the scholars who have carried out many studies on schooling outcomes since the 70s. He is among researchers finding that school level variables have greater effect on achievement than any other variables. For instance, while comparing results from Uganda and those from more industrialised nations, Heyneman concluded that the relationship between socio-economic status and academic achievement appeared weaker in less industrialized societies. His results also suggested that there was no relationship between the measures of a students' socio-economic background and their total academic achievement score on the National Primary Leaving Examination in the Uganda case (Heyneman, 1976a, 1976b).

Heyneman and Loxley (1982) re-analysed data from the International Association for the Evaluation of Educational Achievement (IEA) and found different results from those that had been found earlier. These data were collected from 10,000 schools, 50,000 teachers, recorded test scores in six subjects on about 260,000 students with about 500 independent variables. The IEA was the first attempt at modelling school and student background variables across countries. The initial findings from this study showed that students from privileged and richer backgrounds had higher academic achievement scores and that the "measure of parental education, occupational prestige, and other indicators of home circumstances was somewhat larger than the sum total of influence resulting from the measured effects of school and teacher quality" (Heyneman & Loxley, 1982, p. 8).

Heyneman and Loxley approached their analysis differently by examining the variables of interest at individual country level. They argued that original IEA results had systematically underestimated the effects of school and teacher quality because of how variables had been selected. For the four low income countries (at that time) in the IEA sample (India, Thailand, Iran and Chile), their re-analysis suggested that the portion of science achievement explained by school quality variables jumped from 11.5% to 20.8% and that the effect of school and teacher quality on achievement moved from 6% to 20% in Chile and from 8% to 28% in India (Heyneman & Loxley, 1982). These were data collected in the 70s and many things have certainly changed especially in Africa. This study seeks to model the effect of teacher-based variables on student academic achievement using their KCPE scores and attempt to contribute to the debate on what drives the observed achievement gap between students and between schools in Kenya.

Are teacher-based variables still as significant today as they were found in these studies more than 30 years ago?

In another study, Heyneman and Loxley (1983) examined the effect of primary school quality on academic achievement across 29 high and low income countries in Africa, Asia, Latin America and the Middle East. They concluded that teacher and school quality variables were the most important in influencing student learning and academic achievement. They also argued that ‘‘the poorer the national setting in economic terms, the more powerful this school and teacher quality effect appears to be” (Heyneman & Loxley, 1983, p. 1184). Their conclusion is commonly referred to as the ‘‘Heyneman–Loxley effect’’ or ‘‘HL effect’’ in educational literature and is considered important because it supports the linkage between educational achievement and national economic development. These findings are however silent on any differences between public and private schools or between students in such schools. This is probably because the study was limited to public schools. The analysis did also not employ HLM which was hardly used then. This study seeks to fill this gap by using HLM to model the effect of teacher-based variables on academic achievement between students and between schools (public and private schools) in two distinct Sub-Counties.

With a database of approximately 3 million records for Tennessee’s entire grade 2-6 student population for the period between 1990 and 1996 involving student achievement scores in mathematics, reading, language arts, science, and social studies, the Tennessee Value-Added Assessment System (TVAAS) investigated the cumulative effect of teachers on student academic achievement over grade levels. A summary of findings from this longitudinal study indicate that teacher effects were highly significant in 20 of the 30 analyses done and had larger effect sizes than any other factor. This study supports the view that the teacher is the most important factor affecting student learning (Sanders & Rivers, 1996; Wright et al., 1997).

Another interesting study that supports the centrality of teachers in predicting student academic achievement was done by Alvidrez and Weinstein (1999). They used data from Jack and Jeanne Block's 20-year longitudinal investigation of ego and cognitive development, which began in 1968 involving 128 boys and girls. The study examined relationships between preschool teachers' appraisals of intelligence, concurrent child characteristics, and future high school performance in a sample of 110 involving 4-year-olds (Alvidrez & Weinstein, 1999). The study found a moderate relationship between preschool teacher ratings of child ability and IQ scores at age 4 and some consistency between teacher perceptions of children from age 4 to age 11 (Alvidrez & Weinstein, 1999).

The prominence of the teacher’s importance in student academic achievement is also supported by findings from a 50-state survey of policies in the US in 94 schools using Staffing Surveys (SASS) and the National Assessment of Educational Progress (NAEP). The study examined the ways in which teacher qualifications and other school inputs were related to student achievement across states (Darling-Hammond, 1999). The findings suggest that policy investments in improving the quality of teachers may be related to improvements in student achievement. For instance, teacher preparation and certification were the strongest correlates of student achievement in reading and mathematics, both before and after controlling for student poverty and language status

(Darling-Hammond, 1999). The conclusion from this study perhaps points to the importance of good quality teachers. This US study however dealt only with public schools and did also not use HLM. The researcher proposes to use HLM and include private schools in the sample to enrich the analysis.

Although it may be difficult to get untrained teachers in service in Kenya's public primary schools, it may be possible to find such teachers in private schools. However, current teacher shortages have led schools, both public and private, to enlist the services of volunteers and other uncertified teachers. Laczko-Kerr and Berliner (2002), compared the academic achievements of students taught by regularly certified primary school teachers with the achievements of students taught by under-qualified and under-certified teachers in the US. The results suggested that students of certified teachers out-performed students of under-certified teachers. In reading, mathematics, and language, the students of certified teachers outperformed students of under-certified teachers by about 2 months on a grade equivalent scale (Laczko-Kerr & Berliner, 2002). The results further suggested that students of under-certified teachers made about 20% less academic growth per year compared with that made by students of teachers with regular certification. These results are interesting and from a Kenyan context, the researcher collected and analysed teacher-based variables such as their education, certification and experience among others to model their effect on student academic achievement.

Wenglinsky (2002) explored the link between classroom practices and student academic performance using Multilevel Structural Equation Modelling (MSEM) on the 1996 National Assessment of Educational Progress in mathematics in the US. The study concluded that the effects of classroom practices were comparable in size to those of student background especially when added to those of other teacher characteristics (Wenglinsky, 2002). This finding suggests that teachers can contribute as much to student learning as the students themselves.

Nye, Konstantopoulos, and Hedges (2004) used HLM on data from a four-year experiment involving teachers and students. These were randomly assigned to classes to estimate teacher effects on student achievement. They found that teachers had larger effects on achievement in mathematics than in reading and that there was a substantial relationship between teacher experience and student achievement gains. They also found that there was a larger teacher effect in low socioeconomic status (SES) schools than in high SES schools.

Rivkin et al. (2005) employed a value-added model on matched panel data from UTD Texas Schools Project containing test scores for three cohorts of students between grade three and seven in the mid-90s and found that teacher variables had huge effects on achievement in reading and mathematics and that the benefit of reducing class sizes was smaller than the benefit of improving teacher quality.

Using structural equation modelling, Caprara, Barbaranelli, Steca, and Malone (2006) examined teacher's self-efficacy beliefs and job satisfaction as well as student's academic achievement aggregated at the school level, focusing on indicators of school functioning. A sample of 2184 teachers in 75 Italian junior high schools was administered self-report questionnaires to assess self-efficacy beliefs and their job satisfaction. Standardized final examination grades at the end of the third year of junior high school were used to assess the students' achievement. The findings suggested that previous student's academic achievement predicted subsequent achievement as well as teacher's self-efficacy beliefs, which, in turn, contributed significantly to student's achievement and teacher's job satisfaction (Caprara et al., 2006).

Neild (2009) employed a three-level HLM on data created from a student report card and administrative files merged with human resource files on teacher characteristics from an urban district in the USA to estimate the impact of different teacher certification categories on middle-grades students’ learning gains in mathematics and science. The student sample comprised of grades 5 through 8 in all public, non-charter middle schools in the 2002-2003 school year. The findings suggested that in mathematics, students with elementary and secondary-certified teachers outscored those with uncertified teachers and those whose teachers were certified in special education. Strong effects were seen in science, where students with secondary science-certified teachers substantially outscored those with any other kind of teacher (Neild, 2009).

A more recent analysis of data from Project STAR and the Lasting Benefits Study in the USA by Konstantopoulos and Chung (2011) using a three-level hierarchical linear model examined whether teacher effects from kindergarten to fifth grade can simultaneously affect sixth grade achievement. Their findings demonstrated that teachers affect student achievement positively and that teacher effects persist through the sixth grade for mathematics, reading, and science achievement. Further, they suggest that this cumulative effect of teachers on student achievement was considerable (Konstantopoulos & Chung, 2011).

Although studies as reviewed in this sub-section have found significant teacher effects on student academic achievement, some renowned scholars in economics of education such as Eric Hanushek, have reported a lack of significant positive relationship between school-level variables and student achievement.

Several findings from the publications of Eric Hanushek suggest that these school and teacher quality effects on achievement are minimal or even not statistically significant. For instance, in examining teacher characteristics and gains in student achievement, his analysis of data on grade three students found that teaching experience and graduate education did not contribute to gains in student achievement scores and that teachers did not appear to count for Mexican-American students in the sample (Hanushek, 1971). Generalization from these findings should perhaps be done with caution as the data only involved one school system, one measure of output and the third grade in elementary schools only. In another related study, Hanushek (1986) also found that estimated coefficients for teacher-based variables were statistically insignificant and that there was no strong evidence suggesting that PTR, teacher education or teacher experience had an expected positive effect on student achievement. Similar results are reflected from Hanushek's (1989b) review of 187 studies on expenditure relationships in schools. From the studies, only 14 out of 152 that dealt with effects of class size reported statistically significant relationships. On teacher education, 100 out of 113 studies showed statistically insignificant coefficients. The conclusion from this review argued that there was no strong evidence that PTR, teacher education, or teacher experience had the expected positive effects on student achievement and that there was no strong or systematic relationship between school expenditures and student performance (Hanushek, 1989b). With current analysis of academic achievement studies adopting HLM techniques, prior and current papers reporting findings on achievement need to be reviewed against this current practice.

This study modelled three teacher-level variables. These were teacher's age in years (t22a), number of in-service courses attended by the subject teacher in their respective subjects (t214), and the number of formal written tests in the teacher's subject (t227).

2.4.2 The Relationship Between Non-Teacher School Resource Input Variables and Student Academic Achievement

As mentioned earlier, the Coleman Report on the Equality of Educational Opportunity in the US made some landmark findings that spurred lots of research in education production functions and schooling outcomes. An unexpected finding from the study that took many policy analysts by surprise suggested that variations in the level of students' achievements bore little or no relationship with school resources or programs. That instead, out-of-school variables such as family background and neighbourhood characteristics accounted for the observed achievement differences between students (Coleman et al., 1966).

Like the Coleman Report, Eric Hanushek is one of the researchers who have written extensively on education production functions in relation to academic achievement. Most, if not all his writing on resource inputs, have concluded that there is no significant relationship between student academic achievement and school resources. For instance, he argues that despite an increase in expenditure per pupil in public schools in the US from USD992 in 1960 to USD1898 in 1975 coupled with falling Pupil Teacher Ratios (PTR) and a 32% increase in teacher salaries over the same period, student academic work kept dropping (Hanushek, 1981). He reviewed 38 journal publications on the relationship between school inputs and student academic achievement. He concluded that there was no compelling evidence to suggest that higher school expenditures per pupil translate to student academic achievement. In another synthesis of 147 studies using education production functions, Hanushek (1986) concludes that the results are consistent in finding no strong evidence that PTR, teacher education or experience have effect on student achievement. Another similar synthesis of 400 education production function regression equations did not find strong or consistent relationship between student performance and school resources, at least after variations in family inputs were considered. Schools also seemed to be operated in an economically inefficient manner (Hanushek, 1997).

But several researchers have faulted these conclusions by Hanushek. For instance, Hedges, Laine, and Greenwald (1994a) used combined significance tests and combined estimation methods to re-analyse the evidence examined by Hanushek. They examined whether his conclusions about the lack of relationship between school inputs and student outcomes, and particularly his general conclusion that per pupil expenditure (PPE) and achievement are unrelated, were supported by a synthesis of the results of his sample of studies. Their results suggested that an increase of PPE by $500 (approximately 10% of the national average for the US) would be associated with a 0.7

standard deviation increase in student outcome, which by the standards of educational treatment interventions, would be considered a large effect.

This conclusion generated a heated scholarly debate with Hanushek responding with an article titled “An Exchange: Part II: Money Might Matter Somewhere: A Response to Hedges, Laine, and Greenwald” (Hanushek, 1994). He argued that Hedges, Laine and Greenwald (1994a) misapplied their statistical approach and ignored key assumptions and analytical choices that each work to invalidate their technical analysis. He argued that “if their implied predictor of a point-seven-standard-deviation improvement in student performance over the past quarter century had been realized, Albert Einstein would currently rate below the national average” (Hanushek, 1994, p. 7).

Hedges, Laine, and Greenwald (1994b) replied in an article titled “Money Does Matter Somewhere: A Reply to Hanushek” in which they defended their methodology and submitted that if the underlying studies used were somewhat flawed, as Hanushek seemed to agree, then neither Hanushek's analysis nor their reanalysis would be valid. They argued that since they had not previously published on education production function, they had no vested interests or bias and that their interest was only methodological. That is, whether the data that Hanushek had been citing for over a decade supported his conclusions about the lack of relation between resource inputs and educational outcomes. They insisted that their analyses had clearly suggested that it did not. This scholarly exchange serves to bring to the fore some methodological issues that have, and continue to bedevil studies on the effect of school resources on academic achievement. As discussed earlier, HLM, which the researcher proposes to use for this study, has gained a lot of traction as part of the solution to these challenges especially in dealing with nested data.

Despite these dissenting opinions, Hanushek still argued that the weight of the evidence supported the view that there was no compelling evidence to suggest a significant relationship between school resources and academic achievement. While examining Black-White achievement differentials, Hanushek (2001) found that neither the level nor the distribution of school spending provided much or any explanation for the gaps. In analyzing data from the Third International Mathematics and Science Study (TIMSS) on efficiency and equity in schools around the world, Hanushek and Luque (2003) argued that effects on academic performance were not related to income levels of the country or resource allocation at school level and that the widely accepted view that school resources are relatively more important in poor countries did not find support in their analysis of the data.

On school-level resource factors, Shimada (2010) found that school resources had positive effects on reading scores and that students who attended well-equipped schools tended to have higher scores than those enrolled in less-endowed schools. His findings also suggested that smaller class size was an important predictor of academic achievement with students in such classes performing better than those in larger classes. Of course, this finding points to PTR issues and the importance of close contact between the teacher and student.

To contribute to this debate between Hanushek on one side and Hedges, Laine, and Greenwald on the other, the researcher estimated, using HLM, the effect of four non-teacher school-level input variables on student academic achievement in Mumias and Kuria East Sub-Counties. These were: Whether a school had piped water (h31e), whether a school had electricity (h31f), whether a school had a typewriter (h31i), and whether a school had a feeding programme (h32). This study also contributes a Kenyan angle to the debate, one that has not featured prominently in the reviewed literature.

2.4.3 The Relationship Between School Characteristic Variables and Student Academic Achievement

Pupil Teacher Ratios (PTR) or class size is one of the characteristics of schools that has attracted lots of research effort. Nye, Hedges, and Konstantopoulos (1999) used a two-level HLM on data from the Tennessee class size experiment (Project STAR). They set out to address the question of the long-term effects of small classes by examining the achievement of students who were involved in Project STAR for the 5 years after the experiment ended, when these students were in Grades 4 to 8. They found that the effects of small classes in kindergarten through Grade 3 on achievement did not disappear by Grade 8. They argue that although there were positive effects of small classes on achievement, there was no compelling evidence for differentially larger effects of small classes for lower achieving students (Nye et al., 2002). Deutsch (2003) has also found that small classes benefitted high school students through positive teacher-student interaction, increased time on instruction rather than on discipline and high teacher morale.

While acknowledging that the broader literature on class-size effects was inconclusive despite results from experimental studies, Milesi and Gamoran (2006) examined the effects of class size on achievement in kindergarten with data from the USA's Early Childhood Longitudinal Study involving the Kindergarten Class of 1998-99. They utilized HLM and found no evidence of class-size effects on student achievement in either reading or mathematics, and their results indicated that class size was equally insignificant for students from different race, economic, and academic backgrounds. Teacher fixed-effects analyses also yielded null findings for class size. However, instructional activities offered significant boosts to achievement, although these effects did not differ between small and large classes. Like research on teacher effects and school resources, these results from class-sizes effects also point to variability and divergence meaning that research in these areas will continue to understand contextual issues. As cited earlier, Hanushek and Rivkin (2009) examined the change in black-white achievement gap in the US as students' progress through school and found that there was an adverse effect on achievement of attending a school with a high percentage of black students.

Carbonaro and Elizabeth (2010) examined whether standards based accountability reforms closed the achievement gap among public and private high school students. They analyzed data from the US Education Longitudinal Study to examine sector differences in high school achievement in the era of standards based reforms. They found that students in Catholic and private secular schools enjoyed greater math gains from 10th to 12th grade compared with those in public schools and that these advantages were largely concentrated among more advanced math skills (Carbonaro & Elizabeth, 2010). Even after accounting for family background and prior achievement, students in private schools were found to have taken more academic math courses than students in public school (Carbonaro & Elizabeth, 2010). These differences in course taking accounted for most of the public-private difference in achievement gains. This study modelled the effect of these school-level variables on student academic achievement between public and private primary schools in two distinct Sub-Counties in Kenya.

Legewie and DiPrete (2012) used a quasi-experimental research design to estimate the gender difference in the causal effect of peer socioeconomic status as an important school resource on test scores using 4372 cases from the longitudinal German ELEMENT dataset for 4^{th} to 6^{th} graders within Berlin's schools supplemented with the German PISA-I-Plus 2003 data. They found substantial variation in the gender gap in academic performance across schools and that this variation was related to average school performance (Legewie & DiPrete, 2012). They also found that boys were more sensitive to peer-SES composition as an important dimension of school quality related to the learning environment and that on average, boys did as well or better than girls in mathematics, and the male advantage was larger on the right tail of the distribution.

A policy brief from SACMEQ III data collected in 2007 involving 4,436 Standard 6 pupils in 193 primary schools in all eight provinces in Kenya (provinces were scrapped with the enactment of the Constitution of Kenya, 2010) examined the quality of education in primary schools and shows worrying trends. Evidence from this third wave of data collection found that one in every five pupils did not have all the three basic learning materials needed for effective participation in classroom activities. In the light of FPE which annually allocates finances for the purchase of text books, a worrying finding from the study suggested that at least four in every five pupils did not have sole use of mathematics textbooks and that most of the pupils without these mathematics textbooks were in public schools (Southern and Eastern Africa Consortium for Measuring Education Quality, 2011).

Hungi and Thuku (2010) examined important pupil, class and school-related variables that contributed to differences in mathematics and reading achievement among Grade 6 pupils in Kenya. They used SACMEQ II data with a sample of 3299 pupils, 320 classes in 185 schools in Kenya. Using a three-level multilevel model, they found that PTR ratio was an important variable in predicting student achievement.

Accounting for socio-economic status and individual student characteristics, Ejakait et al. (2011) found that a pupil attending a public school irrespective of the residential location (Korogocho, Viwandani, Harambee or Ofafa Jerocho in Nairobi) would score up to 49.5 points less in the KCPE examination than what a pupil in an informal private school would score. These findings are from a longitudinal study that has been running since 2005 and may only be limited to the four research sites as their characteristics are different from other urban areas and certainly from rural settings. Although Ejakait et al. (2011) disaggregated the school variable into public and private, they did not control for other school level variables such as teaching and learning materials, PTR, staffing norms and quality and class sizes among. It is therefore possible that the effect of this finding is over-stated. This current study modelled the effect of eight school-level variables on student academic in Mumias and Kuria East Sub-County. These were Sub-county (h16), boarding status at class 8 (h24a), mean parental contribution 0-10 scale (h218z), mean community school participation 0-10 scale (h227z), mean teacher years since first employment (h49a), number of female teachers (h432), number of graduate teachers (h487), and students disallowed from borrowing library books to take home (h5122).

2.5 Summary

Despite the rich literature available on the effect of school-level variables on student achievement, the results remain variable and the differences seem to be explained more by choice of statistical strategies. As can been seen from the review there is still no compelling agreement about whether teacher-based variables have any effect on student achievement. Similarly, there is no convergence of research evidence on whether non-teacher school-level resources have any effect on student achievement. As reviewed, two strands of findings stand out and seem to militate against each other. On one hand, several studies have argued that teacher-level variables have greater effect on student achievement after controlling for individual student characteristics and socioeconomic background. On the other hand, several other studies argue that there is no compelling evidence to suggest that teacher-based variables such as their education level, experience, salaries among others, have any effect on student achievement. The same divergence can be said of the available literature on the effect of non-teacher school resources on student achievements. The divergence in these findings, as mentioned earlier, seems to point to shortcomings in sampling, data handling and analytical approaches and difficulties in controlling for other relevant achievement inputs. This means that despite many studies on what drives student achievement, there is no conclusive agreement yet. Again, it appears that many of these studies have been done in the USA and other developed countries.

The current study modelled student academic achievement using a large sample drawn from two Sub-Counties in Kenya and disaggregated by type of school and Sub-County academic performance index. In most of the studies reviewed, private primary schools were left out of the analysis or their data not collected at all. This study included these private schools for comparative analysis. It also compared between students and schools in a top-ranked Sub-County in the KCPE with those in a low-ranked one. The study has hopefully contributed to ongoing debate on school-level effects on student academic achievement regarding Kenya.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Design

The study used the ex post facto research design which is ideal for conducting social science research in order to reveal possible relationships by observing existing conditions and state of affairs and searching back in time for plausible and possible contributing factors (Kerlinger, 1986; Kerlinger & Rint, 1986). The design can be considered as experimental research in reverse because it does not take equivalent groups and subject them to different treatments to determine differences in the dependent variable. Instead, it begins with groups that are already different in some respect and searches in retrospect for what brought about these differences (Cohen, Manion, & Morison, 2000).

Public and private schools are already different in their academic performance indices in KCPE just in the same way as Mumias and Kuria East are on the same index. In retrospect, this design helped isolate variables at student, teacher and school levels that drive the observed differences in the Sub-Counties of Mumias and Kuria East. The analysis also allowed a comparison of the effect of the predictors on the outcome variable between the two Sub-Counties. Some descriptions of the two Sub-Counties are provided in sections 3.3.1 and 3.3.2.

3.2.1 Mumias Sub-County

Mumias is in Kakamega County which has six other Sub-Counties namely: Kakamega Central, Kakamega North, Kakamega East, Kakamega South, Lugari and Matete. Its geo-location is given as latitude 0.354274180 and longitude 34.487620310 (Kenya Open Data, 2012b). Annual rainfall ranges between 1500-2000mm and the main cash crop is sugarcane although residents also plant maize, beans, and bananas for subsistence. In the census of 2009, the Sub-County had 78,685 households with a population of 359,381 individuals of which 186,362 (51.86%) were female (Kenya Open Data, 2012a). The population density as of the 2009 Census was 550 people per km^2 compared with 66 nationally with a poverty gap based on KIHBS (2005/2006) of 17.4 against 19 nationally (Commission on Revenue Allocation, 2013). As of July 2014, Mumias had 99 registered primary schools of which five were private with 4712 as the total enrolment in Class 8 of which 2467 (52.36%) were female students (Mumias District Education Office, 2014). Teenage pregnancies and school dropouts are challenges facing the Sub-County with boys opting for casual work in the sugar cane plantations (Mwanza, 2010)

3.2.2 Kuria East Sub-County

Kuria East is part of Migori County which has three other Sub-Counties namely: Kuria West, Migori and Rongo. Its geo-location is given as latitude -1.2797534110 and longitude 34.656995090 (Kenya Open Data, 2012b). Annual rainfall ranges between 700-1800mm which helps residents grow coffee, maize, tobacco, sugar cane and keep cattle. In the census of 2009, the Sub-County had 13,513 households with a population of 81,833 individuals of which 41,585 (50.82%) were female (Kenya Open Data, 2012a). The population density as of the 2009 Census was 353 people per km^2 compared with 66 nationally with a poverty gap based on KIHBS (2005/2006) of 19.0 same as the national gap of 19 (Commission on Revenue Allocation, 2013). As of January 2014, Kuria east had 62 primary schools of which 13 were private. The total enrolment in Class 8 was 1498 with 47.56% (996) female students (Kuria East District Education Office, 2014). Challenges facing schooling include teenage pregnancies, school dropouts (Omwancha, 2012) and female genital mutilation involving school-going female students (Ondiek, 2010).

3.3 Target Population

Table 3.1 presents the distribution of the target population in the two Sub-Counties.

Table 3.1. Distribution of the target population in the two Sub-Counties in 2014

	Mumias	Kuria East	Total
Public schools	94	49	143
Private schools	5	13	18
Head teachers	99	62	161
Teachers	1258	806	2064
Class 8 candidates in 2014	4712	1498	6210

*Source:*Mumias District Education Office. (2014). Mumias District Provisional EMIS Data: Term II, 2014. Mumias, Kenya: Mumias District EMIS/Statistics Section; Kuria East District Education Office. (2014). Kuria East District Provisional EMIS Data: Term II, 2014. Kegonga, Kenya: Kuria East District EMIS/Statistics Section

There were 6210 candidates in Class 8 who sat the 2014 KCPE examination in 161 public and private primary schools. There were 161 head teachers and 2064 teachers in the two Sub-Counties.

3.4 Sample Size and Sampling Procedures.

A sample of 1,824 students sitting the KCPE examination in 2014 was drawn for the study using multi-stage stratified cluster sampling. Since the unit of analysis was at individual pupil level and the interest was to model the effect of school effects on pupil achievement, the first stage was to determine the sample size. The study used a formula suggested by (Meier & Brudney, 1993) for calculating an effective sample size (Chuan, 2006; Nachmias-Frankfort & Nachmias, 2008; Welch & Comer, 1988).

$$n = \left(\frac{z \times \sigma}{E}\right)^2$$

Where;

n = is the sample size

z = z score associated with the desired confidence level (1.96 for 95%)

σ = is the population standard deviation (0.5)

E = is the percentage of error that the study was willing to tolerate ($\pm 2.5\%$)

With a 95% confidence level for the results and a ±2.5% sampling error which was better than ±3% that is widely accepted in social science research (Welch & Comer, 1988), the sample size was 1,537 calculated as follows;

$$n = \left(\frac{1.96 \times 0.5}{0.025}\right)^2$$

$$n = (39.2)^2$$

$$n = 1537$$

Israel (2009) recommends that sample size formulae provide the number of responses that need to be obtained and that this sample size often needs to be adjusted for various reasons. He observes that many researchers commonly add 10% to the sample size to compensate for persons that the researcher is unable to get. For this study, the researcher adjusted for this 10% (154 additional candidates) to compensate for schools that had less than 30 candidates in Class 8 bringing the figure to 1691. Israel (2009) and (Welch & Comer, 1988), also recommend that the sample size is often adjusted by up to 30% to compensate for non-response. To compensate for any eventuality of cancelled examination results by the KNEC in case any of the sampled schools would be found to have participated in examination irregularities such as cheating or for poorly completed questionnaires, this study adjusted the sample of 1537 by a further 7.5% (115) bringing the total sample size to 1806 $(1537 + 154 + 115 = 1806)$. Data were however collected from 1824 which surpassed this sample size by 18 cases because of varying student numbers in sampled schools.

The second stage was to sample the Sub-Counties where these candidates would sit their KCPE examination. To measure the relationship between school effects and student academic achievement, the researcher analysed results from schools in a top and bottom ranked Sub-County. The study posited that school effects in top ranked Sub-Counties was high, therefore enhancing student academic achievement. Academic achievement in the KCPE examination can be stratified by Sub-County. For the period 2010-2012, six Sub-Counties were ranked in the top five percent. Mumias Sub-County was purposively sampled because it was ranked in position one as the best Sub-County for the three years. Table 3.2 shows the ranking of Sub-Counties in the top five percent for the reference period.

Table 3.2. Ranking of the top Five Percent Sub-Counties in KCPE, 2010-2012

Sub-County Name	2010 mean score	2010 rank (N=239)	2011 mean score	2011 rank (N=272)	2012 mean score	2012 rank (N=280)	Freq.	Av. mean score	Ovl. rank
Mumias	287	1	290	1	294	1	3	290	1
Athi River	287	2	290	2	289	2	3	289	2
Kirinyaga Central	285	3	282	5	278	11	3	282	3
Makindu	282	4	284	3	278	10	3	281	4
Makueni	281	5	278	7	282	6	3	280	5
Kisumu Municip.	274	12	278	8	278	12	3	277	6
Samburu North	280	6	284	4			2		
Kathonzweni	275	9	277	9			2		
Isinya			278	6	286	3	1		
Samia			277	12	283	4	1		
Nandi East	275	10			283	5	1		
Mogotio	275	11			282	7	1		
Nandi North			274	13	279	9	1		
Ijara			277	10			1		
Nambale			277	11			1		
Koibatek			273	14			1		
Kitale Municipality	278	7					1		
Keiyo South	277	8					1		
Marakwet East					282	8	1		
Tinderet					278	13	1		
Eldoret West					277	14	1		

Note. Freq.=Frequency; Av.=Average; Ovl.=Overall; Municip.=Municipality; Sorted by average mean score; Source: Researcher's analysis using the 2010-2012 KCPE datasets

For the three years, ten Sub-Counties were ranked in the bottom five percent category with Mandera Central ranked last. Thus, Mandera Central should have been selected purposively to represent this category. However, the ongoing security operation in Somalia had scaled up security surveillance in Kenya’s North Coast Sub-Counties of Lamu, Magarini and Malindi as well as those in North Eastern including Mandera Central. Research in these Sub-Counties would most likely have therefore required additional logistical support such as escort to schools by security personnel or additional financial commitment or would have taken inordinately long to collect data from. Kuria East Sub-County was the only other lowly ranked Sub-County that was not in the northern Sub-Counties of the Coast or North Eastern and was therefore purposively sampled (Chuan, 2006; Israel, 2009; Lenth, 2001). Table 3.3 presents the ranking of Sub-Counties in the bottom five percent category.

Table 3.3. Ranking of the Bottom Five Percent Sub-Counties in KCPE, 2010-2012

Sub-County Name	2010 mean score	2010 rank (N=239)	2011 mean score	2011 rank (N=272)	2012 mean score	2012 rank (N=280)	Freq.	Av. mean score	Ovl. rank
Malindi	216	228	215	265			2	216	279
Kyuso	215	229	215	266			2	215	280
Kuria East	214	230	212	268			2	213	281
Lamu East	206	234	211	269	182	271	3	200	282
Magarini	201	236	196	272			2	199	283
Fafi	209	232			187	270	2	198	284
Mandera North	204	235	213	267	175	276	3	197	285
Banisa			218	262	170	278	2	194	286
Daadab			219	259	163	279	2	191	287
Mandera Central	199	238			156	280	2	178	288
Balambala					193	267	1		
Mandera East					191	268	1		
Mandera West					191	269	1		
Hulugho					182	272	1		
Habaswein					179	273	1		
Wajir South					179	274	1		
Nakuru					178	275	1		
Lagdera	184	239			174	277	1		
Kisasi			219	260			1		
Msambweni			218	261			1		
Loiyangalani			218	263			1		
Merti			217	264			1		
Kinango			210	270			1		
Buna			207	271			1		
Buuri	212	231					1		
Marani	208	233					1		
Wajir West	201	237					1		

Note. Freq.=Frequency; Av.=Average; Ovl.=Overall; Sorted by average mean score; Source: Researcher's analysis using the 2010-2012 KCPE datasets

From the foregoing, Mumias and Kuria East were selected to represent the top and bottom 5% Sub-Counties in the KCPE examination for the period 2011-2012. The two provided rich ground to explore the drivers of the observed variations in student academic achievement.

Since the study was also interested in analysing between-school variations, the third stage of sampling was to stratify the schools by type, either public or private and then proceed to draw a Probability Proportion to Size (PPS) sample (Bennett, Woods, Liyanage, & Smith, 1991; Ross, 2005; Ross & Genevois, 2006). Using PPS, 1068 students were sampled from Mumias Sub-County (978 and 90 from public and private schools respectively) and 756 from Kuria East Sub-County (704 and 52 from public and private schools respectively). Since schools were either single or multi-streamed, all Class 8 students in randomly sampled single streamed schools were included in the sample. In multi-streamed schools, one stream was randomly sampled and all students in such streams included in the sample. Data from the respective Sub-County Education Offices indicated that there were 4712 and 1498 Class 8 candidates in Mumias and Kuria East Sub-Counties respectively and that a single stream in Mumias on average had 35 students while a similar stream in Kuria East had 25 students (Kuria East District Education Office, 2014; Mumias District Education Office, 2014). This assumption informed the 35 (28 public and 4 private) and 29 (24 public and 5 private) schools randomly sampled in Mumias and Kuria East Sub-Counties respectively, bringing the total to 61 schools (52 public and 9 private). In each of the schools, the Head teacher and the six KCPE subject teachers were purposively sampled bringing the total sample size to 2190 (1824 students, 305 teachers and 61 Head teachers). Table 3.4 shows the distribution of the sample by Sub-County and school type.

Table 3.4. Distribution of the Sample for Schools and Students

	Schools			Students		
	Public	Private	Row total	public	private	Row total
Mumias Sub-County	28	4	32	978	90	1068
Kuria East Sub-County	24	5	29	704	52	756
Column total	52	9	61	1682	142	1824

Source: Researcher's sampling using Probability Proportion to Size

3.5 Research Instruments and Their Piloting

Interviewer-administered survey instruments were used for data collection. One questionnaire was administered to the head teacher and solicited data on staffing, teaching processes, enrolment, textbooks and other learning materials. Other variables of interest were school physical facilities, parental and community support and quality control measures among other variables. The teacher questionnaire was administered to each of the six teachers handling the KCPE examinable subjects (Maths, English, Kiswahili, Science, Social Studies and Religious Studies). It collected data on individual teacher demographics, educational attainment and professional training, length of service, socio-economic background, pedagogy, and learner support strategies among other variables.

The student questionnaire was administered to class eight students in sampled streams and schools and collected their demographic data, family background and socio-economic data, parental/guardian educational attainment and their employment and support to individual students with school work. Other variables of interest were their attitude towards different subjects and schooling, their aspirations beyond primary school and information about their peers.

These questionnaires were piloted in four schools, one public and one private in each of the two Sub-Counties. This was to gauge whether the design of the instruments would elicit desired data (Postlethwaite, 2005). Piloting helped identify weaknesses and inconsistencies which were corrected based on the results of the pilot. The four schools in each Sub-County were excluded from the final sampling for the study.

3.6 Validity

Validity can be defined as the degree to which a test measures what it is supposed to measure (Gay, 1992). There are three basic approaches to the validity of tests and measures. These are content validity, construct validity, and criterion-related validity (Mason, 1989). Content validity was more appropriate for this study as it measures the degree to which the test items represent the domain or property being measured. Identifying the universe of content is often complex and it is generally accepted and suggested that a panel of experts in the field to be studied, be used to identify content area (Gay, 1992; Mason, 1989). The researcher's supervisors from the Departments of Educational Foundations and Management and Educational Psychology at Maseno University who are experts in Planning and Economics of Education as well as Statistics helped in ensuring content validity.

3.7 Reliability

Reliability is the extent to which a measuring instrument may contain errors that appear inconsistently between observations in a sample either once or each time a given variable is measured by the same instrument (Nachmias-Frankfort & Nachmias, 2008). Some of the common methods used in estimating reliability include the inter-rater technique, the test-retest method, the parallel forms technique and the internal consistency method (Beukman, 2005). The internal consistency method has several measures: the average inter-item correlation, the average total item correlation, the split-half reliability and the alpha reliability. This study used the internal consistency method and determined the average inter-item correlation of all the items in the questionnaire designed to measure the same construct (Acock, 2006). The internal consistency method was preferred because it neither required the splitting of items into halves nor the multiple administration of instruments and provided a unique estimate of reliability for the items of interest (Anastasi, 1988; Beukman, 2005; Gay, 1992). A correlation coefficient of more than 0.68 shows an acceptable reliability (Acock, 2006;

Marston, Beguy, Kabiru, & Cleland, 2013; Taylor, 1990). After piloting, the average inter-item correlation for the school, teacher and student questionnaires was 0.812, 0.793, and 0.778 respectively. These correlation coefficients were deemed strong, with acceptable reliability.

3.8 Ethical Considerations

The study was authorized and permitted by the National Commission for Science, Technology, and Innovation (NACOSTI) vide reference number NACOSTI/P/14/0177/2906 dated 26th August 2014, presented under Appendix D. The study only involved human subjects. Structured questionnaires were used for collecting schooling and demographic data from the subjects. The head teacher, teacher and student questionnaires had filters and skips that protected respondents from answering questions that were not applicable to them. The respondents also had the option of not answering any question they did not wish to answer. This minimized any harm or negative psychological effects to the subjects. Informed consent was sought from individual head teachers, teachers, and students before they responded to their respective questionnaires. The consent form was laid out on the first page of each questionnaire. Consenting head teachers gave a general nod for the study to proceed in their schools. No head teacher declined to grant consent. For anonymity and confidentiality, schools and individuals in the study were assigned unique identifiers generated by the researcher. No names of schools or respondents were thus reported in the thesis or subsequent publications. Data were stored in an Epi-Info database with limited access to the researcher only.

3.9 Data Collection Procedures

After clearance from the School of Graduate Studies (SGS) and the Maseno University Research Ethics Committee, the researcher proceeded to the two Sub-Counties for clearance and letters of introduction to the schools for data collection from the Sub-County Education Officers (DEO) in Mumias and Kuria East Sub-Counties, before visiting the schools. In each sampled school, the researcher first sought an introductory meeting with the Head Teacher for consent to collect data before completing the school questionnaire with the Head Teacher and the six subject teachers of class eight. Thereafter, the researcher proceeded to sample the students and complete the student questionnaire with them at a convenient time within the school timetable. It took a complete day to administer the questionnaires in each school. In each sub-County, the researcher recruited and trained two suitable teachers at primary school level with prior experience in quantitative data collection to assist in questionnaire administration. It took 61 days excluding weekends to collect the data from the 61 sampled schools.

3.10 Methods of Data Analysis

Both descriptive and inferential statistics were used for analysis of the data collected at both pupil and school level with the outcome variable being student scores in the KCPE examination of 2014. This score was modelled as a function of teacher-level variables, non-teacher school-level resource inputs and school-level characteristics adjusting for individual student characteristics (family background and SES, parental involvement, and peer group influence). Descriptive statistics helped summarize the data and included the mean, standard deviation, standard error of the mean, and variance. Bivariate statistics such as pair-wise correlation, chi-square and independent sample two-tailed t-test (assuming unequal variance) were used to explore relationships between variables. A one-way analysis of variance was used to compare the means between the five KCPE subject areas. Finally, the researcher fitted two and three-level hierarchical linear models (HLM) with 1824 students (level-1) nested within 305 teachers (level-2) nested within 61 schools (level-3). The models followed Rabe-Hesketh and Skrondal (2012) in fitting random intercepts at the teacher and school levels specified as;

$$y_{jk} = X_{jk}\beta + Z_{jk}^{(3)}u_k^{(3)} + Z_{jk}^{(2)}u_k^{(2)} + \epsilon_{jk}$$

for $i = 1, \ldots, n_{jk}$ Level-1observations (students) nested within $j = 1, \ldots, M_k$ Level-2 groups (teachers), which were nested within $k = 1, \ldots, M$ Level-3 groups (schools). Group j, k consisted of n_{jk} observations so that y_{jk}, X_{jk}, and ϵ_{jk} each now had dimension n_{jk}. $Z_{jk}^{(3)}$ was the $n_{jk} \times q3$ design matrix for the Level-3 random effects $u_k^{(3)}$, and $Z_{jk}^{(2)}$ was the $n_{jk} \times q2$ design matrix for the Level-2 random effects $u_k^{(2)}$. The researcher also assumed that

$$u_k^{(3)} \sim N(0, \Sigma_3);\ u_{jk}^{(2)} \sim N(0, \Sigma_2);\ \epsilon_{jk} \sim N(0, \sigma_\epsilon^2 \mathrm{I})$$

and that $u_k^{(3)}, u_k^{(2)}$ *and* ϵ_{jk} were independent (StataCorp, 2013a, p. 299).

Hierarchical Linear Models were appropriate for analysis of the data because the dependent variable (student KCPE score) was at level-1 while the independent variables (predictors) were at level-2 and level-3 with control variables cutting across the three levels. This generated a hierarchical dataset with observations between students within schools not being independent. Students attending the same school shared certain similar characteristics such as teachers and other school processes. Ordinary regression approaches are based on the fundamental assumption that individual pupils are independent of each other. A HLM approach recognized inter-dependency by allowing for the clustering of pupils within teachers, within schools. This enabled separate estimates of the variability in individual performance due to the teacher and the school attended to be obtained in addition to estimates of the variability in performance between pupils regardless of where they attended school (Smith & Barrett, 2011). Some econometricians and statisticians have suggested that the minimum number of groups in HLM should be 20 (Goldstein et al., 1993; Leeuw & Jan, 1998). For instance, Raudenbush and Willms (1995) estimated a HLM with data from 5,054 students attending 20 secondary schools in Fife Education Authority, Scotland. In the current study, level-1 had 1824 cases nested within 305 teachers in level-2 who were in turn nested within 61 schools in level-3.

In HLM, fixed effects are observed characteristics used to model the outcomes for the primary units of analysis (in this case the students) while random effects model the unobserved characteristics of the nesting groups (in this case teachers and schools) (Rabe-Hesketh & Skrondal, 2012; StataCorp, 2013a).

Using unique student and school examination index numbers, the researcher extracted the students' KCPE results after they were released by the Kenya National Examinations Council (KNEC) in late December 2014. All data were entered into a Microsoft Access database through an Epi Info (version 7.1.3.10) data entry screen before exporting the same into Stata version 13 for data cleaning, coding and analysis (StataCorp, 2013b). This version of Stata (even 11 and 12) has multilevel estimators that can support two, three or higher-level data. A HLM not only estimates model coefficients at each level, but also predicts the random effects associated with each sampling unit at every level (Raudenbush & Bryk, 2002). While commonly used in education research due to the prevalence of hierarchical structures in data from this field, it is suitable for use with data from any research field that have a hierarchical structure (Raudenbush & Bryk, 2013). For ease of presentation, results were discussed in text and presented using tables and figures. By hypotheses, Table 3.5 presents a summary of the analysis plan.

Table 3.5. Summary of Statistical Analysis Plan

Hypotheses	Outcome variable	Explanatory variables	Control variables	Proposed statistical analysis
$H_0$1: There is no statistically significant relationship between teacher-based attributes and student academic achievement in the KCPE examination	Level-1: student academic achievement in the KCPE examination, measured on the interval scale and marked out of a maximum score of 500	Level-2: teacher-based variables e.g. sex; age; level of education completed; level of professional completed; experience (years) in teaching; years in current school; syllabus coverage; number of subject tests etc.	Level-1; student characteristics and Level-3 school characteristics	Descriptive statistics; pair-wise correlation; three-level hierarchical linear model
$H_0$2: There is no statistically significant relationship between non-teacher school resource inputs and student academic achievement in the KCPE examination	Level-1: student academic achievement in the KCPE examination, measured on the interval scale and marked out of a maximum score of 500	Level-3: non-teacher school resource inputs e.g. textbook pupil ratio; school feeding programme; annual student levies; library; staff room; store room; electricity; water source; sports field; telephone; type writer; computer; school garden etc.	Level-1: student characteristics;	Descriptive statistics; pair-wise correlation; t-test; two-level hierarchical linear model
$H_0$3: There is no statistically significant relationship between school characteristics and student academic achievement in the KCPE examination	Level-1: student academic achievement in the KCPE examination, measured on the interval scale and marked out of a maximum score of 500	Level-3: school characteristics e.g. school type; age of school; negative student behaviour index; negative teacher behaviour index; pupil teacher ratio; enrolment; number of quality assurance visits; etc.	Level-1: student characteristics	Descriptive statistics; pair-wise correlation; t-test; one-way ANOVA; two-level hierarchical linear model

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.1 Introduction

This chapter covers the analysis of data, their presentation and discussion. The presentation is done following the three objectives which sought to (a) examine the relationship between teacher-level variables and student academic achievement in the KCPE examination, (b) establish the relationship between non-teacher school-level resource inputs and student academic achievement in the KCPE examination and (c) determine the relationship between school-level characteristics and student academic achievement in the KCPE examination. The study involved public and private primary schools in Mumias and Kuria East Sub-Counties. Section 4.2 and 4.3 present a description of the dataset and variables used in the analysis respectively.

4.2 Description of the Sample and Analytical Datasets

The study was carried out in 61 schools in Mumias and Kuria East Sub-Counties with 1824 Class 8 candidates, 305 teachers of academic subjects in Class 8 and 61 Head Teachers providing school-level data. Table 4.1 summarizes the student sample in the two Sub-Counties. As can be seen, majority of the students, 1682 (92.21%) were from public primary schools with 978 (58.15%) sampled in Mumias Sub-County and 704 (41.85%) from Kuria East Sub-County.

Table 4.1 Distribution of Student Respondents

Sub-County		School classification		Total
		Private	Public	
Mumias Sub-County		90	978	1,068
	a	8.43	91.57	100
	b	63.38	58.15	58.55
Kuria East Sub-County		52	704	756
	a	6.88	93.12	100
	b	36.62	41.85	41.45
Total		142	1,682	1,824
	a	7.79	92.21	100
	b	100	100	100

Note. n=1824
[a] row percentages: [b] column percentages

Table 4.2 presents the distribution of sampled teachers across the two Sub-Counties. Again, majority, 260 (85.25%) were from public primary schools with 140 (53.85) sampled from Mumias and 120 (46.15%) from Kuria East.

Table 4.2 Distribution of Teacher Respondents

Sub-County		School classification		Total
		Private	Public	
Mumias Sub-County		20	140	160
	a	12.5	87.5	100
	b	44.44	53.85	52.46
Kuria East Sub-County		25	120	145
	a	17.24	82.76	100
	b	55.56	46.15	47.54
Total		45	260	305
	a	14.75	85.25	100
	b	100	100	100

Note. n=305
[a] row percentages: [b] column percentages

Table 4.3 summarizes the distribution of the schools sample across the two sub-Counties. A total of 61 schools were visited, 52 (85.25%) were public and 9 (14.75%)

private. Of the 52 public schools, 28 (53.85%) were sampled in Mumias and 24 (46.15%) in Kuria East.

Table 4.3 Distribution of Head Teacher (School) Respondents

Sub-County		School classification		Total
		Private	Public	
Mumias Sub-County		4	28	32
	a	12.5	87.5	100
	b	44.44	53.85	52.46
Kuria East Sub-County		5	24	29
	a	17.24	82.76	100
	b	55.56	46.15	47.54
Total		9	52	61
	a	14.75	85.25	100
	b	100	100	100

Note. *n*=61
[a] row percentages [b] column percentages

The study generated three datasets: A student-level dataset (180 variables for 1824 cases), a teacher-level dataset (107 variables for 305 cases) and a school-level dataset (137 variables for 61 cases). These three were used to generate two analytical hierarchical datasets. The first was a long format hierarchical dataset used for fitting a three-level hierarchical linear model for objective 1 and had 223 variables for 9120 student-records (1824*5) because each pupil had a score on each of the five distinct subjects: English, Kiswahili, Mathematics, Science and Social and Religious Studies corresponding with one distinct teacher for each of the listed subjects in each of the 61 schools. The second was a hierarchical dataset for 1824 students with 377 variables and was used for fitting two-level hierarchical linear models for objective 2 and 3.

4.3 Description of the Variables Used in the Analysis of Data

For objective 1, the outcome variable (s17g) was student academic achievement in the five KCPE subject areas modelled as a function of student, teacher and school effects.

For ease of interpretation, this outcome variable was transformed to a standard normal score with a Mean of zero (0) and Standard Deviation and Variance of one (1) so that the residuals at each level better approximate the normality assumptions of the models. Equation 4.1 shows how raw scores were transformed into z-scores.

$$z = \frac{x-\mu}{\sigma} \tag{4.1}$$

Where

x is the raw score

μ is the mean of the population, and

σ is the standard deviation of the population (Harris, 1998; Ingule & Gatumu, 1996; Meier & Brudney, 1993; Ravid, 2010).

This transformation allowed the effects of the covariates in HLM to be interpreted in terms of standard deviation units of the outcome variable (Leckie, 2013; Raudenbush & Bryk, 2002). The student-level variables were prefixed with letter "s", the teacher-level variables with letter "t" and the school-level variables with letter "h". Table 4.4 presents a description of the variables used in the analysis of the data at these three levels.

Table 4.4 Description of Variables Used in the Analysis of the Data

Variable	Variable Label	Variable scale	Variable values
s17f	Student's total KCPE score (z-score)	Interval	-2.84 - 2.37
s17g	Student's running score in the five KCPE subjects (z-score)	Interval	-3.07 - 2.93
s21	Female student	Nominal	0=Male; 1=Female
s22a	Student's age in years	Interval	12.19 - 22.18
s23a	Student's years in current school	Interval	0.56 - 10.70
s27	Number of times student spoke English in the last 7 days	Ratio	0 - 7
s313x	Student's Wealth Index (3 Tertiles)	Categorical	1=High tertile; 2=Middle tertile; 3=Low tertile
s36c	Number of siblings	Ratio	0-16
s314a	Looking after younger relatives	Categorical	1=Never; 2=Some days; 3=Most days
s314b	Looking after elderly relatives	Categorical	1=Never; 2=Some days; 3=Most days
s314d	Cooking	Categorical	1=Never; 2=Some days; 3=Most days
s314e	House cleaning	Categorical	1=Never; 2=Some days; 3=Most days
s314h	Fetching water	Categorical	1=Never; 2=Some days; 3=Most days
s314i	Chopping fire wood	Categorical	1=Never; 2=Some days; 3=Most days
s314l	Gardening/working in a vegetable garden	Categorical	1=Never; 2=Some days; 3=Most days
s314m	Taking care of livestock	Categorical	1=Never; 2=Some days; 3=Most days
s332	Mother has some primary education	Dummy	0=Otherwise; 1=Mother has some primary education
s333	Mother has completed primary education	Dummy	0=Otherwise; 1=Mother has completed primary education
s334	Mother has some secondary education	Dummy	0=Otherwise; 1=Mother has some secondary education
s336	Mother has completed post-secondary training	Dummy	0=Otherwise; 1=Mother has completed post-secondary training
s353	Father has completed primary education	Dummy	0=Otherwise; Father has completed primary education
s356	Father has completed post-secondary training	Dummy	0=Otherwise; 1=Father has completed post-secondary training
s58x	Number of times student has repeated classes	Ratio	0-3
s61x	Student keeps negative company (z-score)	Interval	-0.74 - 2.65
t22a	Teacher's age in years	Interval	18.21 - 58.07
t214	Number of in-service courses	Ratio	0 - 8
t227	Number of formal written tests in teacher's subject	Interval	1 - 40
h31e	School has piped water	Nominal	0=No; 1=Yes
h31f	School has electricity	Nominal	0=No; 1=Yes
h31i	School has a typewriter	Nominal	0=No; 1=Yes
h32	School has a feeding programme	Nominal	0=No; 1=Yes
h16	Kuria East Sub-County	Nominal	0=Mumias; 1=Kuria East
h24a	Boarding status at class 8	Categorical	1=Day; 2=Boarding; 3=Day and boarding
h218z	Mean parental contribution 0-10 scale	Interval	0-10
h227z	Mean community school participation: 0-10 scale	Interval	0-10
h49a	Mean teacher years since first employment	Interval	0.10-25.21
h432	Number of female teachers	Ratio	1-30

(continued)

Table 4.4 Description of Variables Used in the Analysis of the Data (continued)

Variable	Variable Label	Variable scale	Variable values
h487	Number of graduate teachers	Ratio	0-12
h5122	Students disallowed from borrowing library books to take home	Dummy	0=Otherwise; 1=Students disallowed from borrowing library books to take home

Note. Student Level-1 variables are prefixed with letter "s", Teacher Level-2 with letter "t" and School Level-3 with letter "h"

Ratio-scale variables such as Number of times a student spoke English in the last 7 days (s27) had a true zero value which differentiated them from interval-scale variables. Dummies were generated from categorical variables so that 0=Otherwise and 1=Yes (affirmation of what was being measured). For instance, students were asked to indicate the highest level of education their father or mother had attained (or male/ female guardian if father/ mother were not there). This was a 10-level categorical variable with the options 11=Did not go to school; 12=Some primary education; 13=Completed primary education; 14=Some secondary education; 15=Completed secondary education; 16=Completed some training after secondary education (e.g. Teacher training); 17=Completed university education; 96=Other (specify); 98=I don't know; 99=I do not have a mother or female guardian.

A dummy for "(s332) Mother has some primary education" would therefore be 0=Otherwise (all other responses) compared with 1=Mother has some primary education.

4.4 Objective 1: Modelling Teacher-Level Effects on Student Academic Achievement in the KCPE Examination in Mumias and Kuria East Sub-Counties

The first objective sought to examine the relationship between teacher-level variables and student academic achievement in the KCPE examination in Mumias and Kuria East

Sub-Counties. The null hypothesis stated that there was no statistically significant relationship between teacher-level variables and student academic achievement in the KCPE examination in Mumias and Kuria East Sub-Counties. The outcome variable was the students' running score on the five KCPE academic subjects, transformed to a standard normal score with a Mean of zero (0) and Standard Deviation and Variance of one (1). Table 4.5 presents descriptive statistics for each of the academic subjects as well as for the students' running score on the five subjects (each of the 1824 students had 5 unique subject score records totalling to 9120).

Table 4.5 Descriptive Statistics for the Outcome Variable (s17g) Under Objective 1

Variable label	Mean	Standard error (mean)	Standard deviation	Min	Max	N
Student's standardized running score on the 5 subjects	0.00	0.01	1.00	-3.07	2.93	9120
Student's English score	-0.16	0.02	1.05	-2.57	2.93	1824
Student's Kiswahili score	0.14	0.02	0.96	-3.07	2.74	1824
Student's Maths score	0.08	0.02	0.98	-2.06	2.11	1824
Student's Science score	-0.04	0.02	0.94	-2.82	1.48	1824
Student's SRS score	-0.03	0.02	1.04	-3.07	2.30	1824

Note. Min=Minimum; Max=Maximum; SRS= Social and Religious Studies

Each student had five unique subject scores in the analytical dataset measured on the interval scale with standardized scores ranging between -3.07and 2.93. As can be seen, Kiswahili had the highest performance with 0.14 standard deviation units above the mean while English had the lowest with -0.16 below the mean. Only Maths and Kiswahili scored above the mean.

4.4.1 Pair-Wise Correlation Between the Outcome Variable and Teacher-Level Variables (Objective 1)

Since the outcome variable was measured on the interval scale, pair-wise correlation was the preferred statistical method used to determine which plausible interactions between variables "qualified" to be pursued further in the three-level HLM for the

Objective 1. Pair-wise correlation is advantageous because it returns results with sample sizes and p-values if requested. Using the two-tailed significance value, it can be determined whether the correlation is significant. The null hypothesis is that the correlation coefficient is zero and this is rejected at the 5% level if the significance is less than α=.05 (Acock, 2006).

There were 27 student-level control variables in the master analytical dataset for Objective 1. Out of these, the number of a student's siblings had the largest correlation coefficient with the outcome variable (r=.286, p<.001). This is however interpreted as weak because a correlation coefficient that is ≤0.35 is interpreted as weak; 0.36-0.67 as moderate; 0.68-0.89 as strong; and ≥0.90 as very strong (Taylor, 1990). Table 4.6 presents the subsequent correlation coefficient matrix. Because of space constraints, it was not possible to present the entire matrix for all the variables. The matrix of interest is however covered sufficiently under the outcome variable's column that runs through all the listed variables.

Table 4.6 Pair-Wise Correlation Matrix for Variable in the Modelling Under Objective 1

Variable	Variable		s17g	s21	s22a	s23a	s27	s314a	s314b
s17g	Student's running score in the five KCPE subjects (z-score)		1						
s21	Female student	a	-0.099	1					
		b	<.001						
s22a	Student's age in years	a	-0.183	-0.068	1				
		b	<.001	<.001					
s23a	Student's years in current school	a	-0.091	-0.034	0.052	1			
		b	0.000	0.001	<.001				
s27	Number of times student spoke English in the last 7 days						1		
		a	0.178	-0.048	-0.044	-0.021			
		b	<.001	<.001	<.001	0.042			
s314a	Looking after younger relatives	a	-0.128	-0.019	0.071	0.092	0.000	1	
		b	<.001	0.075	<.001	<.001	0.993		
s314b	Looking after elderly relatives	a	-0.167	-0.019	0.116	0.044	-0.009	0.371	1
		b	<.001	0.071	<.001	<.001	0.396	<.001	
s314d	Cooking	a	-0.069	0.149	0.131	0.034	0.035	0.239	0.209
		b	<.001	<.001	<.001	0.001	0.001	<.001	<.001
s314e	House cleaning	a	-0.064	0.160	0.015	0.020	0.006	0.167	0.182
		b	<.001	<.001	0.150	0.056	0.601	<.001	<.001
s314h	Fetching water	a	0.032	0.147	-0.005	0.015	0.043	0.130	0.144
		b	0.003	<.001	0.642	0.147	<.001	<.001	<.001
s314i	Chopping fire wood	a	-0.148	0.021	0.116	0.067	-0.004	0.236	0.223
		b	<.001	0.049	<.001	<.001	0.685	<.001	<.001
s314l	Gardening/working in a vegetable garden	a	-0.104	-0.172	0.141	0.069	-0.022	0.254	0.243
		b	<.001	<.001	<.001	<.001	0.037	<.001	<.001
s314m	Taking care of livestock	a	-0.102	-0.346	0.139	0.095	0.009	0.208	0.227
		b	<.001	<.001	<.001	<.001	0.419	<.001	<.001
s332	Mother has some primary education	a	-0.180	-0.046	0.098	0.006	-0.119	0.006	0.013
		b	<.001	<.001	<.001	0.548	<.001	0.556	0.231
s333	Mother has completed primary education	a	-0.107	0.017	0.050	0.070	-0.033	0.074	0.064
		b	<.001	0.103	<.001	<.001	0.002	<.001	<.001
s334	Mother has some secondary education	a	0.032	0.024	-0.009	-0.012	0.055	0.029	0.032
		b	0.002	0.025	0.399	0.236	<.001	0.006	0.003
s336	Mother has completed post-secondary training	a	0.195	0.011	-0.152	-0.059	0.061	-0.047	-0.064
		b	<.001	0.296	<.001	<.001	<.001	<.001	<.001

(continued)

Table 4.6 Pair-Wise Correlation Matrix for Variable in the Modelling Under Objective 1 (continued)

Variable	Variable		s17g	s21	s22a	s23a	s27	s314a	s314b
s353	Father has completed primary education	a	-0.184	-0.039	0.067	0.084	-0.053	0.053	0.069
		b	<.001	<.001	<.001	<.001	<.001	<.001	<.001
s356	Father has completed post-secondary training	a	0.137	0.060	-0.090	-0.078	0.087	-0.049	-0.043
		b	<.001	<.001	<.001	<.001	<.001	<.001	<.001
s36c	Number of siblings	a	-0.286	0.019	0.161	0.090	-0.053	0.106	0.099
		b	<.001	0.071	<.001	<.001	<.001	<.001	<.001
s58x	Number of times student has repeated classes	a	-0.162	-0.028	0.282	0.056	-0.085	0.072	0.038
		b	<.001	0.007	<.001	<.001	<.001	<.001	<.001
s61x	Student keeps negative company (z-score)	a	-0.237	-0.051	0.090	0.006	-0.102	-0.015	0.013
		b	<.001	<.001	<.001	0.554	<.001	0.163	0.205
s313x	Student's Wealth Index (3 Tertiles)	a	0.182	0.044	-0.138	-0.103	0.108	-0.115	-0.101
		b	<.001	<.001	<.001	<.001	<.001	<.001	<.001
t22a	Teacher's age in years	a	-0.160	0.005	0.033	0.045	0.015	0.027	-0.005
		b	<.001	0.644	0.002	<.001	0.165	0.011	0.649
t214	Number of in-service courses	a	0.039	-0.025	-0.026	-0.051	0.036	-0.042	-0.011
		b	<.001	0.016	0.013	<.001	0.001	<.001	0.301
t227	Number of formal written tests in teacher's subject	a	0.349	0.004	-0.042	-0.099	0.084	-0.090	-0.047
		b	<.001	0.672	<.001	<.001	<.001	<.001	<.001
h16	Kuria East Sub-County	a	-0.513	-0.057	-0.137	0.000	-0.133	0.058	0.100
		b	<.001	<.001	<.001	0.995	<.001	<.001	<.001
h24a	Boarding status at class 8	a	0.394	0.009	-0.243	-0.117	0.086	-0.200	-0.195
		b	<.001	0.394	<.001	<.001	<.001	<.001	<.001
h218z	Mean parental contribution 0-10 scale	a	0.324	-0.027	-0.056	-0.101	0.104	-0.113	-0.141
		b	<.001	0.009	<.001	<.001	<.001	<.001	<.001
h227z	Mean community school participation: 0-10 scale	a	0.249	0.035	-0.113	-0.013	0.057	-0.075	-0.183
		b	<.001	0.001	<.001	0.217	<.001	<.001	<.001
h49a	Mean teacher years since first employment	a	-0.180	0.012	0.069	0.068	0.035	0.031	-0.036
		b	<.001	0.271	<.001	<.001	0.001	0.003	0.001
h432	Number of female teachers	a	0.435	0.038	-0.053	-0.088	0.122	-0.061	-0.135
		b	<.001	<.001	<.001	<.001	<.001	<.001	<.001
h487	Number of graduate teachers	a	0.189	-0.022	-0.139	-0.074	-0.018	-0.122	-0.063
		b	<.001	0.033	<.001	<.001	0.085	<.001	<.001
h5122	Students disallowed from borrowing library books to take home	a	0.082	0.021	-0.104	-0.066	0.057	-0.059	-0.053
		b	<.001	0.046	<.001	<.001	<.001	<.001	<.001

Note. Pair-wise correlation: ≤0.35 = Weak correlation; 0.36-0.67 = Moderate correlation; 0.68-0.89=Strong correlation; ≥0.90 = Very strong correlation; Adapted from "Interpretation of Correlation Coefficient, " by R. Taylor, 1990, Journal of Diagnostic Medical Sonography, 6(1), p. 37

[a] Pearson correlation coefficient; [b] *p*-values (α=.05)

The focus in Objective 1 was to model teacher-level effects on student academic achievement. Of the three teacher-level variables, the number of formal written tests in the teacher's subject (t227) had the ‘strongest’ correlation with the outcome variable, r=0.349, p=<.001. This is however considered weak (Taylor, 1990). The other two variables; Teacher's age in years (t22a) and number of in-service courses attended by the teacher in their respective subjects (t214) had much weaker correlations with the outcome variable compared with t227. The ‘strongest’ correlation with the outcome variable in the entire matrix was the Sub-County where the school was located (h16), r=0.513, p=<.001. The entire matrix did not have any strong correlations equal to or greater than 0.900 signalling that the regression models would not suffer multicollinearity issues.

4.4.2 Descriptive Statistics for Variables Used in Data Analysis

Table 4.7 presents the descriptive statistics for variables used in the analysis of data for objective 1 through 3. Interval and Ratio-scale variables are presented first followed by categorical variables, then dummies and lastly nominal variables. As expected, there was a lot more variation in teacher-age (*SD*=9.40) than there was among students (*SD*=0.03). The standard deviation of a probability distribution indicates how much, on average, each of the values in the distribution deviates from the mean, or centre of the distribution. A low standard deviation indicates that the data points tend to be very close to the mean while a high standard deviation indicates that the data points are spread out over a large range of values (Ingule & Gatumu, 1996; Vittinghoff, Shiboski, Glidden, & McCulloch, 2005).

Table 4.7. Descriptive Statistics for Variables Used in the Modelling Objectives 1 Through 3

Variable	Variable label	N	Mean	Standard error (mean)	Standard deviation	Min	Max
s17f	Student's total KCPE score (z-score)	1824	0.00	0.02	1.00	-2.84	2.37
s17g	Student's running score in the five KCPE subjects (z-score)	9120	0.00	0.01	1.00	-3.07	2.93
s22a	Student's age in years	1824	15.27	0.03	1.31	12.19	22.18
s23a	Student's years in current school	1824	6.23	0.07	2.79	0.56	10.70
s61x	Student keeps negative company (z-score)	1824	0.00	0.01	0.49	-0.74	2.65
t22a	Teacher's age in years	9120	37.89	0.10	9.40	18.21	58.07
t227	Number of formal written tests in teacher's subject	9120	11.14	0.07	6.44	1	40
h218z	Mean parental contribution 0-10 scale	1824	2.98	0.05	2.18	0	10
h227z	Mean community school participation: 0-10 scale	1824	6.38	0.06	2.72	0	10
h49a	Mean teacher years since first employment	1824	13.6	0.11	4.74	1.00	25.21
s27	Number of times student spoke English in the last 7 days	1824	3.52	0.04	1.83	0.00	7
s36c	Number of siblings	1824	5.07	0.06	2.36	0	16
s58x	Number of times student has repeated classes	1824	0.74	0.02	0.72	0	3
t214	Number of in-service courses	9120	0.88	0.01	1.27	0	8
h432	Number of female teachers	1824	6.88	0.11	4.86	1	30
h487	Number of graduate teachers	1824	1.71	0.05	2.15	0	12
Categorical variables [% in ()]		N	1=High tertile	2=Middle tertile	3.Low tertile		
s313x	Student's Wealth Index (3 Tertiles)	1824	608 (33.33)	608 (33.33)	608 (33.33)		
		1824	1=Never	2=Some days	3=Most days		
s314a	Looking after younger relatives	1824	458 (25.11)	1,009 (55.32)	357 (19.57)		
s314b	Looking after elderly relatives	1824	800 (43.86)	798 (43.75)	226 (12.39)		
s314d	Cooking	1824	247 (13.54)	921 (50.49)	656 (35.96)		
s314e	House cleaning	1824	146 (8.00)	802 (43.97)	876 (48.03)		
s314h	Fetching water	1824	182 (9.98)	738 (40.46)	904 (49.56)		
s314i	Chopping fire wood	1824	534 (29.28)	901 (49.40)	389 (21.33)		
s314l	Gardening/working in a vegetable garden	1824	407 (22.31)	953 (52.25)	464 (25.44)		

(continued)

Table 4.7. Descriptive Statistics for Variables Used in the Modelling Objectives 1 Through 3 (continued)

Variable	Variable label	N	Mean	Standard error (mean)	Standard deviation	Min	Max
s314m	Taking care of livestock	1824	677 (37.12)	751 (41.17)	396 821.71)		
			1=Day	2=Boarding	=Day and boarding		
h24a	Boarding status at class 8	1824	1,583 (86.79)	79 (4.33)	162 (8.88)		
Dummy variables [% in ()]		N	0=Otherwise	1=Yes			
s332	Mother has some primary education	1824	1,406 (77.08)	418 (22.92)			
s333	Mother has completed primary education	1824	1,372 (75.22)	452 (24.78)			
s334	Mother has some secondary education	1824	1,630 (89.36)	194 (10.64)			
s336	Mother has completed post-secondary training	1824	1,653 (90.63)	171 (9.38)			
s353	Father has completed primary education	1824	1,483 (81.30)	341 (18.70)			
s356	Father has completed post-secondary training	1824	1,556 (85.31)	268 (14.69)			
h5122	Students disallowed from borrowing library books to take home	1824	1,569 (86.02)	255 (13.98)			
Nominal variables [% in ()]		N	0=Male	1=Female			
s21	Female student	1824	927 (50.82)	897 (49.18)			
Nominal variables [% in ()]		N	0=No	1=Yes			
h31e	School has piped water	1824	591 (32.40)	1,233 (67.60)			
h31f	School has electricity	1824	653 (35.80)	1,171 (64.20)			
h31i	School has a typewriter	1824	1,535 (84.16)	289 (15.84)			
h32	School has a feeding programme	1824	829 (45.45)	995 (54.55)			
h16	Kuria East Sub-County	1824	1,068 (58.55)	756 (41.45)			

Note. n=1824; Min=Minimum; Max=Maximum; percentages in parentheses (); Student Level-1 variables are prefixed with letter "s", Teacher Level-2 with letter "t" and School Level-3 with letter "h"

The number of female teachers had the smallest Standard Error of the Mean (SEM) of 0.01 as was the number of times a student had repeated classes (*SEM*=0.02). The SEM is the estimate of the amount that an obtained Mean may be expected to differ by chance from the true mean. The smaller the standard error, the more representative the sample will be of the overall population. The standard error is also inversely proportional to the sample size. The larger the sample size, the smaller the standard error because the statistic will approach the actual value (Harris, 1998; Ravid, 2010).

4.4.3 A Three-Level Mixed Effects Hierarchical Linear Model for Teacher-Level Effects on Student Academic Achievement in the KCPE Examination.

A three-level mixed effects model (with fixed and random effects) was fitted to examine the relative importance of teachers and their influence on student academic achievement in the KCPE examination using data from 9120 student-records (Level-1) nested within 305 teachers (Level-2) nested within 61 schools (Level-3). In mixed models, fixed effects are analogous to standard regression coefficients and are estimated directly. The random effects are often not directly estimated but are summarized according to their estimated variances and covariances. Random effects may take the form of either random intercepts or random coefficients (Leckie, 2013).

As is usual for HLM, the starting point was to fit an unconditional model (also called intercept-only, null or empty model) in order to obtain the amounts of variance available for explanation at each level of the hierarchy (Hungi & Thuku, 2010; Raudenbush & Bryk, 2002).

4.4.3.1 The Unconditional Model (Intercept-only, Null, Empty)

A three-level variance components model was specified and fitted including only an intercept, school and teacher effects, and a student level residual error term. The model did not make any adjustments for predictor variables, only decomposing the total variance in the outcome variable (students' standardized running score on the five KCPE subjects) into separate school, teacher and student variance components.

The researcher followed Raudenbush and Bryk (2002) and Leckie (2013) in specifying the models used in the analysis. In Level-1, student academic achievement in the five

KCPE academic subjects was modelled as a function of a teacher mean plus a random error:

$$Y_{ijk} = u_{0jk} + e_{ijk} \tag{4.2}$$

Where:

Y_{ijk} is the observed KCPE academic subject score for student i ($i = 1, \dots, 9120$) nested within teacher j ($j = 1, \dots, 305$) nested within school k ($k = 1, \dots, 61$);

u_{0jk} is the mean achievement of teacher j in school k; and

e_{ijk} is a random "student effect", that is, the deviation of student $ijk's$ score from the teacher mean. These effects are assumed normally distributed with a mean of 0 and a variance σ_e^2.

The Level-2 model viewed each teacher mean (u_{0jk}) as an outcome varying randomly around some school mean:

$$u_{0jk} = v_{00k} + r_{0jk} \tag{4.3}$$

Where

v_{00k} is the mean achievement in school k;

r_{0jk} is a random "teacher effect", that is, the deviation of teacher $jk's$ mean from the school mean. These effects are assumed normally distributed with a mean of 0 and a variance σ_u^2. Within each of the k schools, the variability among the teachers is assumed the same.

The Level-3 model represented the variability among schools. The school means v_{00k} were viewed as varying randomly around a grand mean γ_{000}.

$$v_{00k} = \gamma_{000} + u_{00k} \tag{4.4}$$

Where

γ_{000} is the grand mean;

u_{00k} is a random "school effect", that is, the deviation of a school $k's$ mean from the grand mean. These effects are assumed normally distributed with a mean of 0 and a variance σ_v^2.

Equations 4.2, 4.3 and 4.4 partitioned the total variability in the outcome variable Y_{ijk} into its three components: Among students within teachers (Level-1), σ_e^2; among teachers within schools (Level-2), σ_u^2; and among schools, σ_v^2. These equations also allowed the estimation of the proportion of variance that was among students, among teachers within schools, and among schools. The proportion of variation among students (Level-1) was estimated as:

$$\sigma_e^2/(\sigma_e^2 + \sigma_u^2 + \sigma_v^2) \tag{4.5}$$

While the proportion of variation among teachers within schools was estimated as

$$\sigma_u^2/(\sigma_e^2 + \sigma_u^2 + \sigma_v^2); \tag{4.6}$$

and the proportion of variation among schools was estimated as:

$$\sigma_v^2/(\sigma_e^2 + \sigma_u^2 + \sigma_v^2) \tag{4.7}$$

The researcher followed Leckie (2013) in specifying the unconditional/null model as:

$$Y_{ijk} = \beta_0 + v_k + u_{jk} + e_{ijk} \quad (4.8)$$

Assuming that; $v_k \sim N(0, \sigma_v^2)$

$u_{jk} \sim N(0, \sigma_v^2)$

$e_{ijk} \sim N(0, \sigma_v^2)$

Where:

Y_{ijk} is the KCPE academic subject score for student i $(i = 1, \dots, 9120)$ nested within teacher j $(j = 1, \dots, 305)$ in school k, $(k = 1, \dots, 61)$;

β_0 is the mean score across all schools;

v_k is the effect of school k;

u_{jk} is the effect of teacher j; and

e_{ijk} is the student level residual error term.

The school, teacher effects and the student level residual errors are assumed independent and normally distributed with zero means and constant variances.

Table 4.8 presents the results of this null model.

Table 4.8 Three Level Unconditional Model

Fixed Effect			
Variable	Variable label	Null Model	
		Est. (Std. Err.)	*p*
	Intercept, β_{0jk}	-0.02 (0.09)	0.834
Random Effect		*Variance Component*	
Student (Level-1), e_{ijk}		0.4358 (0.01)	
Teacher (Level-2), u_{jk}		0.0490 (0.01)	
School (Level-3), v_k		0.5084 (0.09)	
Variance Partition Coefficient (VPC)			
Student (Level-1), σ^2_e		0.4388	
Teacher (Level-2), σ^2_u		0.0493	
School (Level-3), σ^2_v		0.5119	
Model Fit Statistics			
Deviance		18963	
Akaike Information Criterion (AIC)		18971	
Bayesian Information Criterion (BIC)		19000	
Likelihood Ratio test vs. OLS Regression		χ^2= 6917	<.001

Note. N= 9120 (1824*5 = 9120, each student has 5 academic subject records); Est. = Estimate; Std. Err. = Standard Error (in parentheses); AIC and BIC statistics = smaller-is-better fit; OLS=Ordinary Least Squares

The random intercept, β_0, has the student's z-score in any of the Five KCPE examination Subjects as -0.02 (*SE*=0.09, *p*=.834). Since the outcome variable is approximately normalised, an estimated random intercept of zero, an estimated total variance of approximately one and a non-significant intercept are all expected. The random part of the model presents the Variance Partition Coefficient (VPC) for each HLM level with $\sigma_e^2 = Var(e_{ijk})$ yielding 0.4358 which is the variance among students within teachers and $\sigma_u^2 = Var(u_{jk})$ yielding 0.0490 which is the variance between teachers within schools and $\sigma_v^2 = Var(v_k)$ yielding 0.5084 which is the variance between schools. Each of these variance estimates was deemed statistically significant since each was much larger than its corresponding standard error (if the variance estimate is divided by its standard error and the result is >1.96, then the estimate is statistically significant).

Substituting the Variance Components into equation 4.5, 4.6 and 4.7, the VPC available for explanation at Student (σ_e^2), Teacher (σ_u^2) and School (σ_v^2) levels was 0.4388 (43.88%), 0.0493 (4.93%) and 0.5119 (51.19%) respectively. The largest variance lay between schools (51.19%) while a substantial one lay among students within teachers (43.88%). Only 4.93% of the variance lay between teachers within schools suggesting that there was only modest variation in the five subjects between teachers. Most of the variation in students' scores was seen between their schools and among themselves.

Deviance, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) measured how well the model fitted the data. A reduction in the estimates of each in subsequent models when predictors were introduced suggested that those subsequent models were better in fitting the data compared with the preceding model(s). The researcher also carried out a Likelihood Ratio (*LR*) test to compare the null model to a single-level model with no school effects and no teacher effects (i.e. Ordinary Least Squares linear regression). The *LR* test statistic was $\chi^2(2)=6917$, $p<.001$ implying that a three-level model offered a significantly better fit to the data than the single-level model with the conclusion that the 1,824 students did not act as 1,824 independent observations. Rather, students were clustered around teachers and schools with students from the same school being significantly more alike than students from different schools. Similarly, students taught by the same teacher in one subject were significantly more homogenous than schoolmates taught by another teacher in the other four subjects. This also meant that the subject scores varied significantly across schools and across teachers. A multilevel approach to analyse the data was clearly favoured over a single-level approach.

Having fitted the model, the researcher predicted Empirical Bayes Estimates (i.e. posterior, shrunken, or best linear unbiased predictions, [BLUPs]) of the school and teacher effects together with their associated standard errors. This helped check whether the random effects at each level were normally distributed as well as to help make inferences about specific schools or teachers. Table 4.9 presents the BLUPs with the Empirical Bayes Estimates (EBE) showing that school 41 in Kuria East Sub-County with a score of -1.33 was predicted to be the lowest scoring school while school 29 in Mumias Sub-County with a score of 1.52 was predicted to be the highest scoring school.

Table 4.9 Empirical Bayes Estimates of School Effects

School Code	EBE	Std. Error	Rank	School Code	EBE	Std. Error	Rank
41	-1.33	0.12	1	9	0.12	0.11	32
40	-1.25	0.11	2	44	0.15	0.13	33
59	-1.20	0.11	3	38	0.15	0.15	34
49	-1.01	0.12	4	19	0.16	0.11	35
46	-0.98	0.13	5	8	0.22	0.12	36
47	-0.91	0.11	6	32	0.23	0.13	37
42	-0.91	0.11	7	3	0.24	0.11	38
60	-0.88	0.11	8	4	0.24	0.11	39
35	-0.87	0.12	9	26	0.25	0.11	40
57	-0.79	0.11	10	24	0.26	0.11	41
28	-0.77	0.12	11	54	0.29	0.11	42
45	-0.75	0.12	12	17	0.31	0.12	43
37	-0.70	0.12	13	25	0.32	0.11	44
55	-0.64	0.11	14	5	0.37	0.11	45
51	-0.60	0.11	15	22	0.38	0.11	46
27	-0.58	0.11	16	39	0.46	0.13	47
56	-0.57	0.11	17	52	0.52	0.15	48
61	-0.55	0.11	18	7	0.74	0.11	49
48	-0.53	0.11	19	2	0.74	0.12	50
34	-0.44	0.11	20	6	0.74	0.11	51
50	-0.37	0.11	21	30	0.87	0.12	52
53	-0.24	0.12	22	14	0.87	0.11	53
20	-0.23	0.11	23	31	0.93	0.11	54
43	-0.23	0.11	24	15	0.98	0.11	55
36	-0.22	0.11	25	1	0.98	0.11	56
23	-0.22	0.11	26	58	1.02	0.12	57
33	-0.18	0.11	27	18	1.07	0.11	58
10	-0.05	0.12	28	12	1.21	0.11	59
11	0.04	0.12	29	13	1.41	0.11	60
21	0.08	0.11	30	29	1.52	0.11	61
16	0.10	0.11	31				

Note. EBE = Empirical Bayes Estimates; Std. Err. = Standard Error

The difference between the highest and the lowest scoring schools was huge (1.52 - [-1.33] = 2.85) given that these are Z-scores ranging between -4.0 and 4.0 with Mean Zero (0) and Standard Deviation of one (1). Since there were 305 teachers, a similar table as 4.9 would be rather long. A summary of the teacher effect would thus suffice (*M* = 0.00, *SE* = 0.17, Minimum = -0.54, Maximum = 0.47).

Using a quantiles of normal distribution graph, Figure 4.1 checked whether the school random effects were normally distributed. All the data would be plotted along the 45 degree line if the random effects were normally distributed.

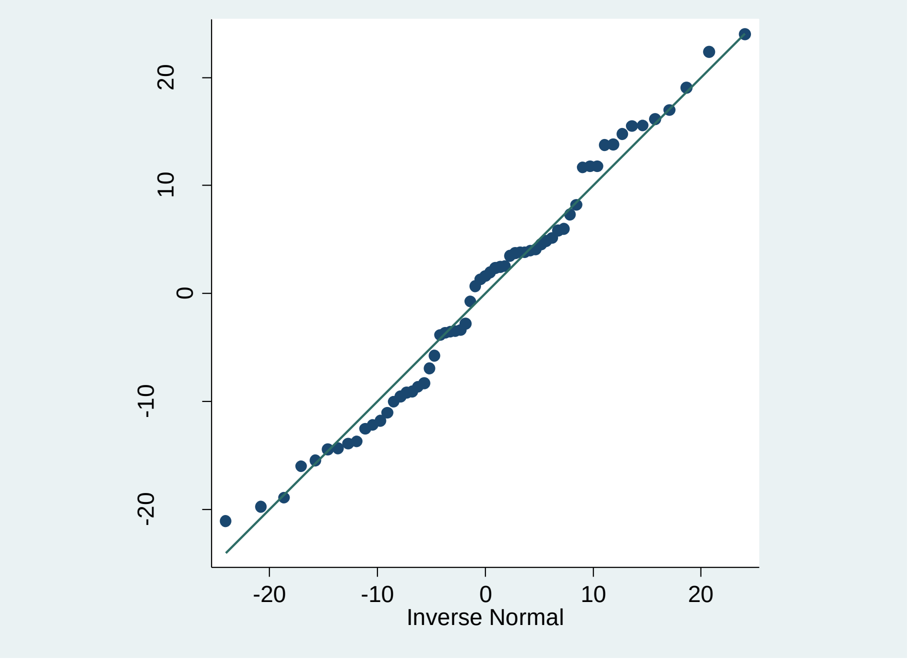

Figure 4.1 Quantiles of Normal Distribution for School Effects

Although not perfectly aligned, the 61 schools lay close to the line suggesting that the predicted effects were approximately normally distributed. The graph for the teacher effects in Figure 4.2 shows that these effects were normally distributed.

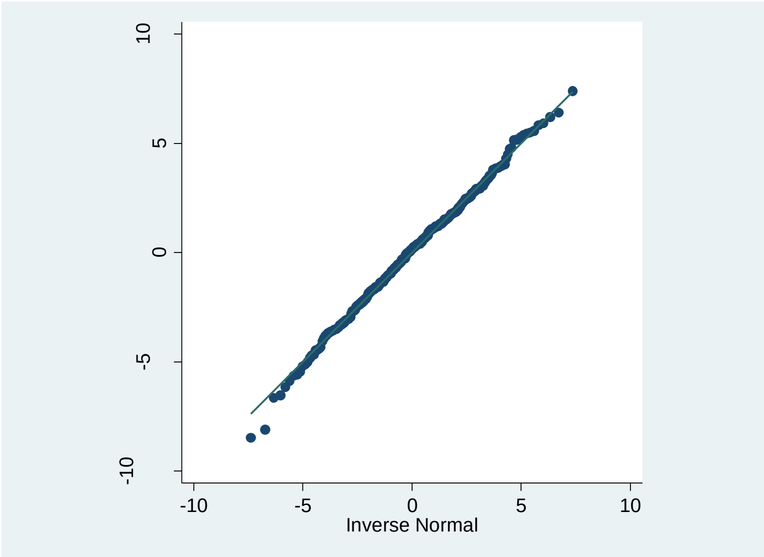

Figure 4.2 Quantiles of Normal Distribution for Teacher Effects

The researcher also examined the magnitude of the school effects by counting the number of schools that differed significantly from the average school. Figure 4.3 presents the resulting graph.

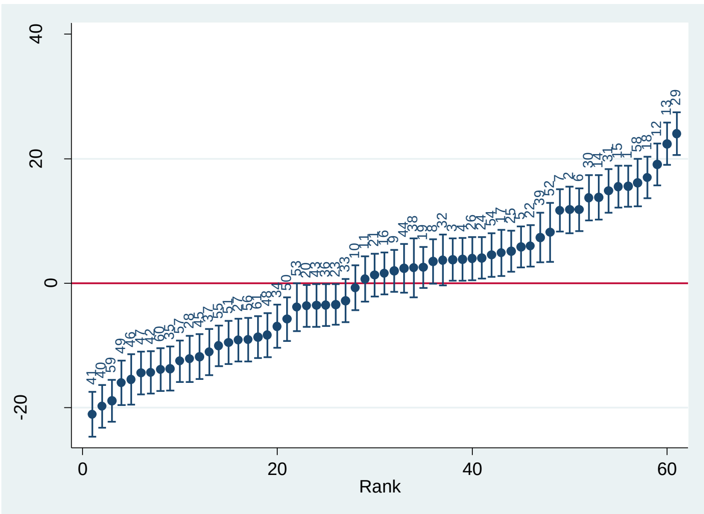

Figure 4.3 The Magnitude of School Effects

The plot shows that 43 out of the 61 schools differed significantly from the average school while 21 schools scored significantly lower than this average school. Majority of schools from Mumias (numbered 1-32) had effects above that of the average school numbered 11 located in Mumias. This suggests that schools in Mumias Sub-County had stronger effects on student KCPE scores compared with schools from Kuria East (numbered 33-61). Only 6 out of 29 (44, 38, 54, 39, 52, and 58) schools in Kuria East had effects above the average school. This shows that although Kuria East is ranked in the bottom 5% of Kenya's Sub-Counties, not all schools there are in that category just like not all schools in Mumias Sub-County scored above the average school (4 out of 32 numbered 27, 20, 23, and 10). This is the dynamic reality of life.

Running the equivalent plot for teachers as presented in Figure 4.4 shows that 34 out of the 305 teachers differed significantly from the average teacher with 17 above and 17 below. This suggests that majority of the teachers (271) were clustered around the 'average teacher' (305-34=271).

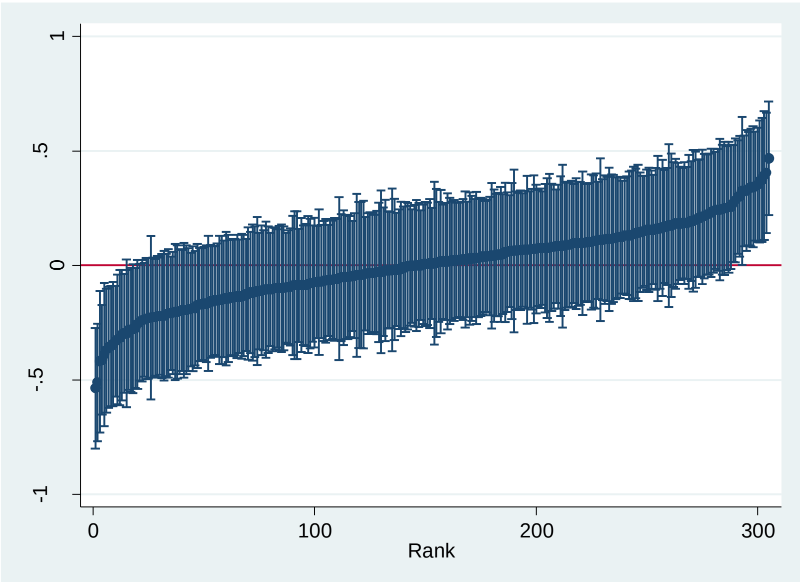

Figure 4.4 The Magnitude of Teacher Effects

4.4.3.2 The Student (Level-1) Random Intercept Model for Objective 1

Under each teacher, student achievement was modelled as a function of student- level predictors plus a random student-level error. As already noted, there was a variance of

43.88% that lay at Level-1 that needed to be explained by modelling Level-1 predictors that were significantly correlated with the outcome variable as summarized in Table 4.6. Again, following Leckie (2013) and Raudenbush and Bryk (2002), the student-level (Level-1) model was specified as:

$$Y_{ijk} = \beta_0 + \beta_1 a_{1ijk} + \beta_2 a_{2ijk} + \cdots + \beta_{pjk} a_{pijk} + v_k + u_{jk} + e_{ijk} \quad (4.9)$$

Assuming that; $v_k \sim N(0, \sigma_v^2)$

$u_{jk} \sim N(0, \sigma_u^2)$

$e_{ijk} \sim N(0, \sigma_e^2)$

Where:

Y_{ijk} is the KCPE academic subject score for student i $(i = 1, \dots, 9120)$ nested within teacher j $(j = 1, \dots, 305)$ in school k, $(k = 1, \dots, 61)$;

β_0 is the mean score across all schools;

a_{pijk} are $p = 1, \dots, P$ student characteristics that predict achievement;

β_{pjk} are the corresponding Level-1 coefficients that indicate the direction and strength of association between each student characteristic, a_p and the outcome under teacher jk;

v_k is the effect of school k;

u_{jk} is the effect of teacher j; and

e_{ijk} is the student level residual error term.

The school, teacher effects and the student-level residual errors are assumed independent and normally distributed with zero means and constant variances.

Selection of "candidate predictors" to be included in the final student-level model involved a two-step process informed by the need for parsimony in the model, that is, striking a balance between simplicity (as few predictors as possible) and fit (as many predictors as needed). In an ideal situation, the model should be as complete and as realistic as possible with every predictor that is even remotely related to the outcome variable being included (fit). But there is also the realization that the model should include as few "relevant" variables as possible because each "irrelevant" predictor decreases the precision of the estimated coefficients and predicted values. Also, the presence of "unnecessary" variables increases the complexity of model maintenance, hence the need for simplicity (Number Cruncher Statistical System [NCSS], 2015). In the first step therefore, all variables that were significantly correlated with the outcome variable were listed. The second step involved running the listed "candidate predictor-variables" in an exploratory student-only-level model while considering the hierarchical nature of the dataset, and excluding teacher-level and school-level variables (Hungi & Thuku, 2010; Leckie, 2010, 2013; Raudenbush & Bryk, 2002; StataCorp, 2013a). Table 4.10 presents non-significant predictors that could not make it into the final student-level model following this two-step screening process.

Table 4.10 Non-significant Variables Dropped from the Student-Model

Variable	Est. (Std. Err.)	*p*
Student is Muslim	0.02 (0.03)	0.454
Sweeping outside the house: 1=Never (Ref.)		
2=Some days	0.04 (0.03)	0.170
3=Most days	0.02 (0.03)	0.505
Collecting fire wood: 1=Never (Ref.)		
2=Some days	-0.02 (0.02)	0.304
3=Most days	-0.03 (0.02)	0.188
Helping in a family business: 1=Never (Ref.)		
2=Some days	0.00 (0.02)	0.793
3=Most days	-0.03 (0.02)	0.159
Washing and ironing clothes: 1=Never (Ref.)		
2=Some days	0.01 (0.02)	0.780
3=Most days	0.00 (0.02)	0.975
Mother did not go to school	0.04 (0.03)	0.205
Father did not go to school	-0.00 (0.04)	0.910
Father has some primary education	-0.03 (0.02)	0.110

Note. Std. Err. = Standard Error (in parentheses)

Substituting the remaining student-level predictors into the Level-1 model (4.9) yielded:

$$Y_{ijk} = \beta_0 + \beta_1 s21_{ijk} + \beta_2 s22a_{ijk} + \beta_3 s23a_{ijk} + \beta_4 s27_{ijk} + \beta_5 s314a_{ijk} + \beta_6 s314b_{ijk} + \beta_7 s314d_{ijk} + \beta_8 s314e_{ijk} + \beta_9 s314h_{ijk} + \beta_{10} s314i_{ijk} + \beta_{11} s314l_{ijk} + \beta_{12} s314m_{ijk} + \beta_{13} s332_{ijk} + \beta_{14} s333_{ijk} + \beta_{15} s334_{ijk} + \beta_{16} s336_{ijk} + \beta_{17} s353_{ijk} + \beta_{18} s356_{ijk} + \beta_{19} s36c_{ijk} + \beta_{20} s58x_{ijk} + \beta_{21} s61x_{ijk} + \beta_{22} s313x_{ijk} + v_k + u_{jk} + e_{ijk} \quad (4.9a)$$

Where s21= Student's sex (Ref. 1= Female); s22a= Student's age in years; s23a= Student's years in current school; s27= Number of times student spoke English in last 7 days; s314a= Looking after younger relatives; s314b= Looking after elderly relatives; s314d= Cooking; s314e= House cleaning; s314h= Fetching water; s314i= Chopping fire wood; s314l= Gardening/working in a vegetable garden; s314m= Taking care of livestock; s332= Mother has some primary education; s333= Mother has completed primary education; s334= Mother has some secondary education; s336= Mother has completed post-secondary training; s353= Father has completed primary education; s356= Father has completed post-secondary training; s36c= Number of siblings; s58x= Number of times student has repeated classes; s61xStudent keeps negative company (z-score); and s313x= Student's Wealth Index (3 tertiles).

4.4.3.3 The Teacher (Level-2) Random Intercept Model for Objective 1

In each school, student achievement was modelled as a function of teacher- level independent variables plus a random teacher-level error. As already noted, there was a variance of 4.93% that lay at Level-2 that needed to be explained by modelling Level-2 independent variables that were significantly correlated with the outcome variable as summarized in Table 4.6. The teacher-level (Level-2) model was an extension of model 4.9 and 4.9a specified as:

$$Y_{ijk} = \beta_0 + \beta_1 a_{1ijk} + \beta_2 a_{2ijk} + \beta_3 c_{3jk} + \beta_4 c_{4jk} + \cdots + \beta_{gjk} c_{gjk} + v_k + u_{jk} + e_{ijk} \quad (4.10)$$

Assuming that; $v_k \sim N(0, \sigma_v^2)$

$u_{jk} \sim N(0, \sigma_u^2)$

$e_{ijk} \sim N(0, \sigma_e^2)$

Where:

Y_{ijk} is the KCPE academic subject score for student

$(i = 1, \ldots, 9120)$ nested within teacher j $(j = 1, \ldots, 305)$ in school k, i $(k = 1, \ldots, 61)$;

β_0 is the mean score across all schools;

c_{gjk} are $g = 1, \ldots, G$ teacher characteristics that predict achievement;

β_{gjk} are the corresponding Level-2 coefficients that indicate the direction and strength of association between each teacher characteristic, c_g and the outcome under school k;

v_k is the effect of school k;

u_{jk} is the effect of teacher j; and

e_{ijk} is the student level residual error term.

The school, teacher effects and the student level residual errors are assumed independent and normally distributed with zero means and constant variances.

The two-step selection process for predictors described in section 4.4.3.2 was similarly considered for the teacher-level variables. The first step listed teacher-level variables that were correlated with the outcome variable. These were then screened in a teacher-only-level model (excluding student-level and school-level variables). The predictors summarized in Table 4.11 did not return statistically significant effects on the outcome variable at $p<.05$ and were consequently dropped and not considered in the final teacher-level model as their presence in this and the subsequent school-level model would add little explanatory value (Leckie, 2010).

Table 4.11 Non-significant Variables Dropped from the Teacher-Model

Variable	Est. (Std. Err.)	*p*
TSC teacher	-0.07 (0.07)	0.331
Teacher's professional grade in 2014: 11=Untrained (Ref)		
15=P1	0.06 (0.08)	0.441
16=S1/Diploma	0.08 (0.09)	0.408
17=ATS	0.14 (0.10)	0.177
18=Graduate	0.07 (0.09)	0.445
Teacher's adequacy of teaching subject 0-10	-0.00 (0.01)	0.841
Teacher lessons per week	-0.01 (.01)	0.519
Number of times HT observed teacher teaching	-0.01 (0.01)	0.143
School has a resource centre serving it	-0.06 (0.05)	0.250
Grade 8 subject specific syllabus coverage	-0.00 (0.00)	0.862
Teacher has additional textbooks	-0.04 (0.05)	0.430

Note. Std. Err. = Standard Error (in parentheses)

This process left three teacher-level variables for modelling: Teacher's age in years (t22a); number of in-service courses attended (t214) and number of formal written tests in the teacher's subject (t227). Since HLM is additive by level, these three variables were brought into the teacher-level model and specified as:

$$Y_{ijk} = \beta_0 + \beta_1 s21_{ijk} + \beta_2 s22a_{ijk} + \beta_3 s23a_{ijk} + \beta_4 s27_{ijk} + \beta_5 s314a_{ijk} + \beta_6 s314b_{ijk} + \beta_7 s314d_{ijk} + \beta_8 s314e_{ijk} + \beta_9 s314h_{ijk} + \beta_{10} s314i_{ijk} + \beta_{11} s314l_{ijk} + \beta_{12} s314m_{ijk} + \beta_{13} s332_{ijk} + \beta_{14} s333_{ijk} + \beta_{15} s334_{ijk} + \beta_{16} s336_{ijk} + \beta_{17} s353_{ijk} + \beta_{18} s356_{ijk} + \beta_{19} s36c_{ijk} + \beta_{20} s58x_{ijk} + \beta_{21} s61x_{ijk} + \beta_{22} s313x_{ijk} + \beta_{23} t22a_{jk} + \beta_{24} t214_{jk} + \beta_{25} t227_{jk} + v_k + u_{jk} + e_{ijk} \quad (4.10a)$$

Where the Model-2 specific variables introduced in the model were t22a= Class 8 teacher's age in years; t214= Number of in-service courses attended by teacher in their teaching subject and t227= Number of formal written tests in teacher's subject. The Student Level-1 variables in this model are described under Model 4.9a and for conciseness there is need of describing the same here.

4.4.3.4 The School (Level-3) Random Intercept Model for Objective 1

In this final model, student achievement was modelled as a function of school- level predictors plus a random school-level error. As already noted, there was a variance of 51.19% that lay at Level-3 that needed to be explained by modelling Level-3 covariates that were significantly correlated with the outcome variable as summarized in Table 4.6. The school-level (Level-3) model was an extension of model 4.10 and 4.10a and was specified as:

$$Y_{ijk} = \beta_0 + \beta_1 a_{1ijk} + \beta_2 a_{2ijk} + \beta_3 c_{3jk} + \beta_4 c_{4jk} + \beta_5 d_{5k} + \beta_6 d_{6k} + \cdots + \beta_{mk} l_{mk} + v_k + u_{jk} + e_{ijk} \quad (4.11)$$

Assuming that; $v_k \sim N(0, \sigma_v^2)$

$u_{jk} \sim N(0, \sigma_u^2)$

$e_{ijk} \sim N(0, \sigma_e^2)$

Where:

Y_{ijk} is the KCPE academic subject score for student $(i = 1, \dots, 9120)$ nested within teacher j $(j = 1, \dots, 305)$ in school k, i $(k = 1, \dots, 61)$;

β_0 is the mean score across all schools;

l_{mk} are $m = 1, \dots, M$ school characteristics that predict achievement;

β_{mk} are the corresponding Level-3 coefficients that indicate the direction and strength of association between each school characteristic, l_m and the outcome in school k;

v_k is the effect of school k;

u_{jk} is the effect of teacher j; and

e_{ijk} is the student level residual error term.

The school, teacher effects and the student level residual errors are assumed independent and normally distributed with zero means and constant variances.

The two-step selection process for predictors described in section 4.4.3.2 was followed for screening of the school-level variables. The first step listed all school-level variables that were correlated with the outcome variable. These were then screened in a school-only-level model (excluding student-level and teacher-level variables). The variables summarized in Table 4.12 did not return significant effects on the outcome variable at $p<.05$ and were consequently dropped and not considered in Model-3 (school-level) as their presence in this model under Objective 1 would add little explanatory value (Leckie, 2010).

Table 4.12 Non-significant Variables Dropped from the School-Model

Variable	Est. (Std. Err.)	*p*
Public primary school	-0.15 (0.21)	0.47
Girls Latrine Ratio	-0.00 (0.00)	0.1
Mean parental contribution 0-10 scale	0.05 (0.03)	0.06
School has a feeding programme	0.21 (0.13)	0.12
Mean student negative behaviour 0-10 scale	0.06 (0.04)	0.14

Note. Std. Err. = Standard Error (in parentheses)

The school-level model (Model-3) was specified as:

$$Y_{ijk} = \beta_0 + \beta_1 s21_{ijk} + \beta_2 s22a_{ijk} + \beta_3 s23a_{ijk} + \beta_4 s27_{ijk} + \beta_5 s314a_{ijk} + \beta_6 s314b_{ijk} + \beta_7 s314d_{ijk} + \beta_8 s314e_{ijk} + \beta_9 s314h_{ijk} + \beta_{10} s314i_{ijk} + \beta_{11} s314l_{ijk} + \beta_{12} s314m_{ijk} + \beta_{13} s332_{ijk} + \beta_{14} s333_{ijk} + \beta_{15} s334_{ijk} + \beta_{16} s336_{ijk} + \beta_{17} s353_{ijk} + \beta_{18} s356_{ijk} + \beta_{19} s36c_{ijk} + \beta_{20} s58x_{ijk} + \beta_{21} s61x_{ijk} + \beta_{22} s313x_{ijk} + \beta_{23} t22a_{jk} + \beta_{24} t214_{jk} + \beta_{25} t227_{jk} + \beta_{26} h22a_k + \beta_{27} h24a_k + \beta_{28} h227z_k + \beta_{29} h5122_k + v_k + u_{jk} + e_{ijk}$$

(4.11a)

Where the Model-3 specific variables introduced in the model were h16= Sub-County (Ref: 1=Kuria East); h24a= Boarding status at class 8; h227z= Mean community school participation: 0-10 scale; and h5122= Students not allowed to borrow school books and take home. The other variables are described under Model 4.10a.

Table 4.13 presents the regression results from the three models (Student, Teacher and School).

Table 4.13 Three Level School Model (Level-3), Objective 1

Fixed Effect Variable	Model 1 (Student)		Model 2 (Teacher)		Model 3 (School)	
	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*
Female student	-0.29 (0.02)	<.001	-0.29 (0.02)	<.001	-0.29 (0.02)	<.001
Student's age in years	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001
Student's years in current school	-0.02 (0.002)	<.001	-0.02 (0.003)	<.001	-0.02 (0.002)	<.001
Number of times student spoke English in the last 7 days	0.03 (.004)	<.001	0.03 (0.004)	<.001	0.03 (0.004)	<.001
Looking after younger relatives: 1= Never (Ref.)						
2= Some days	-0.03 (.018)	0.076	-0.03 (0.02)	0.077	-0.03 (0.02)	0.153
3= Most days	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001
Looking after elderly relatives: 1= Never (Ref.)						
2= Some days	-0.03 (0.02)	0.033	-0.03 (0.02)	0.032	-0.04 (0.02)	0.03
3= Most days	-0.09 (0.02)	<.001	-0.09 (0.02)	<.001	-0.09 (0.02)	<.001
Cooking: 1= Never (Ref.)						
2= Some days	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001
3= Most days	-0.08 (0.03)	0.004	-0.08 (0.03)	0.004	-0.08 (0.03)	0.004
House cleaning: 1= Never (Ref.)						
2= Some days	0.10 (0.02)	<.001	0.10 (0.03)	<.001	0.09 (0.03)	0.001
3= Most days	0.16 (0.03)	<.001	0.16 (0.09)	<.001	0.16 (0.03)	<.001
Fetching water: 1= Never (Ref.)						
2= Some days	0.08 (0.03)	0.002	0.08 (0.03)	0.002	0.08 (0.03)	0.003
3= Most days	0.14 (0.03)	<.001	0.14 (0.03)	<.001	0.14 (0.03)	<.001
Chopping fire wood: 1= Never (Ref.)						
2= Some days	-0.01 (0.02)	0.609	-0.01 (0.02)	0.608	-0.01 (0.02)	0.742
3= Most days	-0.07 (0.02)	0.001	-0.07 (0.02)	0.001	-0.07 (0.02)	0.002
Gardening/working in a vegetable garden: 1= Never (Ref.)						
2= Some days	0.07 (0.02)	<.001	0.07 (0.02)	<.001	0.07 (0.02)	0.001
3= Most days	0.08 (0.02)	0.001	0.08 (0.02)	0.001	0.07 (0.02)	0.002

(continued)

Table 4.13 Three Level School Model (Level-3), Objective 1 (continued)

Fixed Effect Variable	Model 1 (Student)		Model 2 (Teacher)		Model 3 (School)	
Taking care of livestock: 1= Never (Ref.)						
2= Some days	-0.02 (0.02)	0.339	-0.02 (0.02)	0.336	-0.02 (0.02)	0.288
3= Most days	-0.07 (0.02)	0.001	-0.07 (0.02)	0.001	-0.07 (0.02)	0.002
Mother has some primary education	0.07 (0.02)	0.001	0.07 (0.02)	0.001	0.07 (0.02)	0.001
Mother has completed primary education	0.08 (0.02)	<.001	0.08 (0.02)	<.001	0.08 (0.02)	<.001
Mother has some secondary education	0.06 (0.02)	0.007	0.06 (0.02)	0.007	0.06 (0.02)	0.009
Mother has completed post-secondary training	0.05 (0.03)	0.042	0.05 (0.03)	0.042	0.05 (0.03)	0.042
Father has completed primary education	-0.07 (0.02)	<.001	-0.07 (0.02)	<.001	-0.07 (0.02)	<.001
Father has completed post-secondary training	0.05 (0.02)	0.025	0.05 (0.02)	0.025	0.04 (0.02)	0.023
Number of siblings	-0.01 (0.003)	<.001	-0.01 (0.003)	<.001	-0.01 (0.00)	<.001
Number of times student has repeated classes	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001
Student keeps negative company (z-score)	-0.21 (0.01)	<.001	-0.21 (0.01)	<.001	-0.20 (0.01)	<.001
Student's Wealth Index: 1= High tertile (Ref.)						
2= Middle tertile	-0.04 (0.02)	0.009	-0.04 (0.02)	0.009	-0.04 (0.02)	0.013
3= Low tertile	-0.13 (0.02)	<.001	-0.13 (0.02)	<.001	-0.13 (0.02)	<.001
Teacher's age in years			-0.01 (0.002)	0.001	-0.01 (0.002)	0.001
Number of in-service courses			0.03 (0.01)	0.029	0.02 (0.01)	0.059
Number of formal written tests in teacher's subject			0.01 (0.003)	0.001	0.01 (0.003)	<.001
County: 1= Kuria East Sub-County					-0.85 (0.09)	<.001
Boarding status at class 8: 1=Day (Ref.)						
2=Boarding					0.81 (0.21)	<.001
3=Day and boarding					0.65 (0.15)	<.001
Mean community school participation: 0-10 scale					0.04 (0.02)	0.029
Students disallowed from borrowing library books to take home					-0.11 (0.02)	<.001
Intercept	1.37 (0.13)	<.001	1.48 (0.15)	<.001	1.54 (0.17)	<.001

(continued)

Table 4.13 Three Level School Model (Level-3), Objective 1 (continued)

Random Effect	Model 1 (Student)		Model 2 (Teacher)		Model 3 (School)	
	Variance Component		*Variance Component*		*Variance Component*	
Student (Level-1), e_{ijk}	0.3763 (0.01)		0.3763 (0.01)		0.3753 (0.01)	
Teacher (Level-2), u_{jk}	0.0511 (0.01)		0.0467 (0.01)		0.0467 (0.01)	
School (Level-3), v_k	0.4420 (0.08)		0.3862 (0.07)		0.0968 (0.02)	
Variance Explained (%)						
Student (Level-1), σ^2_e	0.0599		0.0599		0.0609	
Teacher (Level-2), σ^2_u	-0.0021		0.0023		0.0023	
School (Level-3), σ^2_v	0.0669		0.1230		0.4144	
Model Fit Statistics						
Deviance	17661		17635		17532	
Akaike Information Criterion (AIC)	17731		17711		17618	
Bayesian Information Criterion (BIC)	17980		17981		17924	
Likelihood Ratio test vs. OLS Regression	χ^2 (2) = 5455	<.001	χ^2 (2) = 4625	<.001	χ^2 (2) = 2097	<.001
Likelihood Ratio test (Preceding Model vs. Next)	χ^2 (31) = 1302	<.001	χ^2 (3) = 27	<.001	χ^2 (5) = 103	<.001

Note. N= 9120 (1824*5 = 9120, each student has 5 records); Est. = Estimate; Std. Err. = Standard Error (in parentheses); AIC and BIC statistics = smaller-is-better fit; OLS=Ordinary Least Squares

Absolute values of standardised coefficients can be used to rank variables in terms of their relative degree of influence on the outcome variable within the same sample (Hox, 1995, p. 26). In research studies in education, a standardised regression coefficient is considered relatively more important if its magnitude taken in absolute terms is ≥0.10 (Hungi & Thuku, 2010). This cut-off suggests that although statistically significant, the three teacher variables cannot be flagged as predictors of student academic achievement in the KCPE examination.

Controlling for student and school-level covariates in model 1 and 3 respectively, the direction and effect-strength of the three teacher-level predictors remained pretty much the same as in Model-2. From Model-3 therefore, a one-year increase in teacher age was associated with a drop in student academic achievement of 0.01 standard deviation units below the mean (SE=0.01, p=0.001) while one more formal written test in the teacher's subject was associated with an increase of 0.01 standard deviation units above the mean (SE=0.01, p=0.001). The effect of the number of teacher in-service courses on student academic achievement was insignificant in the final Model-3.

Using the ≥0.10 cut-off for standardized regression coefficients, student sex was flagged as a predictor of academic achievement in KCPE. Female students scored up to 0.29 standard deviation units below what their male colleagues with similar characteristics scored (SE=0.02, p <.001). Participation in home chores after school had mixed results for the students. Students who looked after their younger siblings most of the days while at home scored up to 0.10 standard deviation units (SE=0.02, p <.001) below their colleagues who never participated in this chore at all. Participation in cooking also had negative effect on academic achievement while house-cleaning and fetching water had positive effect on student KCPE scores. Students who kept negative company (standardized variable) scored lower than those who did not. A one standard deviation increase in keeping negative company was associated with up to -0.20 standard deviation units (*SE*=0.01, p <.001) below the mean. Negative behaviour was defined as company with friends who took alcohol and/or sneaked away from home without parental permission and/or got/get into trouble with school administration or Police for something bad they did and/or engaged in sex or sexual activity and/or smoked cigarettes or used hard drugs such as bang' and/or got into fights and quarrels with other people. Positive behaviour was defined as regular attendance of church/mosque and/or desire to join secondary school, and/or working hard in academic work, and/or get good marks in academic work and/or been commended or given a gift for good work or good behaviour.

Students' wealth index was also flagged as a predictor of achievement in KCPE with those from the low wealth tertile scoring up to 0.13 standard deviation units (*SE*=0.02, p <.001) below their colleagues from the high tertile. Using Principal Components Analysis (PCA) with non-income or expenditure data as proposed by Filmer and Pritchett (1999) and as computed in the Demographic Health Surveys (Rutstein & Kiersten, 2004; ORC Macro, 2016), the students' wealth index was determined from their reported home ownership of assets, such as cars motor cycles, electronics (including fridges), and bicycles among others; materials used for housing construction; source of lighting; and types of water access and sanitation facilities. This wealth index was then divided into three tertiles of 608 students each categorized as 1=High tertile (wealthiest of the three), 2=Middle tertile and 3= Low tertile (least wealthy of the three).

Level-3 covariates had the largest effect on students' KCPE scores. Students who sat their exams in Kuria East Sub-County scored up to 0.85 standard deviation units (*SE*=0.09, p <.001) below what their colleagues with similar characteristics scored in Mumias Sub-County. Students in boarding schools or in boarding and day schools scored higher than their colleagues in day schools by up to 0.81 and 0.65 standard deviation units respectively. Finally, students in schools that disallowed them from borrowing text books and other materials for private study away from school scored up to 0.11 standard deviation units below their colleagues who could borrow such books and materials from their schools (*SE*=0.02, p <.001). The intercept for the final model was statistically significant at 1.54 standard deviation units above the mean (*SE*=0.17, p<.001).

After accounting for school-level (Level-3) covariates in Model-3, the variance at student (e_{ijk}) and teacher (u_{jk}) levels remained pretty much the same as in Models 1 and 2. There was however a huge decline of 74.94% in the school-level variance (v_k) from 0.3862 in Model-2 (teacher) to 0.0968 in Model-3 (school). The proportion and percentage of total variance explained after fitting Model-3 (school) was 0.4777 (47.77%) as calculated in equation 4.12.

$$0.0609 + 0.0023 + 0.4144 = 0.4777\ (47.77\%) \qquad (4.12)$$

Where

0.0609 is the student-level variance, σ_e^2, explained after fitting the school-level model; and

0.0023 is the teacher-level variance, σ_v^2, explained after fitting the school-level model; and

0.4144 is the school-level variance, σ_u^2, explained after fitting the school-level model.

Deviance, AIC and BIC estimates reduced from 17661, 17731 17980 in the student-level model to 17635, 17711, 17981 in the teacher-level model and further to 17532, 17618 17924 in the school-level model respectively indicating that the school-level model improved the overall model fit compared with the student and teacher-level models. Model-3 was also deemed better than the single level Ordinary Least Squares linear regression, $LR\ \chi^2(2) = 2097, p =< .001$. Similarly, it was also better than Model-2 (the teacher-level model) at fitting the data, $LR\ \chi^2(5) = 103, p =< .001$.

4.4.3.5 The School (Level-3) Random Slopes Model for Objective 1

Equations 4.9, 4.10 and 4.11 for the student, teacher and school models respectively specified random intercepts and fixed coefficients. The random intercept model constrained the slopes thereby assuming that the same were constant at teacher and school levels. Two random slopes models (4 and 5) were specified and fitted to estimate the net effect of the three teacher predictors: Class 8 teacher's age in years; The number of in-service courses attended by the teachers in their specific subject areas and the number of formal written tests in those specific subject areas. Model-4 omitted these three variables while Model-5 included them to assess their net effect. Therefore, subtracting the variance explained in Model-4 from that explained in Model-5 gave the net-variance effect of the three predictors.

At 0.000000177, the unstructured random variance for the age of the Class 8 teacher was not statistically significant given its standard error of 0.00000165. A Likelihood Ratio test comparing the final iteration convergence log likelihood for Model-3 -8766) with -8766 in model-5 returned non-significant results, $LR = \chi^2(2) = 0.05,\ p = .977$ suggesting that this slope did not vary across schools. Similar tests for the number of in-service courses ($LR = \chi^2(2) = 1.69,\ p = .429$) and the number of formal written tests in teacher's subject ($LR = \chi^2(2) = 1.82,\ p = .402$) did also not return significant results, suggesting that these slopes did not vary across schools. These non-significant results paved the way for consideration of student-level covariates in the random slopes school model (Model-5).

Two student-level covariates, sex of student as well as student keeps negative company (standardized score) had the largest standardized coefficients beyond the ≥0.10 cut-off compared with any other covariate at that level. Equation 4.11 with its results in Model-3 of Table 4.13 assumed that the variability in student-specific deviations from the intercept was the same for female and male students as well as same for students who kept positive or negative company. To check this assumption, these two covariates were introduced into the random component of the model. Model-5 (the random slopes model) allowed a random intercept as well as random slopes. The fixed effect referred to the overall expected effect of a student's gender on KCPE academic subject-scores while the random effect gave information on whether this effect differed across schools. Allowing the random intercepts and slopes to covary, Model-5 (random slopes model) was specified as:

$$Y_{ijk} = \beta_0 + \beta_1 s21_{ijk} + \beta_2 s22a_{ijk} + \beta_3 s23a_{ijk} + \beta_4 s27_{ijk} + \beta_5 s314a_{ijk} + \beta_6 s314b_{ijk} + \beta_7 s314d_{ijk} + \beta_8 s314e_{ijk} + \beta_9 s314h_{ijk} + \beta_{10} s314i_{ijk} + \beta_{11} s314l_{ijk} + \beta_{12} s314m_{ijk} + \beta_{13} s332_{ijk} + \beta_{14} s333_{ijk} + \beta_{15} s334_{ijk} + \beta_{16} s336_{ijk} + \beta_{17} s353_{ijk} + \beta_{18} s356_{ijk} + \beta_{19} s36c_{ijk} + \beta_{20} s58x_{ijk} + \beta_{21} s61x_{ijk} + \beta_{22} s313x_{ijk} + \beta_{23} t22a_{jk} + \beta_{24} t214_{jk} + \beta_{25} t227_{jk} + \beta_{26} h22a_j + \beta_{27} h24a_j + \beta_{28} h227z_j + \beta_{29} h5122_j + v_{0k} + v_{1k} s21_{ijk} + v_{14k} s61x_{ijk} + u_{jk} + e_{ijk} \quad (4.13)$$

A description of these variables is given under models 4.9a, 4.10a and 4.11a.

Two new terms v_{1k} and v_{14k} were added to the model, so that the coefficients of the sex of the student and whether or not the student kept negative company became $\beta_{1k} = \beta_1 + v_{1k}$ and $\beta_{14k} = \beta_1 + v_{14k}$ respectively and the community-level variance replaced by a matrix with three new parameters, σ^2_{v0}, σ_{v01} and σ_{v014};

Where

$$\begin{pmatrix} v_{0k} \\ v_{1k} \\ v_{14k} \end{pmatrix} \sim N(0, \Omega_v),\ \Omega_v = \begin{pmatrix} \sigma^2_{v0} & & \\ \sigma_{v01} & \sigma^2_{v1} & \\ \sigma_{v014} & \sigma_{v114} & \sigma^2_{v14} \end{pmatrix}, e_{ijk} \sim N(0, \sigma^2_e)$$

Table 4.14 presents the results

Table 4.14 Three Level Random Slope School Model (Level-3), Objective 1

Fixed Effect Variable	Model 1 (Student)		Model 2 (Teacher)		Model 3 (School)		Model 4 (School [Random slope on s21, s61x omitting t22a, t214, t227])		Model 5 (School [Random slope on s21, s61x including t22a, t214, t227])	
	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*
Female student	-0.29 (0.02)	<.001	-0.29 (0.02)	<.001	-0.29 (0.02)	<.001	-0.29 (0.03)	<.001	-0.29 (0.03)	<.001
Student's age in years	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001
Student's years in current school	-0.02 (0.002)	<.001	-0.02 (0.003)	<.001	-0.02 (0.002)	<.001	-0.02 (0.003)	<.001	-0.02 (0.002)	<.001
Number of times student spoke English in the last 7 days	0.03 (.004)	<.001	0.03 (0.004)	<.001	0.03 (0.004)	<.001	0.03 (0.004)	<.001	0.03 (0.004)	<.001
Looking after younger relatives: 1= Never (Ref.)										
2= Some days	-0.03 (.018)	0.076	-0.03 (0.02)	0.077	-0.03 (0.02)	0.153	-0.03 (0.02)	0.116	-0.03 (0.02)	0.122
3= Most days	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001
Looking after elderly relatives: 1= Never (Ref.)										
2= Some days	-0.03 (0.02)	0.033	-0.03 (0.02)	0.032	-0.04 (0.02)	0.03	-0.04 (0.02)	0.01	-0.04 (0.02)	0.010
3= Most days	-0.09 (0.02)	<.001	-0.09 (0.02)	<.001	-0.09 (0.02)	<.001	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001
Cooking: 1= Never (Ref.)										
2= Some days	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001	-0.10 (0.02)	<.001	-0.08 (0.03)	0.001	-0.08 (0.03)	0.001
3= Most days	-0.08 (0.03)	0.004	-0.08 (0.03)	0.004	-0.08 (0.03)	0.004	-0.07 (0.03)	0.012	-0.07 (0.03)	0.012
House cleaning: 1= Never (Ref.)										
2= Some days	0.10 (0.02)	<.001	0.10 (0.03)	<.001	0.09 (0.03)	0.001	0.09 (0.03)	0.001	0.09 (0.03)	0.001
3= Most days	0.16 (0.03)	<.001	0.16 (0.09)	<.001	0.16 (0.03)	<.001	0.16 (0.029)	<.001	0.16 (0.03)	<.001
Fetching water: 1= Never (Ref.)										
2= Some days	0.08 (0.03)	0.002	0.08 (0.03)	0.002	0.08 (0.03)	0.003	0.06 (0.025)	0.015	0.06 (0.03)	0.016
3= Most days	0.14 (0.03)	<.001	0.14 (0.03)	<.001	0.14 (0.03)	<.001	0.13 (0.03)	<.001	0.12 (0.03)	<.001
Chopping fire wood: 1= Never (Ref.)										
2= Some days	-0.01 (0.02)	0.609	-0.01 (0.02)	0.608	-0.01 (0.02)	0.742	-0.003 (0.02)	0.877	-0.002 (0.02)	0.887
3= Most days	-0.07 (0.02)	0.001	-0.07 (0.02)	0.001	-0.07 (0.02)	0.002	-0.07 (0.02)	0.001	-0.07 (0.02)	0.001

(continued)

Table 4.14 Three Level Random Slope School Model (Level-3), Objective 1 (continued)

Fixed Effect Variable	Model 1 (Student)		Model 2 (Teacher)		Model 3 (School)		Model 4 (School [Random slope on s21, s61x omitting t22a, t214, t227])		Model 5 (School [Random slope on s21, s61x including t22a, t214, t227])	
Gardening/working in a vegetable garden: 1= Never (Ref.)										
2= Some days	0.07 (0.02)	<.001	0.07 (0.02)	<.001	0.07 (0.02)	0.001	0.06 (0.02)	0.002	0.06 (0.02)	0.002
3= Most days	0.08 (0.02)	0.001	0.08 (0.02)	0.001	0.07 (0.02)	0.002	0.07 (0.02)	0.003	0.07 (0.02)	0.003
Taking care of livestock: 1= Never (Ref.)										
2= Some days	-0.02 (0.02)	0.339	-0.02 (0.02)	0.336	-0.02 (0.02)	0.288	-0.02 (0.02)	0.245	-0.02 (0.02)	0.243
3= Most days	-0.07 (0.02)	0.001	-0.07 (0.02)	0.001	-0.07 (0.02)	0.002	-0.07 (0.02)	0.002	-0.07 (0.02)	0.002
Mother has some primary education	0.07 (0.02)	0.001	0.07 (0.02)	0.001	0.07 (0.02)	0.001	0.09 (0.02)	<.001	0.09 (0.02)	<.001
Mother has completed primary education	0.08 (0.02)	<.001	0.08 (0.02)	<.001	0.08 (0.02)	<.001	0.08 (0.02)	<.001	0.08 (0.02)	<.001
Mother has some secondary education	0.06 (0.02)	0.007	0.06 (0.02)	0.007	0.06 (0.02)	0.009	0.04 (0.02)	0.078	0.04 (0.02)	0.077
Mother has completed post-secondary training	0.05 (0.03)	0.042	0.05 (0.03)	0.042	0.05 (0.03)	0.042	0.05 (0.03)	0.053	0.05 (0.03)	0.052
Father has completed primary education	-0.07 (0.02)	<.001	-0.07 (0.02)	<.001	-0.07 (0.02)	<.001	-0.07 (0.02)	<.001	-0.07 (0.02)	<.001
Father has completed post-secondary training	0.05 (0.02)	0.025	0.05 (0.02)	0.025	0.04 (0.02)	0.023	0.04 (0.02)	0.031	0.04 (0.02)	0.032
Number of siblings	-0.01 (0.003)	<.001	-0.01 (0.003)	<.001	-0.01 (0.00)	<.001	-0.01 (0.003)	<.001	-0.01 (0.003)	<.001
Number of times student has repeated classes	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001	-0.08 (0.01)	<.001	-0.09 (0.01)	<.001	-0.09 (0.01)	<.001
Student keeps negative company (z-score)	-0.21 (0.01)	<.001	-0.21 (0.01)	<.001	-0.20 (0.01)	<.001	-0.16 (0.03)	<.001	-0.16 (0.03)	<.001
Student's Wealth Index: 1= High tertile (Ref.)										
2= Middle tertile	-0.04 (0.02)	0.009	-0.04 (0.02)	0.009	-0.04 (0.02)	0.013	-0.04 (0.02)	0.013	-0.04 (0.02)	0.013
3= Low tertile	-0.13 (0.02)	<.001	-0.13 (0.02)	<.001	-0.13 (0.02)	<.001	-0.13 (0.02)	<.001	-0.13 (0.02)	<.001
Teacher's age in years			-0.01 (0.002)	0.001	-0.01 (0.002)	0.001	omitted	omitted	-0.01 (0.002)	0.003
Number of in-service courses			0.03 (0.01)	0.029	0.02 (0.01)	0.059	omitted	omitted	0.03 (0.01)	0.052
Number of formal written tests in teacher's subject			0.01 (0.003)	0.001	0.01 (0.003)	<.001	omitted	omitted	0.01 (0.003)	<.001
County: 1= Kuria East Sub-County					-0.85 (0.09)	<.001	-0.84 (0.06)	<.001	-0.80 (0.08)	<.001
Boarding status at class 8: 1=Day (Ref.)										
2=Boarding					0.81 (0.21)	<.001	0.86 (0.21)	<.001	0.80 (0.20)	<.001
3=Day and boarding					0.65 (0.15)	<.001	0.70 (0.15)	<.001	0.64 (0.14)	<.001

(continued)

Table 4.14 Three Level Random Slope School Model (Level-3), Objective 1 (continued)

Mean community school participation: 0-10 scale					0.04 (0.02)	0.029	0.03 (0.02)	0.076	0.03 (0.02)	0.072
Students disallowed from borrowing library books to take home					-0.11 (0.02)	<.001	-0.11 (0.02)	<.001	-0.11 (0.02)	<.001
Intercept	1.37 (0.13)	<.001	1.48 (0.15)	<.001	1.54 (0.17)	<.001	1.55 (0.15)	<.001	1.62 (0.17)	<.001
Random Effect	*Variance Component*		*Variance Component*		*Variance Component*		*Variance Component*		*Variance Component*	
Student (Level-1), e_{ijk}	0.3763 (0.01)		0.3763 (0.01)		0.3753 (0.01)		0.3635 (0.01)		0.3634 (0.01)	
Teacher (Level-2), u_{jk}	0.0511 (0.01)		0.0467 (0.01)		0.0467 (0.01)		0.0516 (0.01)		0.0471 (0.01)	
School (Level-3), v_k	0.4420 (0.08)		0.3862 (0.07)		0.0968 (0.02)		0.1036 (0.02)		0.0932 (0.02)	
Variance Explained (%)										
Student (Level-1), σ^2_e	0.0599		0.0599		0.0609		0.0728		0.0729	
Teacher (Level-2), σ^2_u	-0.0021		0.0023		0.0023		-0.0026		0.0019	
School (Level-3), σ^2_v	0.0669		0.1230		0.4144		0.4076		0.4181	
Variance-Covariance Matrix							Est. (Std. Err.)	95% CI	Est. (Std. Err.)	95% CI
s21, σ^2_{v1}							0.0372 (0.01)	.02, .06	0.0372 (0.01)	.02, .06
s61x, σ^2_{v14}							0.0248 (0.01)	.01, .04	0.0247 (0.01)	.01, .04
Intercept, σ^2_{v0}							0.1036 (0.02)	.07, .16	0.0932 (0.02)	.06, .14
s21, s61x, σ_{v114}							-0.0020 (0.01)	-.01, .01	-0.0019 (0.01)	-.01, .01
s21, Intercept, σ_{v01}							-0.0033 (0.01)	-.02, .02	-0.0056 (0.01)	-.02, .01
s61x, Intercept, σ_{v014}							0.0204 (0.01)	.00, .04	0.0172 (0.01)	-.00, .04
Model Fit Statistics										
Deviance	17661		17635		17532		17415		17391	
Akaike Information Criterion (AIC)	17731		17711		17618		17505		17487	
Bayesian Information Criterion (BIC)	17980		17981		17924		17825		17829	
Likelihood Ratio test vs. OLS Regression	χ^2 (2) = 5455	<.001	χ^2 (2) = 4625	<.001	χ^2 (2) = 2097	<.001	χ^2 (2) = 2538	<.001	χ^2 (2) = 2238	<.001
Likelihood Ratio test (Preceding Model vs. Next)	χ^2 (31) = 1302	<.001	χ^2 (3) = 27	<.001	χ^2 (5) = 103	<.001	na	<.001	χ^2 (5) = 141	<.001

Note. n= 9120 (1824*5 = 9120, each student has 5 records); Est. = Estimate; Std. Err. = Standard Error (in parentheses); AIC and BIC statistics = smaller-is-better fit; OLS=Ordinary Least Squares

Except for -0.20 in Model-3 and -0.16 in Model-5 regarding whether a student kept negative company, the rest of the estimates in Model-5 in the fixed part of the model were pretty much the same as those in Model-3 (the random intercept school-level model). A test involving the final log likelihood iteration for Model-3 (the random intercept school-level model, -8766) and Model-5 (the random slopes school-level model (-8695) returned $\chi^2(5) = 141$, $p<.001$ showing that the effect of s21 and s61x indeed varied across schools. Table 4.15 presents the resulting random effects covariance matrix that is also presented in Table 4.14 in long format.

Table 4.15 Random-Effects Covariance and Correlation Matrix for School-Level

Variable	s21	s61x	Intercept, σ^2_{vo}
s21	0.04 (0.01) [1]		
s61x	-0.00 (0.01) [-0.063]	0.02 (0.01) [1]	
Intercept, σ^2_{vo}	-0.01 (0.01) [-0.095]	0.02 (0.01) [0.359]	0.09 (0.02) [1]

Note. Standard Error in parentheses ( ); Correlation Coefficient in square brackets [ ]; s21= Sex of student (Ref: 1=Female); s61x=Student keeps negative company (standardized items)

For the average school, the intercept for an average student was 1.62 (*SE*=0.17) (with a between-school variance in the slopes estimated as 0.09 (*SE*=0.02) This intercept decreased by an average of -0.29 standard deviation units (*SE*=0.03) if that average student was female (with a between-school variance in the slopes estimated as 0.04 (*SE*=0.01). A one standard deviation change in the behaviour of the company kept by the students was associated with a decrease of up to -0.16 standard deviation units (*SE*=0.03) with a between-school variance in the slopes estimated as 0.02 (*SE*=0.01). These large variations in the slopes suggest that there existed large differences between schools. The negative covariance estimate of -0.00 (*SE*=0.01) between the slope of s21 and the intercept's variance was not statistically significant given its standard error but never the less, indicated that schools that tended to show higher scores for average students also tended to show smaller gains in scores for female students.

The random slope school-level model (Model-5) suggests that the between-school variance in academic achievement was a function of student sex (s21) and keeping of negative company (s61). This meant that the amount of between-school variance differed across female and male students (s21) and the company of negatively and positively behaved friends (s61x).

There were some adjustments in variance partitioning in Model-5 (the final random slopes school model) compared with Model-3 (the fixed effects model). The variance at student (e_{ijk}), teacher (u_{jk}) and school (v_k) levels now stood at 0.0729 (7.29%), 0.0019 (0.19%) and 0.4181 (41.81%) respectively, bringing the total variance explained to 0.4929 (49.29%). Allowing s21 and s61x to vary across schools in Model-5 therefore explained an additional 0.0167 (1.67%) of the variation calculated as;

$$0.4929 - 0.4777 = 0.0152 * 100 = 1.52\% \qquad (4.14)$$

Where

0.4929 is the total variation explained by Model-5 (the school-level random slopes model allowing s21 and s61x to vary across the schools), and;

0.4777 is the total variation explained by Model-3 (the school-level random intercept model).

Given that the proportion of explainable variance at Level-1 in the unconditional model was 0.4388, and 0.0729 had been explained in Model-5, then just about 15.06% of the available variance at Level-1 had been explained. This is given by

$$(0.0729/0.4388) = 0.1661 * 100 = 16.61\% \qquad (4.15)$$

The within-student-level unexplained variance is therefore 83.39% (or $0.3659\ of\ 0.4388$) suggesting that there were unobserved variables outside this model that still held onto much of that variation at the student-level.

The Level-2 explained variation was 0.0019 (0.19%). Given that the proportion of explainable variance at Level-2 in the unconditional model was 0.0493, and 0.0019 had been explained in this final model, then just about 3.85% of the available variance at Level-2 had been explained. This is given by

$$(0.0019\ /0.0493) = 0.0385 * 100 = 3.85\% \qquad (4.16)$$

Model-1 had a negative variance of -0.0021 at Teacher (Level-2) which is allowable since the inferences were restricted to the implied marginal model. Best practice now allows most contemporary analysis software packages (including Stata version 14.2 which was used for this analysis) to report negative variance values unlike previous versions that would not.

The within-teacher-level unexplained variance is therefore 96.15% (or $0.0474\ of\ 0.0493$) suggesting that other variables outside of this model still hold onto much of that variation at the teacher-level. In Model-5 (final random slopes school model), the explained variation was 0.4181 (41.81%). With the proportion of explainable variance at Level-3 in the unconditional model given as 0.5119, and 0.4181 having been explained in Model-5, then about 81.68% of the available variance at Level-3 had been explained. This is given by

$$(0.4181\ \ /0.5119) = 0.8168 * 100 = 81.68\% \qquad (4.17)$$

The within-school-level unexplained variance is therefore 18.32% (or $0.0938\ of\ 0.5119$) suggesting the school-level variables in Model-5 explained a large proportion of the available variation in student academic achievement at that level.

Deviance, AIC and BIC estimates reduced further from 17532, 17618 and 17924 in Model-3 to 17391, 17487 and 17829 respectively in Model-5 indicating that this model improved the overall model fit compared with Model-3. Model-5 was also deemed better than the single level Ordinary Least Squares linear regression model, $LR\, \chi^2(2) = 2238, p =< .001$. Similarly, Model-5 was deemed better than Models 3 at fitting the data, $LR\ \chi^2(5) = 141, p =< .001$.

The independent variables (predictors) in Objective 1 were the teacher's age in years (t22a); number of in-service courses attended in the teacher's subject area (t214) and number of formal written tests in the teacher's subject (t227). After running Model-4 (omitting these two predictors) and recording the variance components, the researcher ran Model-5 which included these three predictors and other covariates in Model-4 to obtain the variance explained by the three variables. This was calculated as:

$$0.4181 - 0.4076 = 0.0105 * 100 = 1.05\% \quad (4.18)$$

Where

0.4181 (Level1 $= 0.0728 +$ Level2 $= 0.0019 +$ Level3 $= 0.4181$) is the proportion of total variance explained after fitting Model-5 (the final school-level random slopes model) allowing s21 and s61x to vary across schools; and

0.4076 is the proportion of total variance explained after fitting Model-4 which omitted the two teacher variables in order to obtain the proportion and percentage of variance explained by the three independent variables.

4.4.3.6 Testing $H_0 1$ under Objective 1

The null hypothesis for Objective 1 stated that there was no statistically significant relationship between teacher-level variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties. Several tests for this hypothesis for the three teacher-level variables (t22a, t214 and t227) in Model-5 were done. First a post-estimation significance test using the Wald test of simple and composite linear hypotheses for each of the three variables returned significant results at 5% for two of the independent variables: t22a ($\chi^2(1) =$

$9.10, p = 0.003$) and t227 ($\chi^2(1) = 12.14, p < .001$). The test for t214 was not significant at 5%, ($\chi^2(1) = 3.79, p = 0.052$).

```
. test t22a
 (1) [s17g]t22a = 0          chi2(1) =    9.10       Prob > chi2 =    0.0026
. test t214
 (1) [s17g]t214 = 0          chi2(1) =    3.79       Prob > chi2 =    0.0517
. test t227
 (1) [s17g]t227 = 0          chi2(1) =   12.14       Prob > chi2 =    0.0005
```

This test confirms the observed effect of t22a and t227 on student academic achievement in the KCPE examination. Secondly, a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-4 (omitting the three teacher-level predictors) and Model-5 (including the three teacher-level predictors) was done. The *LR* ratio test statistic is calculated as two times the difference in the log likelihood values for the two models assuming that Model-4 is nested in Model-5. The values for Model-4 nested in Model-5 were -8707 and –8695 respectively and were calculated as

$$LR = 2 * (-8695 - (-8707)) = 24 \quad (4.19)$$

With 2 degrees of freedom at $\alpha = .05$, the critical value is 5.99. With χ^2=24, there was sufficient evidence suggesting that the three teacher-level independent variables in Model-5 made it a better model at fitting the hierarchical nature of the data than Model-4 where they were omitted. Thirdly, controlling for Level-1 and Level-3 covariates in Model-5, the proportion of variance explained by the three teacher-level predictors was 0.0105 (1.05%) as calculated in (4.18).

With these three pieces of evidence, there was sufficient evidence to reject the null hypothesis and conclude that the two teacher-level predictors indeed had an effect on student academic achievement in the KCPE examination although they accounted for just 1.05% of the total 49.29% variation explained by the three-level models. The researcher however argues that the three teacher variables cannot be flagged as predictors of student academic achievement in the KCPE examination given that each had lower than the 0.10 cut-off for standardized regression coefficients discussed earlier.

4.4.3.7 Model Diagnostics

Three post-estimation diagnostic tests were run to check the fit of the models. Two of these tests have already been presented in 4.4.3.6: The post-estimation significance test using the Wald test of simple and composite linear hypotheses for each of the three variables and a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-4 (with the three teacher-level independent variables omitted) and Model-5 (with the three variables included). The third important post estimation test was the generation of standardized residuals to see if they followed a standard normal distribution, as they should in any good-fitting model. Figure 4.5 presents a graph for quantiles of normal distribution (qnorm) showing that indeed the residuals were normally distributed.

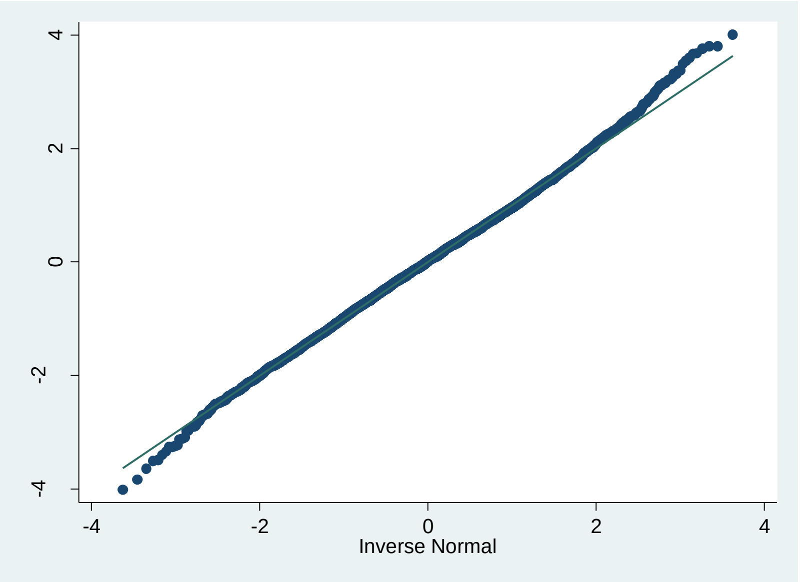

Figure 4.5 Quantiles of Normal Distribution for the Residuals (Objective 1)

4.4.3.8 The Three-Level Comparative Random Slopes School (Level-3) Model

The researcher also fitted a three level random slopes model comparing between the two Sub-Counties to determine any differences in the behaviour and effect of predictors and covariates. Table 4.16 presents the results.

Table 4.16 Comparative Three Level Random Slope School Model (Level-3), Objective 1

Fixed Effect Variable	Mumias Sub-County (*n*= 5340)		Kuria East Sub-County (*n*= 3780)	
	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*
Female student	-0.27 (0.04)	<.001	-0.30 (0.05)	<.001
Student's age in years	-0.09 (0.01)	<.001	-0.05 (0.01)	<.001
Student's years in current school	-0.02 (0.00)	<.001	-0.02 (0.005)	<.001
Number of times student spoke English in the last 7 days	0.02 (0.01)	0.003	0.04 (0.01)	<.001
Looking after younger relatives: 1= Never (Ref.)				
2= Some days	-0.05 (0.02)	0.033	-0.02 (0.03)	0.64
3= Most days	-0.03 (0.03)	0.240	-0.20 (0.04)	<.001
Looking after elderly relatives: 1= Never (Ref.)				
2= Some days	-0.05 (0.02)	0.022	-0.04 (0.03)	0.196
3= Most days	-0.09 (0.03)	0.002	-0.09 (0.04)	0.02
Cooking: 1= Never (Ref.)				
2= Some days	-0.09 (0.03)	0.010	-0.08 (0.04)	0.03
3= Most days	-0.08 (0.04)	0.019	-0.06 (0.04)	0.184
House cleaning: 1= Never (Ref.)				
2= Some days	0.11 (0.03)	0.001	0.03 (0.05)	0.492
3= Most days	0.21 (0.03)	<.001	0.07 (0.05)	0.182
Fetching water: 1= Never (Ref.)				
2= Some days	-0.05 (0.03)	0.159	0.18 (0.04)	<.001
3= Most days	0.05 (0.03)	0.180	0.22 (0.04)	<.001
Chopping fire wood: 1= Never (Ref.)				
2= Some days	-0.02 (0.02)	0.390	0.02 (0.03)	0.497
3= Most days	-0.06 (0.03)	0.036	-0.08 (0.04)	0.026
Gardening/working in a vegetable garden: 1= Never (Ref.)				
2= Some days	0.06 (0.02)	0.010	0.08 (0.03)	0.012
3= Most days	0.01 (0.03)	0.719	0.15 (0.04)	<.001
Taking care of livestock: 1= Never (Ref.)				
2= Some days	-0.00 (0.02)	0.858	-0.02 (0.03)	0.55
3= Most days	-0.07 (0.03)	0.010	-0.03 (0.04)	0.441
Mother has some primary education	0.05 (0.03)	0.039	0.09 (0.03)	0.004
Mother has completed primary education	0.04 (0.03)	0.078	0.10 (0.03)	0.002
Mother has some secondary education	0.06 (0.03)	0.037	0.004 (0.04)	0.931
Mother has completed post-secondary training	0.05 (0.03)	0.051	0.004 (0.06)	0.948
Father has completed primary education	-0.05 (0.03)	0.051	-0.07 (0.03)	0.008
Father has completed post-secondary training	0.04 (0.02)	0.066	0.04 (0.04)	0.321
Number of siblings	-0.02 (0.00)	<.001	-0.01 (0.01)	0.23
Number of times student has repeated classes	-0.10 (0.01)	<.001	-0.06 (0.02)	0.001
Student keeps negative company (z-score)	-0.10 (0.03)	0.005	-0.24 (0.03)	<.001
Student's Wealth Index: 1= High tertile (Ref.)				
2= Middle tertile	-0.08 (0.02)	<.001	0.004 (0.03)	0.879
3= Low tertile	-0.20 (0.03)	<.001	-0.05 (0.03)	0.089
Teacher's age in years	0.00 (0.00)	0.535	-0.01 (0.003)	<.001
Number of in-service courses	-0.00 (0.02)	0.992	0.04 (0.02)	0.035
Number of formal written tests in teacher's subject	0.01 (0.00)	0.015	0.01 (0.004)	0.008

(continued)

Table 4.16 Comparative Three Level Random Slope School Model (Level-3), Objective 1 (continued)

Fixed Effect Variable	Mumias Sub-County (n= 5340)		Kuria East Sub-County (n= 3780)	
	Est. (Std. Err.)	p	Est. (Std. Err.)	p
Boarding status at class 8: 1=Day (Ref.)				
2=Boarding	0.76 (0.24)	0.001	0.70 (0.35)	0.047
3=Day and boarding	0.52 (0.17)	0.002	0.72 (0.23)	0.001
Mean community school participation: 0-10 scale	0.03 (0.02)	0.121	0.02 (0.03)	0.345
Students disallowed from borrowing library books to take home	-0.10 (0.03)	<.001	-0.14 (0.04)	0.001
Intercept	1.80 (0.20)	<.001	0.52 (0.26)	0.045
Random Effect	*Variance Component*		*Variance Component*	
Student (Level-1), e_{ijk}	0.3180 (0.01)		0.4152 (0.01)	
Teacher (Level-2), u_{jk}	0.0397 (0.01)		0.0461 (0.01)	
School (Level-3), v_k	0.0829 (0.02)		0.0919 (0.03)	
Variance Explained (%)				
Student (Level-1), σ^2_e	0.1031		0.0951	
Teacher (Level-2), σ^2_u	-0.0018		0.0179	
School (Level-3), σ^2_v	0.2840		0.2519	
Variance-Covariance Matrix				
s21, σ^2_{v1}	0.0263 (0.01)	0.01, 0.05	0.0491 (0.02)	0.02, 0.11
s61x, σ^2_{v14}	0.0239 (0.01)	0.01, 0.05	0.0160 (0.01)	0.01, 0.05
Intercept, σ^2_{v0}	0.0829 (0.02)	0.05, 0.15	0.0919 (0.03)	0.05, 0.17
s21,s61x, σ_{v114}	0.0036 (0.01)	-0.01, 0.02	-0.0107 (0.01)	-0.03, 0.01
s21, Intercept, σ_{v01}	-0.0012 (0.01)	-0.02, 0.02	-0.0104 (0.02)	-0.04, 0.02
s61x, Intercept, σ_{v014}	0.0173 (0.01)	-0.00, 0.04	0.0192 (0.01)	-0.00, 0.04

The comparative model predicted higher scores for Mumias Sub-County with an intercept of 1.80 (SE=0.20, p<.001) compared with Kuria's East's 0.52 (SE=0.26, p<.001). For instance, adjusting for student, teacher and school covariates, a female student in Kuria East was predicted to score up to 0.03 standard deviation units below what a female student with similar characteristics would score in Mumias Sub-County. Curiously, house cleaning chores had positive effect on student scores in Mumias and not in Kuria East with the reverse being true for water fetching chores. Keeping of negative company by students had more adverse effects for students in Kuria East than it did for those in Mumias. Students' wealth index had statistically significant coefficients for Mumias but not in Kuria East. This suggests that the Kuria East sample is more homogeneous in the components used to generate the wealth index than is Mumias. Students denied the opportunity to borrow school books and materials for private study away from school are more disadvantaged in Kuria East compared with those in Mumias. There is a marginal difference between the Sub-Counties in the total variance explained, 38.53% for Mumias compared with 36.50% for Kuria East.

4.4.4 Discussion of the Findings Under Objective 1.

In Objective 1, three teacher independent variables were modelled in a three-level hierarchical linear model to estimate their effect on student academic achievement. Students (Level-1) were nested within Teachers (level-2) nested within Schools (Level-3). The results show that two of the variables: Teacher's age in years and the number of formal written tests in the teacher's subject, had statistically significant coefficients at 5% while the number of formal written tests in the teachers' subject areas was significant at 10%. Together, the three independent variables influenced student academic achievement in KCPE by accounting for 1.05% of the total variance (49.29%) explained. This result supports those found by Heyneman and Loxley (1982) who re-analysed data from the International Association for the Evaluation of Educational Achievement (IEA) and found that the portion of science achievement explained by school quality variables jumped from 11.5% to 20.8% and that the effect of school and teacher quality on achievement moved from 6% to 20% in Chile and from 8% to 28% in India. In another study, Heyneman and Loxley (1983) examined the effect of primary school quality on academic achievement across 29 high and low income countries in Africa, Asia, Latin America and the Middle East. They concluded that teacher and school quality variables were the most important in influencing student learning and academic achievement. They also argued that ‘‘the poorer the national setting in economic terms, the more powerful this school and teacher quality effect appeared to be” (Heyneman & Loxley, 1983, p. 1184).

Sanders and Rivers (1996) and Wright et al., (1997) investigated the cumulative effect of teachers on student academic achievement over grade levels with a database of approximately 3 million records for Tennessee’s entire grade 2-6 student population for the period between 1990 and 1996 found that teacher effects were highly significant in 20 of the 30 analyses done and had larger effect sizes than any other factor.

Darling-Hammond’s (1999) findings from a 50-state survey of policies in the US in 94 schools using Staffing Surveys (SASS) and the National Assessment of Educational Progress (NAEP) found that teacher preparation and certification were the strongest correlates of student achievement in reading and mathematics, both before and after controlling for student poverty and language status. The findings of Laczko-Kerr and Berliner (2002) also suggest that students of certified teachers out-performed students of under-certified teachers after comparing the academic achievement of students regularly taught by certified primary school teachers with the achievements of students taught by under-qualified and under-certified teachers in the US. Neild (2009) also found strong effects of teacher certification on student academic achievement.

Nye, Konstantopoulos, and Hedges (2004) used HLM on data from a four-year experiment involving teachers and students and found that teachers had larger effects on achievement in mathematics than in reading and that there was a substantial relationship between teacher experience and student achievement gains. They also found that there was a larger teacher effect in low socioeconomic status (SES) schools than in high SES schools. Similar results have also been found by Rivkin et al. (2005) who employed a value-added model on matched panel data from UTD Texas Schools Project containing test scores for three cohorts of students between grade three and seven in the mid-90s.

Using structural equation modelling with a sample of 2184 teachers in 75 Italian junior high schools and standardized final examination grades at the end of the third year of junior high school, Caprara, Barbaranelli, Steca, and Malone (2006) that previous student's academic achievement predicted subsequent achievement as well as teacher's self-efficacy beliefs, which, in turn, contributed significantly to student's achievement and teacher's job satisfaction.

Using a three-level hierarchical linear model with data from Project STAR and the Lasting Benefits Study in the US, Konstantopoulos and Chung (2011) demonstrated that teachers affect student achievement positively and that teacher effects persist through the sixth grade for mathematics, reading, and science achievement. Further, they suggest that this cumulative effect of teachers on student achievement was considerable. Ochwo (2013) has also found that teacher quality measure scores were a significant predictor of students’ mathematics and English test scores, with higher teacher quality rendering higher student mathematics and English scores.

Some researchers have however found minimal or insignificant teacher effects on student academic achievement. For instance, Hanushek (1971) examined teacher characteristics and gains in student achievement using data on grade three students and found that teaching experience and graduate education did not contribute to gains in student achievement scores and that teachers did not appear to count for Mexican-American students in the sample. In other related studies, Hanushek also found that estimated coefficients for teacher-based variables were statistically insignificant and that there was no strong evidence suggesting that PTR, teacher education or teacher experience had an expected positive effect on student achievement (Hanushek, 1986, 1989a, 1989b). The findings of this thesis can also be argued to support the findings of Hanushek since each of the standardized regression coefficients of the three variables did not meet the ≥ 0.10 threshold needed to be flagged as predictors of student academic achievement in the KCPE examination.

4.5 Objective 2: Modelling the Effect of Non-Teacher School-Level Resource Inputs on Student Academic Achievement in the KCPE Examination in Mumias and Kuria East Sub-Counties

The second objective sought to examine the relationship between non-teacher school-level resource input variables and student academic achievement in the KCPE examination in Mumias and Kuria East Sub-Counties. The null hypothesis stated that there was no statistically significant relationship between non-teacher school-level resource input variables and student academic achievement in the KCPE examination in Mumias and Kuria East Sub-Counties.

4.5.1 Description of the Variables Used in the Analysis of Data for Objective 2.

Table 4.4 presents a description of all variables used in the analysis of Objective 1 through 3. For Objective 2, the outcome variable was the student's total score (s17f) from the five KCPE academic subject areas modelled as a function of non-teacher resource inputs adjusting for student and school characteristics. For ease of interpretation, this outcome variable was transformed to a standard normal score with a Mean of zero (0) and Standard Deviation and Variance of one (1) so that the residuals at each level better approximate the normality assumptions of the models. The transformation of the raw scores was presented in equation (4.1). This transformation allowed the effects of the covariates in HLM to be interpreted in terms of standard deviation units of the outcome variable (Leckie, 2013; Raudenbush & Bryk, 2002). The student-level variables were prefixed with letter "s", the teacher-level variables with letter "t" and the school-level variables with letter "h". As expected with a standardized variable, the mean was 0.00 (*SE*=0.02) with scores ranging between -2.84 (minimum) and 2.37 (maximum).

4.5.2 Pair-Wise Correlation Between the Outcome Variable and Non-Teacher School-Level Resource Input Variables in Objective 2

The outcome variable was measured on the interval scale making pair-wise correlation the preferred statistical method to determine plausible interactions with the independent variables and covariates as a basis for their subsequent consideration in the two-level HLM for the Objective 2.

Table 4.17 presents the correlation coefficient matrix for variables used in the analysis of Objective 2. Because of space constraints, the full matrix table was not displayed but the matrix of interest which is between the outcome and its correlates is fully presented under the outcome variable's column. A correlation coefficient that is ≤0.35 is interpreted as weak; 0.36-0.67 as moderate; 0.68-0.89 as strong; and ≥0.90 as very strong (Taylor, 1990). Three of the non-teacher resource input variables had moderate correlations with the outcome variable: School has piped water (r=352, p=<.001); School has a feeding programme (r=471, p=<.001); and School has a typewriter (r=366, p=<.001).

Table 4.17 Pair-Wise Correlation Matrix for Variables used in the Modelling Under Objective 2

Variable		s17z	s21	s22a	s23a	s27	s313x	s36c
Student's running score in the five KCPE subjects (standardized)		1						
Female student	a	-0.111	1					
	b	0.000						
Student's age in years	a	-0.204	-0.068	1				
	b	0.000	0.004					
Student's years in current school	a	-0.102	-0.034	0.052	1			
	b	0.000	0.148	0.027				
Number of times student spoke English in the last 7 days	a	0.199	-0.048	-0.044	-0.021	1		
	b	0.000	0.039	0.062	0.364			
Student's Wealth Index (3 Tertiles)	a	0.203	0.044	-0.138	-0.103	0.108	1	
	b	0.000	0.058	0.000	0.000	0.000		
Number of siblings	a	-0.320	0.019	0.161	0.090	-0.053	-0.156	1
	b	0.000	0.420	0.000	0.000	0.024	0.000	
Looking after younger relatives	a	-0.143	-0.019	0.071	0.092	0.000	-0.115	0.106
	b	0.000	0.426	0.003	0.000	0.997	0.000	0.000
Looking after elderly relatives	a	-0.187	-0.019	0.116	0.044	-0.009	-0.101	0.099
	b	0.000	0.420	0.000	0.062	0.704	0.000	0.000
Gardening/working in a vegetable garden	a	-0.116	-0.172	0.141	0.069	-0.022	-0.214	0.129
	b	0.000	0.000	0.000	0.003	0.351	0.000	0.000
Number of times student has repeated classes	a	-0.181	-0.028	0.282	0.056	-0.085	-0.109	0.122
	b	0.000	0.232	0.000	0.017	0.000	0.000	0.000
Student keeps negative company (z-score)	a	-0.265	-0.051	0.090	0.006	-0.102	-0.009	0.080
	b	0.000	0.030	0.000	0.791	0.0000	0.701	0.0006
School has piped water	a	0.352	0.009	-0.063	-0.036	0.204	0.105	-0.139
	b	0.000	0.716	0.007	0.130	0.0000	0.0000	0.0000
School has a typewriter	a	0.366	0.018	-0.214	-0.091	0.033	0.326	-0.202
	b	0.000	0.451	0.0000	0.0001	0.156	0.0000	0.0000
School has a feeding programme	a	0.471	0.032	0.088	-0.037	0.059	0.065	-0.169
	b	0.000	0.167	0.0002	0.165	0.012	0.0057	0.0000
Kuria East Sub-County	a	-0.574	-0.057	-0.137	0.0001	-0.133	-0.094	0.258
	b	0.000	0.014	0.0000	0.998	0.0000	0.0001	0.0000
Boarding status at class 8	a	0.441	0.009	-0.243	-0.117	0.086	0.405	-0.259
	b	0.000	0.703	0.000	0.000	0.000	0.000	0.000
Students disallowed from borrowing library books to take home	a	0.091	0.021	-0.104	-0.066	0.057	0.128	-0.069
	b	0.000	0.373	0.0000	0.0051	0.015	0.0000	0.003

Note. Pair-wise correlation: ≤0.35 = Weak correlation; 0.36-0.67 = Moderate correlation; 0.68-0.89=Strong correlation; ≥0.90 = Very strong correlation; Adapted from "Interpretation of Correlation Coefficient, " by R. Taylor, 1990, Journal of Diagnostic Medical Sonography, 6(1), p. 37

[a] Pearson correlation coefficient; [b] *p*-values (α=.05)

4.5.3 Bivariate Analysis

The researcher used a two-tailed independent t-test because it was the appropriate statistical approach to examine the means across the three nominal-scale variables under consideration. The t-test results presented in Tables 4.18, 4.19 and 4.20 were statistically significant with medium or large effect sizes.

Table 4.18. Two-tailed independent t-test results comparing the means between schools with piped water and those without.

Group	Obs.	Mean	Std. Err.	Std. Dev.	[95% CI]	
0=Students in schools without piped water	591	-0.51	0.03	0.83	-0.58	-0.44
1=Students in schools with piped water	1,233	0.24	0.03	0.98	0.19	0.30
Combined	1,824	0.00	0.02	1.00	-0.05	0.05
Difference		-0.75	0.04		-0.84	-0.66

Note. Obs.=Observations; Std. Err=Standard Error; Std. Dev.=Standard Deviation; CI=Confidence Interval; n=1824; α=.05: t (1349.48) = -16.99; R^2= 0.18 where 0.01-0.09 is small effect; 0.10-0.25 is medium effect; over 0.25 is a large effect. Adapted from "*A Gentle Introduction to Stata*", by C. A. Acock, 2006, College Station, Texas USA: Stata Press, p. 137

$p < .001$

Table 4.19. Two-tailed independent t-test results comparing the means between schools with functional typewriters and those without.

Group	Obs.	Mean	Std. Err.	Std. Dev.	[95% CI]	
0=Students in schools without a functional typewriter	1,535	-0.16	0.02	0.93	-0.21	-0.11
1=Students in schools with a functional typewriter	289	0.84	0.05	0.92	0.74	0.95
Combined	1,824	0.00	0.02	1.00	-0.05	0.05
Difference		-1.00	0.06		-1.12	-0.89

Note. Obs.=Observations; Std. Err=Standard Error; Std. Dev.=Standard Deviation; CI=Confidence Interval; n=1824; α=.05: t (407.49) = -16.96; R^2= 0.41 where 0.01-0.09 is small effect; 0.10-0.25 is medium effect; over 0.25 is a large effect. Adapted from "*A Gentle Introduction to Stata*", by C. A. Acock, 2006, College Station, Texas USA: Stata Press, p. 137

$p < .001$

Table 4.20. Two-tailed independent t-test results comparing the means between schools with a lunch meal programme and those without.

Group	Obs.	Mean	Std. Err.	Std. Dev.	[95% CI]	
0=Students in schools without a lunch meal programme	829	-0.52	0.03	0.96	-0.58	-0.45
1=Students in schools with a lunch meal programme	995	0.43	0.03	0.81	0.38	0.48
Combined	1824	0.00	0.02	1.00	-0.05	0.05
Difference		-0.95	0.04		-1.03	-0.86

Note. Obs.=Observations; Std. Err=Standard Error; Std. Dev.=Standard Deviation; CI=Confidence Interval; n=1824; α=.05: t (1628.66) = -22.44; R^2= 0.24 where 0.01-0.09 is small effect; 0.10-0.25 is medium effect; over 0.25 is a large effect. Adapted from "*A Gentle Introduction to Stata*", by C. A. Acock, 2006, College Station, Texas USA: Stata Press, p. 137

$p < .001$

Students in schools with piped water scored 0.24 standard deviation units above the mean (0.00) compared with -0.51 for their colleagues in schools without, t (1349) = -16.99; R^2= 0.18. Similarly, students in schools with a lunch-meal programme had a higher mean than their colleagues in schools that did not. Curiously, students in schools with a functional typewriter also posted scores above the mean. Of the nine schools that reported having functional typewriters, six were in Mumias. Eight of the nine schools had means above 0.00. The nine schools scored 1.73 standard deviation units above the mean with a standard error of 0.20 and 95% confidence interval of 1.28, 2.18. It is possible that these schools are probably 'good academic performers' already and a functional typewriter is just one of the rare school inputs 'machines' they share which the other schools do not have.

4.5.4 A Two-Level Mixed Effects Hierarchical Linear Model for the Effect of Non-Teacher Resource Inputs on Student Academic Achievement in the KCPE Examination.

A two-level mixed effects model (with fixed and random effects) was fitted to examine the relative importance of non-teacher resource inputs at school level as influences on student academic achievement in the KCPE examination using data from 1824 student-records (Level-1) nested within 61 schools (Level-2). In mixed models, fixed effects are analogous to standard regression coefficients and are estimated directly. The random effects are often not directly estimated but are summarized according to their estimated variances and covariances. Random effects may take the form of either random intercepts or random coefficients (Leckie, 2013). Model-1 fitted student level covariates while Model-2 fitted non-teacher school-level resource inputs as the independent variables (IVs). Model-3 omitted these Model-2 IVs while fitting other non-teacher school-level variables not designated as inputs. The final model (Model-4) estimated the effect of all IVs and covariates on student academic achievement with the advantage that it was now possible to delineate the variance attributable to the non-teacher school resource input variables.

As is usual for HLM models, the starting point was to fit an unconditional model (also called intercept-only, null or empty model) in order to obtain the amounts of variance available for explanation at each level of the hierarchy (Hungi & Thuku, 2010; Leckie, 2010; Raudenbush & Bryk, 2002).

4.5.4.1 The Unconditional Model (Intercept-only, Null, Empty) for Objective 2

A two-level variance components model was specified and fitted including only an intercept, school and a student level residual error term. The model did not make any adjustments for predictor variables, only decomposing the total variance in students' total score on the five KCPE subjects into separate school and student variance components.

The researcher followed Raudenbush and Bryk (2002) and Leckie (2013) in specifying the models used in the analysis. In Level-1, a student's total score from the five academic subjects in KCPE was modelled as function of a school mean plus a random error:

$$Y_{ij} = \beta_0 + u_{0j} + e_{ij} \tag{4.20}$$

Where:

Y_{ij} is the observed KCPE total score for student i ($i = 1, \ldots ,1824$) nested within school j ($j = 1, \ldots, 61$);

β_0 is the overall mean across schools; and

u_{0j} is the effect of school j on academic achievement; and

e_{ij} is a random "student effect", that is, the deviation of student $ij's$ score from the school mean. These effects are assumed normally distributed with a mean of 0 and a variance σ_e^2.

Model 4.20 partitioned the total variance in the outcome variable Y_{ij} into its two components: Among students within school (Level-1), σ_e^2; and among schools (Level-2), σ_u^2. This equation also allowed the estimation of the proportion of variance that was among students within schools, and between schools. The proportion of variation among students (Level-1) was estimated as:

$$\sigma_e^2/(\sigma_e^2 + \sigma_u^2) \qquad (4.21)$$

While the proportion of variation among schools was estimated as

$$\sigma_u^2/(\sigma_e^2 + \sigma_u^2) \qquad (4.22)$$

Table 4.21 presents the results of this null model.

Table 4.21 Two Level Null (Empty) Model (Objective 2)

Fixed Effect			
Variable	Variable label	Null Model	
		Est. (Std. Err.)	p
	Intercept, β_{0j}	-0.02 (0.10)	0.832
Random Effect		*Variance Component*	
Student (Level-1), e_{ij}		0.3516 (0.01)	
School (Level-2), u_j		0.6393 (0.12)	
Variance Partition Coefficient (VPC)			
Student (Level-1), σ^2_e		0.3548	
School (Level-2), σ^2_u		0.6452	
Model Fit Statistics			
Deviance		3509	
Akaike Information Criterion (AIC)		3515	
Bayesian Information Criterion (BIC)		3531	
Likelihood Ratio test vs. OLS Regression		χ^2 (1) = 1666	<.001

Note. N= 1824; Est. = Estimate; Std. Err. = Standard Error (in parentheses); AIC and BIC statistics = smaller-is-better fit; OLS=Ordinary Least Squares

The random intercept, β_0, has the student's z-score in the KCPE examination as -0.02 (*SE*=0.09, *p*=.832). Since the outcome variable is approximately normalised, an estimated random intercept of zero, an estimated total variance of approximately one and a non-significant intercept are all expected.

The random part of the model presents the variance partitioning where $\sigma_e^2 = Var(e_{ij})$ yielding 0.3516 which is the variance among students within schools and $\sigma_u^2 = Var(u_j)$ yielding 0.6393 which is the variance between schools. Each of these variance estimates was deemed statistically significant since each was much larger than its corresponding standard error (if the variance estimate is divided by its standard error and the result is >1.96, then the estimate is statistically significant).

Substituting each of these variance components into equations 4.21 and 4.22 yielded the proportion of variance in Y_{ij} at each level (Level-1= 0.3548 [35.48%]; and Level-2= 0.6452 [64.52%]). The largest variance lay between schools (64.52%) while a substantial one lay between students within schools (35.48%). Most of the variation in students' scores is thus seen within their schools.

As earlier mentioned, Deviance, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) measure how well the model fits the data. A reduction in the estimates of each in subsequent models when predictors are introduced would suggest that those subsequent models are better in fitting the data compared with the preceding model(s). The researcher also carried out a Likelihood Ratio (*LR*) test to compare the null model to a single-level model with no school effects and no teacher effects (i.e. Ordinary Least Squares linear regression). The *LR* test statistic was $\chi^2(1)$= 1666, *p*<.001 implying that a two-level model offered a significantly better fit to the data than the single-level model with the conclusion that the 1,824 students did not act as 1,824 independent observations; rather, students were clustered by their schools. Students from the same school were therefore significantly more alike than students from different schools. This also meant that the scores varied significantly across schools. A multilevel approach to analyse the data was clearly favoured over a single-level approach.

Having fitted the model, the researcher predicted empirical Bayes estimates (i.e. posterior, shrunken, or best linear unbiased predictions, [BLUPs]) of the school effects with their associated standard errors. This helped check whether the random effects at school were normally distributed as well as to help make inferences about specific schools. The Empirical Bayes Estimates (EBE) showed that school 41 in Kuria East Sub-County with a score of -1.491 was predicted to be the lowest scoring school while school 29 in Mumias Sub-County with a score of 1.708 was predicted to be the highest scoring school. Table 4.22 presents the BLUPs.

Table 4.22 Empirical Bayes Estimates of School Effects for Objective 2

School Code	EBE	Std. Error	Rank	School Code	EBE	Std. Error	Rank
41	-1.491	0.125	1	9	0.140	0.093	32
40	-1.407	0.104	2	38	0.166	0.232	33
59	-1.349	0.095	3	44	0.166	0.161	34
49	-1.135	0.122	4	19	0.181	0.087	35
46	-1.076	0.174	5	8	0.247	0.122	36
47	-1.026	0.107	6	32	0.259	0.174	37
42	-1.022	0.101	7	3	0.268	0.101	38
60	-0.990	0.104	8	4	0.271	0.104	39
35	-0.972	0.122	9	26	0.280	0.111	40
57	-0.895	0.087	10	24	0.289	0.088	41
28	-0.859	0.138	11	54	0.322	0.113	42
45	-0.835	0.128	12	17	0.342	0.142	43
37	-0.780	0.138	13	25	0.366	0.087	44
55	-0.720	0.077	14	5	0.416	0.080	45
51	-0.677	0.111	15	22	0.427	0.089	46
27	-0.652	0.106	16	39	0.512	0.167	47
56	-0.644	0.113	17	52	0.554	0.232	48
61	-0.618	0.097	18	2	0.828	0.142	49
48	-0.591	0.117	19	7	0.832	0.099	50
34	-0.493	0.107	20	6	0.838	0.104	51
50	-0.411	0.111	21	30	0.971	0.131	52
53	-0.270	0.155	22	14	0.977	0.120	53
20	-0.260	0.095	23	31	1.050	0.113	54
43	-0.254	0.102	24	15	1.105	0.098	55
36	-0.250	0.094	25	1	1.112	0.083	56
23	-0.245	0.081	26	58	1.134	0.150	57
33	-0.200	0.111	27	18	1.212	0.085	58
10	-0.054	0.125	28	12	1.361	0.094	59
11	0.047	0.134	29	13	1.594	0.101	60
21	0.090	0.106	30	29	1.708	0.104	61
16	0.112	0.092	31				

The difference between the highest and the lowest scoring schools was huge [1.708- (-1.491) = 3.199] given that these are z-scores ranging between -4.0 and 4.0 with Mean Zero (0) and Standard Deviation and variance of one (1).

Figure 4.6 was drawn from a quantiles of normal distribution graph. All the data would be plotted along the 45 degree line if the random effects were normally distributed. Although not perfectly aligned, the 61 schools lay close to the line suggesting that the predicted effects were approximately normally distributed.

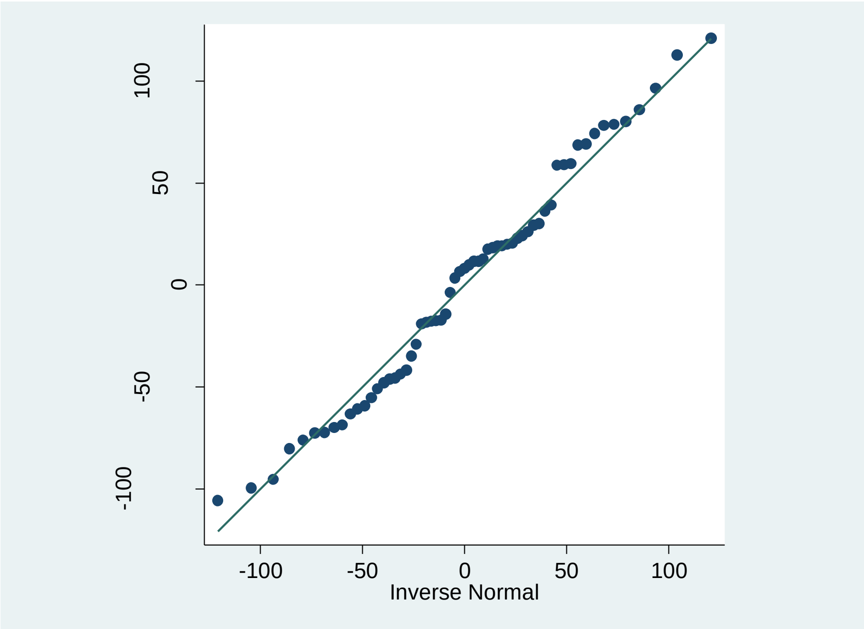

Figure 4.6 Quantiles of Normal Distribution for School Effects (Objective 2)

The researcher also examined the magnitude of the school effects by counting the number of schools that differed significantly from the average school. Figure 4.7 presents the resulting graph.

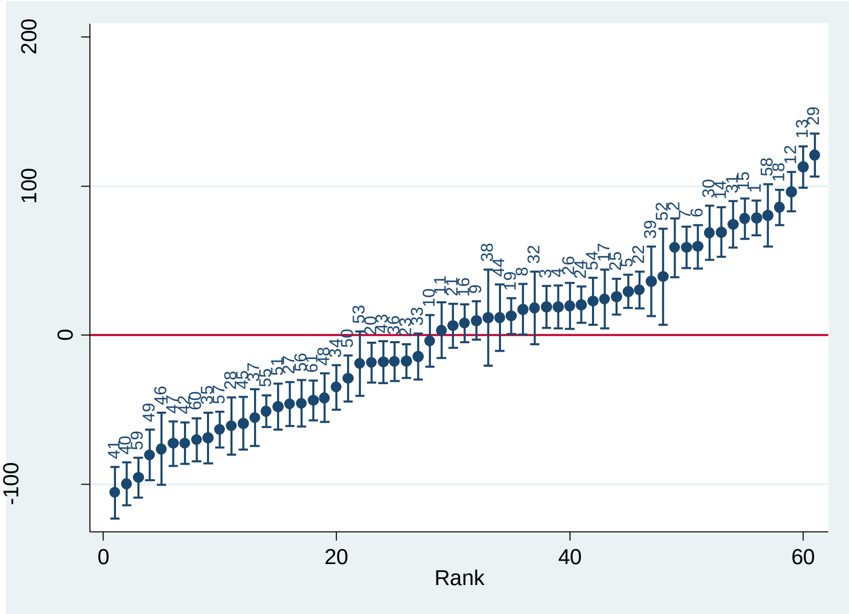

Figure 4.7 The Magnitude of School Effects (Objective 2)

The plot shows that 51 out of the 61 schools differed significantly from the average school with 25 schools scoring significantly lower than the average school and 26 scoring above. This suggested substantial variations between schools. The plot is quite similar to the one presented in Figure 4.3 suggesting that schools from Mumias had stronger positive effects on student academic achievement compared to schools in Kuria East Sub-County.

4.5.4.1 The Student (Level-1) Random Intercept Model for Objective 2

In each school, the student's total KCPE score was modelled as a function of student-level predictors plus a random student-level error. There was a variance of 35.48% that lay at Level-1 that needed to be explained by modelling Level-1 variables that were significantly correlated with the outcome variable. Again, following Leckie (2013) and Raudenbush and Bryk (2002), the student-level (Level-1) model was specified as:

$$Y_{ijk} = \beta_0 + \beta_1 a_{1ij} + \beta_2 a_{2ij} + \cdots + \beta_{pj} a_{pij} + u_j + e_{ij} \quad (4.23)$$

Assuming that; $u_j \sim N(0, \sigma_u^2)$

$e_{ij} \sim N(0, \sigma_e^2)$

Where:

Y_{ij} is the total KCPE score for student i $(i = 1, \dots, 1824)$ nested within school j, $(j = 1, \dots, 61)$;

β_0 is the mean score across all schools;

a_{pij} are $p = 1, \dots, P$ student characteristics that predict achievement;

β_{pj} are the corresponding Level-1 coefficients that indicate the direction and strength of association between each student characteristic, a_p and the outcome in school j;

u_j is the effect of school j; and

e_{ij} is the student level residual error term.

The school, effects and the student level residual errors are assumed independent and normally distributed with zero means and constant variances.

The two-step selection process for predictors described in section 4.4.3.2 was followed for screening of the student-level variables in Objective 2. In the first step, all variables that were significantly correlated with the outcome variable were listed. The second step involved running the listed "candidate predictor variables" in an exploratory student-only-level model while considering the hierarchical nature of the dataset, but excluding non-teacher school-level resource input variables and school variables (StataCorp, 2013a). The predictors summarized in Table 4.23 did not return significant effects on the outcome variable at $p<.05$ and were consequently dropped and not considered in the final student-level model as their presence in this and subsequent models would add little explanatory value (Leckie, 2010; Raudenbush & Bryk, 2002).

Table 4.23 Non-significant Variables Dropped from the Student-Model (Objective 2)

Variable	Est. (Std. Err.)	*p*
Religion of student: 1=Muslim (Ref)	0.04 (0.06)	0.520
Student's father is alive	-0.02 (0.04)	0.524
Number of books at place of usual aboard	0.00 (0.00)	0.902
Washing and ironing clothes: 1=Never (Ref.)		
2=Some days	0.01 (0.04)	0.773
3=Most days	0.00 (0.05)	0.948
Collecting fire wood: 1=Never (Ref.)		
2=Some days	-0.74 (2.53)	0.770
3=Most days	-0.06 (0.05)	0.971
Taking care of livestock: 1=Never (Ref.)		
2=Some days	-0.02 (0.03)	0.528
3=Most days	-0.08 (0.04)	0.158
Helping in a family business: 1=Never (Ref.)		
2=Some days	0.01 (0.03)	0.790
3=Most days	0.04 (0.04)	0.367
Number of homework in a week for all subjects	-0.02 (0.01)	0.239
Someone at home/ school helps with homework	-0.04 (0.03)	0.173
How often teacher corrects homework: 1-5	0.00 (0.02)	0.943
Number of lessons missed in a week for all subjects	-0.01 (0.01)	0.444
Student had extra lessons in mathematics	0.06 (0.05)	0.133
Student had extra lessons in social studies	0.08 (0.06)	0.164

Note. Std. Err. = Standard Error (in parentheses)

Substituting the remaining student-level predictors into the Level-1 model (4.23) yielded:

$$Y_{ij} = \beta_0 + \beta_1 s21_{ij} + \beta_2 s23a_{ij} + \beta_3 s27_{ij} + \beta_4 s313x_{ij} + \beta_5 s36c_{ij} + \beta_6 s314a_{ij} + \beta_7 s314b_{ij} + \beta_8 s314l_{ij} + \beta_9 s58x_{ij} + \beta_{10} s61x_{ij} + u_j + e_{ij} \quad (4.23a)$$

Where s21= Sex of student; s23a= Student's years in current school; s27= Number of times student spoke English in last 7 days; s313x= Student's SES; s36c= Number of siblings; s314a= Looking after younger relatives; s314b= Looking after elderly relatives; s314l= Gardening/working in a vegetable garden; s58x= Number of times student has repeated classes; s61x= Student keeps negative company (standardized items).

4.5.4.2 The School (Level-2) Non-Teacher Resource Inputs Random Intercept Model for Objective 2

Three school-level models were fitted beyond the student-level model. In the first school-level model (Model-2), non-teacher school-level resource inputs were modelled as predictors of a student's total KCPE score plus a random school-level error. Model-3 adjusted for other non-teacher school-level characteristics as well as student-level covariates but omitting the non-teacher school-level resource inputs to determine their 'net worth' after fitting the final Model-4. There was a variance of 64.52% that lay at Level-2 that needed to be explained by modelling Level-2 non-teacher resource input predictors plus the other non-teacher school-level characteristics that were significantly correlated with the outcome variable. Model-2 was an extension of equation 4.23 and model 4.23a and was specified as:

$$Y_{ijk} = \beta_0 + \beta_1 a_{1ij} + \beta_2 a_{2ij} + \beta_3 c_{3j} + \beta_4 c_{4j} + \cdots + \beta_{gj} c_{gj} + u_j + e_{ij} \quad (4.24)$$

Assuming that; $u_j \sim N(0, \sigma_u^2)$

$e_{ij} \sim N(0, \sigma_e^2)$

Where:

Y_{ij} is the total KCPE score for student i $(i = 1, \ldots, 1824)$ nested within school j, $(j = 1, \ldots, 61)$;

β_0 is the mean score across all schools;

c_{gj} are $g = 1, \ldots, G$ non-teacher resource input predictors that predict achievement;

β_{gj} are the corresponding Level-2 coefficients that indicate the direction and strength of association between each -teacher resource input predictor, c_g and the outcome under school j;

u_j is the effect of school j; and

e_{ij} is the student level residual error term.

The school, effects and the student level residual errors are assumed independent and normally distributed with zero means and constant variances.

The two-step selection process for predictors described in section 4.4.3.2 was followed in screening the non-teacher resource input variables in Objective 2. The variables summarized in Table 4.24 did not return significant effects on the outcome variable at the 5% significance level and were consequently dropped and not considered in Model-2 as their presence in this and subsequent models would add little explanatory value (Leckie, 2010; Raudenbush & Bryk, 2002).

Table 4.24 Non-significant Variables Dropped from the Non-Teacher Resource Inputs Model (Objective 2)

Variable	Est. (Std. Err.)	*p*
School has store room	-0.04 (0.15)	0.870
School has a sports area	0.17 (0.20)	0.410
School has electricity	0.25 (0.15)	0.124
School has a telephone	0.32 (0.24)	0.218
School has a radio	-0.22 (0.14)	0.220
School has a computer	0.11 (0.18)	0.685
School has a fence	0.24 (0.16)	0.133
Number of school feeding days	-4.38 (4.34)	0.313

Note. Std. Err. = Standard Error (in parentheses)

This process left three non-teacher resource input predictors for modelling: School has piped water; School has a typewriter; and School has a feeding programme. Since HLM is additive by level, these three variables were brought into Model-2 and specified as:

$$Y_{ij} = \beta_0 + \beta_1 s21_{ij} + \beta_2 s23a_{ij} + \beta_3 s27_{ij} + \beta_4 s313x_{ij} + \beta_5 s36c_{ij} + \beta_6 s314a_{ij} + \beta_7 s314b_{ij} + \beta_8 s314l_{ij} + \beta_9 s58x_{ij} + \beta_{10} s61x_{ij} + \beta_{11} h31e_j + \beta_{12} h31i_j + \beta_{13} h32_j + u_j + e_{ij} \quad (4.24a)$$

Where the Model-2 specific variables introduced in the model were: h31e= School has piped water; h31i= School has a typewriter; and h32= School has a feeding programme. The other variables were described under Model 4.23a.

4.5.4.3 The School (Level-2) Random Intercept Model for Other Non-Teacher School-level Covariates for Objective 2

Model-4 was an extension of equation 4.24 and model 4.24a and was specified as:

$$Y_{ijk} = \beta_0 + \beta_1 a_{1ij} + \beta_2 a_{2ij} + \beta_3 c_{3j} + \beta_4 c_{4j} + \beta_5 d_{5j} + \beta_6 d_{6j} + \cdots + \beta_{mj} l_{mj} + u_j + e_{ij} \qquad (4.25)$$

Assuming that; $u_j \sim N(0, \sigma_u^2)$

$e_{ij} \sim N(0, \sigma_e^2)$

Where:

Y_{ij} is the total KCPE score for student i $(i = 1, \ldots, 1824)$ nested within school j, $(j = 1, \ldots, 61)$;

β_0 is the mean score across all schools;

l_{mj} are $m = 1, \ldots, M$ non-teacher resource input predictors that predict achievement;

β_{mj} are the corresponding Level-2 coefficients that indicate the direction and strength of association between each -teacher resource input predictor, l_m and the outcome under school j;

u_j is the effect of school j; and

e_{ij} is the student level residual error term.

The school, effects and the student level residual errors were assumed independent and normally distributed with zero means and constant variances.

Again, the two-step selection process for predictors described in section 4.4.3.2 was followed in screening the other non-teacher school-level variables in Objective 2. The variables summarized in Table 4.25 did not return significant effects on the outcome variable at the 5% significance level and were consequently dropped and not considered in the other non-teacher resource input model as their presence in this and subsequent models would add little explanatory value (Leckie, 2010; Raudenbush & Bryk, 2002).

Table 4.25 Non-significant Variables Dropped from the Other Non-Teacher School-Level-Only-Model

Variable	Est. (Std. Err.)	*p*
School's sex composition: 1=Boys only (Ref.)		
2=Girls only	-4.07 (4.36))	0.405
3=Mixed boys and girls	-2.19 (2.24)	0.333
Mean school-student negative behaviour 0-10 scale	0.10 (0.06)	0.850
School boys enrolment	0.00 (0.00)	0.280
School girls enrolment	0.00 (0.00)	0.304
Class 8 boys enrolment	-0.01 (0.01)	0.249
Class 8 girls enrolment	0.01 (0.01)	0.298
Boys latrine ratio	1.16 (0.88)	0.186
Girls latrine ratio	0.00 (0.00)	0.778
Number of streams	-0.02 (0.03)	0.283
Number of classrooms	0.06 (0.05)	0.182
Mean community school participation: 0-10 scale	0.08 (0.06)	0.874
Students allowed to borrow library books to take home	0.07 (0.09)	0.897

Note. Std. Err. = Standard Error (in parentheses); Ref.=Reference

This process left three other non-teacher school-level covariates for modelling: Sub-County (h16); Boarding status at Class 8 (h24a) and Students disallowed from borrowing library books to take home (h5122). Since HLM is additive by level, these three other non-teacher school-level covariates were specified as:

$$Y_{ij} = \beta_0 + \beta_1 s21_{ij} + \beta_2 s23a_{ij} + \beta_3 s27_{ij} + \beta_4 s313x_{ij} + \beta_5 s36c_{ij} + \beta_6 s314a_{ij} + \beta_7 s314b_{ij} + \beta_8 s314l_{ij} + \beta_9 s58x_{ij} + \beta_{10} s61x_{ij} + \beta_{11} h31e_j + \beta_{12} h31i_j + \beta_{13} h32_j + \beta_{14} h16_j + \beta_{15} h24a_j + \beta_{16} h5122_j + u_j + e_{ij} \quad (4.25a)$$

Where the Model-4 specific variables introduced in the model were h16= Sub-County (Ref: 1=Kuria East); h24a= Boarding status at Class 8; and h5122= Students not allowed to borrow school books and take home. The other variables were described under Models 4.23, 4.23a, 4.24 and 4.24a.

To determine the variance explained by the independent variables, the researcher fitted Models 3 and 4. Model-3 omitted the non-teacher resource input independent variables and only fitted the student-level covariates as well as the other non-teacher school-level covariates. The final Model-4 estimated the effect of the variables in Models 1 and 2 as well as other non-teacher school-level characteristics. Table 4.26 summarizes the output for these four models.

Table 4.26 Two Level Random Intercept Model for Other Non-Teacher School-Level Predictors (Level-2), Objective 2

Fixed Effect Variable label	Model 1 (Student)		Model 2 (Non-Teacher Resource Inputs)		Model 3 (Omitting h31e, h31i, h32)		Model 4 (Other Non-Teacher School-Level Predictors)	
	Est. (SE)	*p*	Est. (SE)	*p*	Est. (SE)	*p*	Est. (SE)	*p*
Sex of student (Ref: 1=Female)	-0.27 (0.03)	<.001	-0.27 (0.03)	<.001	-0.28 (0.03)	<.001	-0.28 (0.03)	<.001
Student's age in years	-0.09 (0.01)	<.001	-0.09 (0.01)	<.001	-0.10 (0.01)	<.001	-0.10 (0.01)	<.001
Student's years in current school	-0.02 (0.01)	<.001	-0.02 (0.01)	<.001	-0.02 (0.01)	0.000	-0.02 (0.00)	<.001
Number of times student spoke English in last 7 days	0.03 (0.01)	<.001	0.03 (0.01)	<.001	0.03 (0.01)	<.001	0.03 (0.01)	<.001
Student's Wealth Index (3 Tertiles): 1=High (Ref.)								
2=Middle	-0.05 (0.03)	0.154	-0.04 (0.03)	0.167	-0.04 (0.03)	0.167	-0.04 (0.03)	0.183
3=Low	-0.13 (0.04)	<.001	-0.13 (0.04)	<.001	-0.13 (0.04)	0.000	-0.13 (0.04)	<.001
Number of siblings	-0.02 (0.01)	0.002	-0.02 (0.01)	0.002	-0.02 (0.01)	0.005	-0.02 (0.01)	0.004
Looking after younger relatives: 1=Never (Ref.)								
2=Some days	-0.03 (0.03)	0.347	-0.03 (0.03)	0.424	-0.02 (0.03)	0.518	-0.02 (0.03)	0.536
3=Most days	-0.11 (0.04)	0.010	-0.11 (0.04)	0.011	-0.11 (0.04)	0.015	-0.11 (0.04)	0.015
Looking after elderly relatives: 1=Never (Ref.)								
2=Some days	-0.04 (0.03)	0.221	-0.03 (0.03)	0.278	-0.04 (0.03)	0.221	-0.04 (0.03)	0.260
3=Most days	-0.10 (0.05)	0.029	-0.10 (0.05)	0.038	-0.10 (0.05)	0.031	-0.09 (0.05)	0.038

(continued)

Table 4.26 Two Level Random Intercept Model for Other Non-Teacher School-Level Predictors (Level-2), Objective 2 (continued)

Fixed Effect Variable label	Model 1 (Student)		Model 2 (Non-Teacher Resource Inputs)		Model 3 (Omitting h31e, h31i, h32)		Model 4 (Other Non-Teacher School-Level Predictors)	
	Est. (SE)	*p*	Est. (SE)	*p*	Est. (SE)	*p*	Est. (SE)	*p*
Gardening/working in a vegetable garden: 1=Never (Ref.)								
2=Some days	0.09 (0.04)	0.016	0.09 (0.036)	0.011	0.08 (0.04)	0.021	0.09 (0.04)	0.019
3=Most days	0.10 (0.04)	0.025	0.10 (0.04)	0.018	0.09 (0.04)	0.032	0.09 (0.04)	0.029
Number of times student has repeated classes	-0.09 (0.02)	<.001	-0.09 (0.02)	<.001	-0.09 (0.02)	<.001	-0.09 (0.02)	<.001
Student keeps negative company (standardized score)	-0.22 (.03)	<.001	-0.22 (0.03)	<.001	-0.22 (0.03)	<.001	-0.22 (0.03)	<.001
School has piped water			0.39 (0.16)	0.004	omitted	na	0.25 (0.11)	0.025
School has a typewriter			0.72 (0.18)	<.001	omitted	na	0.32 (0.17)	0.069
School has a feeding programme			0.83 (0.13)	<.001	omitted	na	0.30 (0.13)	0.025
Sub-County (Ref: 1=Kuria East)							-0.75 (0.13)	<.001
School's boarding status at Class 8: 1=Day (Ref)								
2=Boarding					1.14 (0.25)	<.001	0.73 (0.27)	0.008
3=Day and boarding					0.97 (0.17)	<.001	0.62 (0.20)	0.002
Students disallowed from borrowing library books to take home					-0.14 (0.04)	0.001	-0.14 (0.04)	0.001
Intercept	1.76 (9.20)	<.001	0.92 (0.21)	<.001	2.12 (0.19)	<.001	1.68 (0.23)	<.001

(continued)

Table 4.26 Two Level Random Intercept Model for Other Non-Teacher School-Level Predictors (Level-2), Objective 2 (continued)

Variable label	Model 1 (Student)		Model 2 (Non-Teacher Resource Inputs)		Model 3 (Omitting h31e, h31i, h32)		Model 4 (Other Non-Teacher School-Level Predictors)	
	Est. (SE)	*p*	Est. (SE)	*p*	Est. (SE)	*p*	Est. (SE)	*p*
Random Effect	*Variance Component*		*Variance Component*		*Variance Component*		*Variance Component*	
Student (Level-1), e_{ij}	0.2856 (0.01)		0.2855 (0.01)		0.2839 (0.01)		0.2839 (0.01)	
School (Level-2), u_j	0.5574 (0.10)		0.2225 (0.04)		0.1585 (0.03)		0.1316 (0.03)	
Variance Explained % (continued)								
Student (Level-1), σ^2_e	0.0666		0.0667		0.0683		0.0683	
School (Level-2), σ^2_u	0.0827		0.4206		0.4852		0.5124	
Model Fit Statistics								
Deviance	3134		3079		3050		3039	
Akaike Information Criterion (AIC)	3170		3121		3094		3089	
Bayesian Information Criterion (BIC)	3269		3237		3215		3227	
Likelihood Ratio test vs. OLS Regression	chibar2 (01) = 1474	<.001	chibar2 (01) = 829	<.001	chibar2 (01) = 571	<.001	chibar2 (01) = 505	<.001
Likelihood Ratio test (Preceding Model vs. Next)	χ^2 (15) = 375	<.001	χ^2 (3) = 54	<.001	χ^2 (2) = 46	<.001	χ^2 (4) = 40ǂ	<.001ǂ

Note. N= 1824; Est. = Estimate; Std. Err. = Standard Error (in parentheses); AIC and BIC statistics = smaller-is-better fit; OLS=Ordinary Least Squares; Ref.=Reference; ǂ = Model 3 nested in model 5; na = not applicable

Controlling for student-level covariates in Model-2, the three non-teacher resource inputs had statistically significant coefficients, well beyond the ≥0.10 threshold for flagging as predictors of academic achievement in the KCPE examination. Students in schools with piped water into their institutions scored 0.39 standard deviation units above the mean (*SE*=0.16, *p*=0.004). This dropped to 0.25 (*SE*=0.11, *p*=0.025) in Model-4 after controlling for other non-teacher school-level characteristics. Similarly, Students in schools with a lunch-meal programme scored 0.83 standard deviation units above the mean (*SE*=0.13, *p*<.001). This however dropped 0.30 (*SE*=0.13, *p*=0.025) in Model-4 after controlling for other non-teacher school-level characteristics. School ownership of a typewriter (h31i) was significant in Model-2 but became insignificant in Model-4 after adjusting for other non-teacher school characteristics.

After accounting for covariates in Models 1, 2 and 4, the following Level-1 covariates were flagged as predictors of student academic achievement with coefficients meeting the ≥0.10 threshold: Female student -0.28 (*SE*=0.03, *p*<.001); Student's age in years -0.10 (*SE*=0.01, *p*<.001); Students in the lowest wealth index -0.13 (*SE*=0.04, *p*<.001); looking after younger relatives most of the days -0.11 (*SE*=0.04, *p*=0.015) and students who kept negative company -22 (*SE*=0.03, *p*<.001).

In the final model, all school-level characteristics had statistically significant coefficients above the ≥0.10 threshold and were therefore flagged as predictors of academic achievement in the KCPE examination. A student sitting the KCPE exam in Kuria East scored up to -0.75 (*SE*=0.13, *p*<.001) standard deviation units below what a student with similar characteristics scored in Mumias Sub-County. Students in boarding schools or in boarding and day schools scored up to 0.73 and 0.62 standard deviation units respectively above what their colleagues with similar characteristics in a day school would score. Students in schools that disallowed their borrowing of books for private and further study away from school scored -0.14 below what their colleagues in alternative schools scored. The intercept for Model-4 was statistically significant at 1.64 standard deviation units (*SE*=0.23, *p*<.001).

The random part of the model saw a huge reduction in the school-level variance component. After running the final model, the proportion of variance at student-level (e_{ij}) dropped to 0.2839 from 0.3516 in the null model while that at the school-level (u_j) dropped from 0.6393 in the null model to 0.1316 in Model-4.

Model-3 omitted the non-teacher resource input predictors to allow for determination of the net variance explained by these predictors. This was determined through (4.26) by subtracting the total variance explained in Model-3 (0.5536) [omitting the non-teacher resource input predictors] from the total variance explained in Model-4 (0.5807) [including the non-teacher resource input predictors].

$$0.5807 - 0.5536 = 0.0271 * 100 = 2.71\% \qquad (4.26)$$

Student-level variables explained 0.0693 (6.93%) of 0.3548 (35.48%) available for explanation in the null model. This translated to just 19.53% of explained variance at student-level leaving up to 80.47% unexplained suggesting the other student-level variables outside these models could be holding onto much of this variation. School-level variables (including the non-teacher resource inputs in Model-2) explained 0.5124 (51.24%) of 0.6452 (64.52%) available for explanation in the null model. This translated to 79.42% of explained variance at school-level leaving just about 20.58% unexplained suggesting the school-level variables estimated in the models explained a huge chunk of the variation available for explanation at school -level. Up to 0.4193 (41.93%) variation in student academic achievement remained unexplained by the two levels.

Deviance, AIC and BIC estimates reduced from 3134, 3170 and 3269 in Model-1 to 3039, 3089 and 3227 in Model-3 respectively. This indicated that adjusting for covariates in Model-4 improved the overall model fit compared with preceding models. Model-4 was also deemed better than the single level Ordinary Least Squares linear regression, LR: $chibar2\ (01) = 505, p =< .001$. Similarly, another LR test shows that Model-4 was better than Model-2 in fitting the data, $\chi^2(4) = 40, p =< .001$.

4.5.4.4 The School (Level-2) Random Slopes Model for Objective 2

Equations 4.23. 4.24 and 4.25 specified random intercepts and fixed coefficients. A random intercept model constrained the slopes and assumed that the slopes were constant at Model-2 and Model-4. An exploratory random slope model was considered for Sex of student (s21) specified as:

$$Y_{ij} = \beta_0 + \beta_1 s21_{ij} + \beta_2 s23a_{ij} + \beta_3 s27_{ij} + \beta_4 s313x_{ij} + \beta_5 s36c_{ij} + \beta_6 s314a_{ij} + \beta_7 s314b_{ij} + \beta_8 s314l_{ij} + \beta_9 s58x_{ij} + \beta_{10} s61x_{ij} + \beta_{11} h31e_j + \beta_{12} h31i_j + \beta_{13} h32_j + \beta_{14} h16_j + \beta_{15} h24a_j + \beta_{16} h5122_j + u_{0j} + u_{1j} s21_{ij} + e_{ij} \quad (4.27)$$

The description of these variables is given under models 4.23a, 4.24a and 4.25a.

After running the model, the results suggested that the slope variance for sex of student was not statistically significant, ($\sigma_{u1}^2 = 0.01, SE = 0.01$), meaning that the slopes for Male and Female students did not differ statistically across the schools. With this result, the researcher reverted to equation (4.25a), the final model (Model-4) for Objective 2.

4.5.4.5 Testing $H_0 2$ under Objective 2

The null hypothesis for Objective 2 stated that there was no statistically significant relationship between non-teacher school-level resource inputs and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties.

Several tests for this hypothesis involving the three non-teacher school-level resource input predictors (h31e, h31i and h32) in Model-4 were done. First a post-estimation significance test using the Wald test of simple and composite linear hypotheses for each of the three variables returning mixed significance results:

. test h31e

(1) [s17f]h31e = 0 chi2(1) = 4.99 Prob > chi2 = 0.0254

. test h31i

(1) [s17f]h31i = 0 chi2(1) = 3.30 Prob > chi2 = 0.0693

. test h32

(1) [s17f]h32 = 0 chi2(1) = 5.06 Prob > chi2 = 0.0245

The Wald test results show that the effect of typewriter ownership (h31i) was not statistically significant $\chi^2(1) = 3.30, p = 0.069$. The other two returned significant results indicating their positive effect on student academic achievement in the KCPE examination.

Secondly, a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-2 (omitting the non-teacher school-level resource inputs) nested in Model-4 (final model with the non-teacher school-level resource inputs included) was done. As earlier noted, the *LR* ratio test statistic is calculated as two times the difference in the log likelihood values for the two models assuming that Model 2 is nested in Model 4. The values for Model-2 nested in Model-4 were -1540 and -1519 respectively and were calculated as

$$LR = 2 * (-1519 - (-1540)) = 42 \qquad (4.28)$$

With 4 degrees of freedom at $\alpha = .05$, the critical value for a chi-square distribution is 9.49. With $\chi^2 = 42, p < .001$, there was sufficient evidence to suggest that the non-teacher school-level resource inputs had a statistically significant effect on student academic achievement in the KCPE examination at the 5% significance level.

Thirdly, adjusting for student-level covariates in Model-1 and other non-teacher school characteristics in Model-4, the three non-teacher school-level resource inputs accounted for 2.71% of the 51.07% of the explained variance by the two levels as calculated in equation (4.26). As already noted, lunch-meal programmes and piped water into schools surpassed the ≥0.10 threshold standardized regression coefficients with 0.30 (*SE*=0.13, *p*=0.025) and 0.25 (*SE*=0.11, *p*=0.025) respectively, thus being flagged as predictors of student academic achievement in KCPE.

With these three pieces of evidence, there was sufficient evidence to reject the null hypothesis. The conclusion was that controlling for student level covariates in Model-1 and other non-teacher school-level covariates in Model-4, the three non-teacher school-level resource inputs (School has piped water, School has a typewriter, and School has a feeding programme) had statistically significant effect on student academic achievement in the KCPE examination.

4.5.4.6 Model Diagnostics

Three post-estimation diagnostic tests were run to check the fit of the models. Two of these tests have already been presented in 4.5.4.5: The post-estimation significance test using the Wald test of simple and composite linear hypotheses of the three variables and a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-2 nested in Model-4. The third important post estimation test was the generation of standardized residuals to see if they followed a standard normal distribution, as they should in any good-fitting model. Figure 4.8 presents a graph for quantiles of normal distribution (qnorm) showing that indeed the residuals were normally distributed.

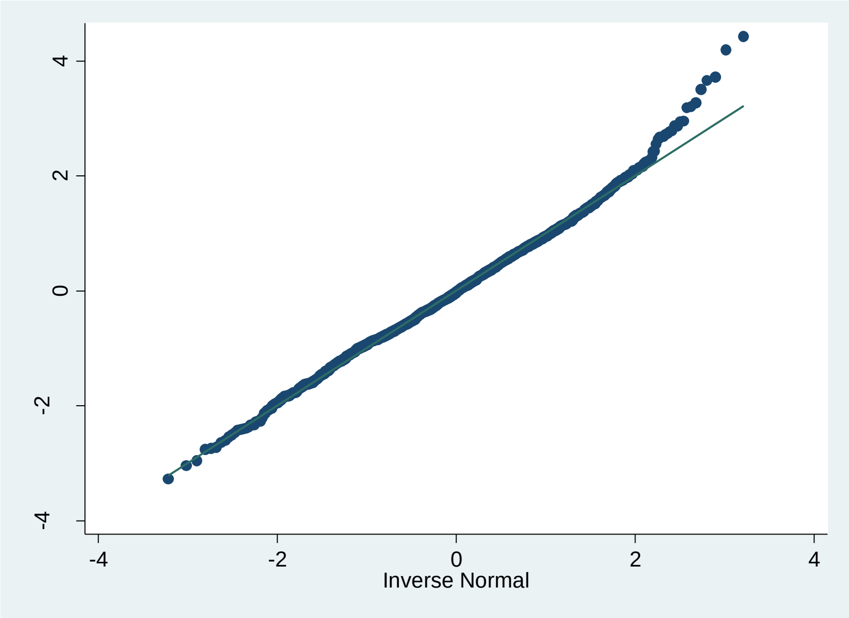

Figure 4.8 Quantiles of Normal Distribution for the Residuals (Objective 2)

4.5.4.7 The Two-Level Comparative Random Intercept School (Level-2) Model

The researcher also fitted a two-level random intercept model comparing between the two Sub-Counties to determine any differences in the behaviour and effect of predictors and covariates. Table 4.26 presents the results.

Table 4.27 Comparative Two-Level Random Intercept School Model (Level-2), Objective 2

Fixed Effect Variable label	Mumias Sub-County (*N*= 1068)		Kuria East Sub-County (*N*= 756)	
	Est. (SE)	*p*	Est. (SE)	*p*
Sex of student (Ref: 1=Female)	-0.28 (0.03)	<.001	-0.28 (0.04)	<.001
Student's age in years	-0.11 (0.01)	<.001	-0.06 (0.02)	0.001
Student's years in current school	-0.02 (0.01)	0	-0.02 (0.01)	0.005
Number of times student spoke English in last 7 days	0.02 (0.01)	0.02	0.05 (0.01)	0.001
Student's Wealth Index (3 Tertiles): 1=High (Ref.)				
2=Middle	-0.09 (0.04)	0.02	0.01 (0.05)	0.908
3=Low	-0.21 (0.05)	<.001	-0.06 (0.06)	0.317
Number of siblings	-0.02 (0.01)	0	-0.01 (0.01)	0.367
Looking after younger relatives: 1=Never (Ref.)				
2=Some days	-0.04 (0.04)	0.33	-0.01 (0.06)	0.907
3=Most days	-0.02 (0.05)	0.67	-0.23 (0.08)	0.003
Looking after elderly relatives: 1=Never (Ref.)				
2=Some days	-0.05 (0.04)	0.21	-0.01 (0.05)	0.855
3=Most days	-0.09 (0.06)	0.14	-0.09 (0.07)	0.233
Gardening/working in a vegetable garden: 1=Never (Ref.)				
2=Some days	0.07 (0.04)	0.1	0.12 (0.06)	0.052
3=Most days	0.02 (0.05)	0.670	0.19 (0.07)	0.005
Number of times student has repeated classes	-0.11 (0.02)	<.001	-0.06 (0.03)	0.046
Student keeps negative company (standardized score)	-0.13 (0.04)	<.001	-0.30 (0.04)	<.001
School has piped water	0.36 (0.16)	0.03	0.15 (0.15)	0.343
School has a typewriter	0.34 (0.29)	0.25	0.34 (0.24)	0.165
School has a feeding programme	0.24 (0.18)	0.19	0.20 (0.24)	0.403
School's boarding status at Class 8: 1=Day (Ref)				
2=Boarding	0.63 (0.40)	0.12	0.85 (0.50)	0.087
3=Day and boarding	0.45 (0.30)	0.13	0.91 (0.36)	0.010
Students disallowed from borrowing library books to take home	-0.14 (0.05)	0.01	-0.17 (0.08)	0.031
Intercept	2.07 (0.29)	<.001	0.34 (0.31)	0.279

In this comparative model, student sex and keeping of negative company were flagged as a predictors of student academic achievement in both Sub-Counties with the later having more adverse effects in Kuria East compared with Mumias. Looking after younger relatives most of the days was a predictor in Kuria East while the number of times a student had repeated classes was flagged as a predictor in Mumias but not in Kuria East. Piped water into schools had a predictive effect in Mumias but not in Kuria East. A day and boarding component at Class 8 had larger positive effects for Kuria East than it did for Mumias. Disallowing students from borrowing school books and other materials for private study away from school was also flagged as a predictor of student academic achievement in both Sub-Counties.

4.5.5 Discussion of the Findings in Objective 2.

Three non-teacher school-level resource input predictors were modelled in Objective 2 to estimate their effect on student academic scores in the KCPE examination. These were: School has piped water; School has a typewriter; and School has a feeding programme. These predictors accounted for 2.71% of the 58.07% variance explained by the two levels. This effect was found to be statistically significant through the tests presented in section 4.5.4.5 (Testing $H_0 2$ under Objective 2). This study therefore found sufficient evidence to support the view that the three predictors had statistically significant effect on student academic achievement in the KCPE examination. This significance seems to be driven by the fact that teacher-related variables were not adjusted for in the models because the focus was to estimate the effect of non-teacher resource input variables. All non-teacher school-level resource inputs that were correlated with the outcome variable could not ‘make it into the models under Objective 3 because of the presence of teacher-variables in the models. This is expected because in the absence of teacher-resources, other non-teacher resource inputs such as lunch-meal programmes and piped water into schools gain significance. This reinforces the centrality of teacher-resources in student academic achievement.

Available literature on school resources presents mixed results. While some researchers have found minimal or no statistically significant effect of school resources on student academic achievement, others have. This divergence is probably driven by choice of statistical methods, variable selection and treatment and sampling. Each finding therefore needs careful assessment on a case by case basis.

The significant finding in this study from two of the three non-teacher school-level resource input predictors disagrees partly (in respect of those two non-teacher school resource inputs) with Hanushek's (1997) review of close to 400 studies on student achievement. He argued that after accounting for family inputs, this large body of literature did not present compelling or consistent results that suggested a relationship between student performance and school resources.

His other analyses reached similar conclusions. That despite an increase in expenditure per pupil in public schools in the US from USD992 in 1960 to USD1898 in 1975 coupled with falling Pupil Teacher Ratios (PTR) and a 32% increase in teacher salaries over the same period, student academic work kept dropping (Hanushek, 1981). This probably mirrors the current situation in Kenya where it can be argued that although there has been increased funding to public primary schools since 2003 coupled with some substantial increases in teacher salaries and allowances over the same period, student academic achievement in such public schools has remained depressed or has recorded minimal improvement, not matching the enhanced investments.

Hanushek's other analyses have argued along similar lines, that PTR, teacher education or experience and school resources did not present compelling evidence to suggest substantial significant effect on student achievement scores (Hanushek, 1986, 1997, 2001; Hanushek & Luque, 2003). The insignificant finding in this thesis with respect to typewriter ownership by schools supports these arguments by Hanushek.

But several researchers have faulted the conclusions by Hanushek. For instance, Hedges, Laine, and Greenwald (1994a) used combined significance tests and combined estimation methods to re-analyze the evidence examined by Hanushek. They examined whether his conclusions about the lack of relationship between school inputs and student outcomes, and particularly his general conclusion that per pupil expenditure (PPE) and achievement are unrelated, were supported by a synthesis of the results of his sample of studies. Their results suggested that an increase of PPE by $500 (approximately 10% of the national average for the US) would be associated with a 0.7 standard deviation increase in student outcome, which by the standards of educational treatment interventions, would be considered a large effect.

This conclusion generated a heated scholarly debate with Hanushek responding with an article titled "An Exchange: Part II: Money Might Matter Somewhere: A Response to Hedges, Laine, and Greenwald" (Hanushek, 1994). He argued that Hedges, Laine and Greenwald (1994a) misapplied their statistical approach and ignored key assumptions and analytical choices that each work to invalidate their technical analysis. He argued that "if their implied predictor of a point-seven-standard-deviation improvement in student performance over the past quarter century had been realized, Albert Einstein would currently rate below the national average" (Hanushek, 1994, p. 7).

Hedges, Laine, and Greenwald (1994b) replied in an article titled "Money Does Matter Somewhere: A Reply to Hanushek" in which they defended their methodology and submitted that if the underlying studies used were somewhat flawed, as Hanushek seemed to agree, then neither Hanushek's analysis nor their reanalysis would be valid. They argued that since they had not previously published on education production function, they had no vested interests or bias and that their interest was only methodological. That is, whether the data that Hanushek had been citing for over a decade supported his conclusions about the lack of relation between resource inputs and educational outcomes. They insisted that their analyses had clearly suggested that it did not. This scholarly exchange serves to bring to the fore some methodological issues that have, and continue to bedevil studies on the effect of school resources on academic achievement.

Despite these dissenting opinions, Hanushek still argued that the weight of the evidence supported the view that there was no compelling evidence to suggest a significant relationship between school resources and academic achievement. While examining Black-White achievement differentials, Hanushek (2001) found that neither the level nor the distribution of school spending provided much or any explanation for the gaps. In analyzing data from the Third International Mathematics and Science Study (TIMSS) on efficiency and equity in schools around the world, Hanushek and Luque (2003) argued that effects on academic performance were not related to income levels of the country or resource allocation at school level and that the widely accepted view that school resources are relatively more important in poor countries did not find support in their analysis of the data.

Besides the findings of Hedges, Laine, and Greenwald, other researchers such as Shimada (2010) while using SACMEQ II data involving Class 6 students in Kenya, found that a one standard deviation change in resource inputs accounted for 0.09 (p<.01) improvement in student scores. He also found that school resources had positive effects on reading scores and that students who attended well-equipped schools tended to have higher scores than those enrolled in less-endowed schools. His findings also suggested that smaller class size was an important predictor of academic achievement with students in such classes performing better than those in larger classes. Of course, this finding points to PTR issues and the importance of close contact between the teacher and student. His main focus though was to model the effect of socioeconomic stratification on student academic scores and observes that "...It is [was] important to notice that no single variable has [had] a strong impact on academic achievement..." (Shimada, 2010, p. 105). This admission probably lends credence to the conclusion of Hanushek that a large review of analyses will find minimal or insignificant effect of school resources on student academic achievement. Just about 15.3% of the variance was explained in Shimada's two-level model with up to 84.7% left unexplained.

4.6 Objective 3: Modelling the Effect of School-Level Characteristics on Student Academic Achievement in the KCPE Examination in Mumias and Kuria East Sub-Counties

The third objective sought to examine the relationship between school-level characteristics and student academic achievement in the KCPE examination in Mumias and Kuria East Sub-Counties. The null hypothesis stated that there was no statistically significant relationship between school-level characteristics and student academic achievement in the KCPE examination in Mumias and Kuria East Sub-Counties.

4.6.1 Description of the Variables Used in the Analysis of Data for Objective 3.

Table 4.4 presents a description of all variables used in the analysis of Objective 1 through 3. For Objective 3, the outcome variable was the student's total score (s17f) from the five KCPE academic subject areas modelled as a function of non-teacher resource inputs adjusting for student and school characteristics. For ease of interpretation, this outcome variable was transformed to a standard normal score with a Mean of zero (0) and Standard Deviation and Variance of one (1) so that the residuals at each level better approximate the normality assumptions of the models. The transformation of the raw scores was presented in equation 4.1. This transformation allowed the effects of the covariates in HLM to be interpreted in terms of standard deviation units of the outcome variable (Leckie, 2013; Raudenbush & Bryk, 2002). The student-level variables were prefixed with letter "s", the teacher-level variables with letter "t" and the school-level variables with letter "h".

4.6.2 Pair-Wise Correlation Between the Outcome Variable and Student and School-Level Characteristics for Objective 3

The outcome variable was measured on the interval scale making pair-wise correlation the preferred statistical method to determine plausible interactions with the independent variables and covariates as a basis for their subsequent consideration in the two-level HLM for the Objective 3.

Table 4.28 presents the correlation coefficient matrix for variables used in the analysis of Objective 3. Because of space constraints, the full matrix table was not displayed but the matrix of interest which is between the outcome and its correlates is fully presented under the outcome variable's column. A correlation coefficient that is ≤0.35 is interpreted as weak; 0.36-0.67 as moderate; 0.68-0.89 as strong; and ≥0.90 as very strong (Taylor, 1990). Of the eight school-level covariates in the correlation matrix, the Sub-County in which the school was located had the 'strongest' correlation with the outcome variable (r=574, p=<.001). This is however categorised as moderate. Number of female teachers also had moderate correlation with the outcome variable (r=486, p=<.001).

4.6.3 Descriptive Statistics for Variables Used in Data Analysis for Objective 3

The effect of 20 variables on student academic achievement was estimated in the models under Objective 3. Their descriptive values are presented in Table 4.4 alongside those for Objectives 1 and 2. As expected with a standardized variable, the mean was 0.00 (*SE*=0.02) with scores ranging between -2.84 (minimum) and 2.37 (maximum).

4.6.4 The Similarities and Differences Between the Models Under Objective 2 and Those Under Objective 3.

Both Objectives 2 and 3 used the same dataset and fitted two-level HLMs with 1824 students (Level-1) nested within 61 schools (Level-2). The main difference between the two objectives was in fitting the independent variables at Level-2. In Objective 2, none of the teacher-variables were estimated while these were estimated in Objective 3. The similarities were in the rest of the preliminary models (unconditional and Level-1) and their outputs. The two Objectives share the same unconditional model (4.20) and its output in Table 4.21. The proportion of variance estimated in equations 4.21 and 4.22 as well as the Empirical Bayes Estimates of school effects in Table 4.22 and Figures 4.6 and 4.7 are also shared. For conciseness and avoidance of repetition. None of these preliminary outputs will be repeated under Objective 3 but reference will be made to them appropriately.

4.6.4.1 Bivariate Analysis

The researcher ran a two-tailed independent t-test to examine whether the mean of Mumias differed significantly from Kuria East's as well as a one-way ANOVA to examine whether there was a significant difference between the means of day, boarding and boarding and day schools. Table 4.28 presents the t-test results. Schools in Mumias Sub-County scored 0.48 standard deviation units above the mean compared with Kuria East's -0.68, and this difference is statistically significant with medium strength (R^2= 0.18).

Table 4.28. Two-tailed independent t-test results comparing the means Mumias and Kuria East Sub-Counties

Group	Obs.	Mean	Std. Err.	Std. Dev.	[95% CI]	
0=Mumias Sub-County	1,068	0.48	0.02	0.81	0.43	0.53
1=Kuria East Sub-County	756	-0.68	0.03	0.83	-0.74	-0.62
Combined	1,824	0.00	0.02	1.00	-0.05	0.05
Difference		1.16	0.04		1.09	1.24

Note. Obs.=Observations; Std. Err=Standard Error; Std. Dev.=Standard Deviation; CI=Confidence Interval; n=1824; α=.05: t (1601.3) = 29.7880; R^2= 0.18 where 0.01-0.09 is small effect; 0.10-0.25 is medium effect; over 0.25 is a large effect. Adapted from "*A Gentle Introduction to Stata*", by C. A. Acock, 2006, College Station, Texas USA: Stata Press, p. 137
p <.001

Table 4.29 presents the results of the one-way ANOVA.

Table 4.29. One-way ANOVA Comparing Between Boarding Status at Class 8

Boarding Status	Mean	Std. Dev.	Frequency
1=Day	-0.19	0.92	1,583
2=Boarding	1.40	0.44	79
3=Day and Boarding	1.13	0.56	162
Total	0.00	1.00	1,824

Source	ss	df	ms
Between groups	414.62	2	207.31
Within groups	1408.38	1821	0.77
Total	1823.00	1823	1.00
F(106.37)=268.04, p <0.001			

Bonferroni post hoc test (p-value in parenthesis)

Row Mean-Column mean	1=Day	2=Boarding
2=Boarding	1.59 (<0.001)	
3=Day and Boarding	1.31 (<0.001)	=-0.28 (0.065)

Note. Std. Dev.=Standard deviation; ss=sum of squares; df=degrees of freedom; ms=mean of squares; α=0.05; η^2=0.2274

A one-way ANOVA was conducted to determine if the academic achievement differed across the three categories of boarding status at Class 8. The results suggest that there was a statistically significant difference between the categories as determined by the one-way ANOVA, $F(1821)=268.04$, $p<0.001$. The Bonferroni post-hoc test showed that the difference between boarding and day schools was 1.59 standard deviation units ($p<.001$) while that between boarding/day and day schools was 1.31 standard deviation units ($p<.001$). the difference between boarding and boarding/days was not statistically different.

4.6.4.2 The Student (Level-1) Random Intercept Model for Objective 3

In each school, the student's total KCPE score was modelled as a function of student-level predictors plus a random student-level error. There was a variance of 35.48% that lay at Level-1 that needed to be explained by adjusting for the Level-1 covariates that were significantly correlated with the outcome variable (s17f). The independent variables were school-level characteristics. Again, following Leckie (2013) and Raudenbush and Bryk (2002), the student-level (Level-1) model was specified as given in model 4.29

$$Y_{ijk} = \beta_0 + \beta_1 a_{1ij} + \beta_2 a_{2ij} + \cdots + \beta_{pj} a_{pij} + u_j + e_{ij} \tag{4.29}$$

Assuming that; $u_j \sim N(0, \sigma_u^2)$

$e_{ij} \sim N(0, \sigma_e^2)$

Where:

Y_{ij} is the total KCPE score for student i $(i = 1, \dots, 1824)$ nested within school j, $(j = 1, \dots, 61)$;

β_0 is the mean score across all schools;

a_{pij} are $p = 1, \dots, P$ student characteristics that predict achievement;

β_{pj} are the corresponding Level-1 coefficients that indicate the direction and strength of association between each student characteristic, a_p and the outcome in school j;

u_j is the effect of school j; and

e_{ij} is the student level residual error term.

The school, effects and the student level residual errors are assumed independent and normally distributed with zero means and constant variances.

The two-step selection process for predictors described in section 4.4.3.2 was followed for screening of the student-level variables in Objective 3. The predictors summarized in Table 4.30 did not return significant effects on the outcome variable at the 5% significance level and were consequently dropped and not considered in the final student-level model as their presence in this and subsequent models would add little explanatory value (Leckie, 2010; Raudenbush & Bryk, 2002).

Table 4.30 Non-significant Variables Dropped from the Student-Model (Objective 3)

Variable	Est. (Std. Err.)	*p*
Religion of student: 1=Muslim (Ref)	0.07 (0.08)	0.784
Student's father is alive	-0.07 (0.06)	0.524
Number of books at place of usual aboard	0.01 (0.02)	0.972
Taking care of sick family members and relatives: 1=Never (Ref.)		
2=Some days	0.07 (0.04)	0.127
3=Most days	0.00 (0.03)	0.803
Cooking: 1=Never (Ref.)		
2=Some days	-0.06 (0.05)	0.119
3=Most days	-0.06 (0.07)	0.722
Washing and ironing clothes: 1=Never (Ref.)		
2=Some days	0.01 (0.05)	0.794
3=Most days	0.00 (0.07)	0.999
Chopping fire wood: 1=Never (Ref.)		
2=Some days	0.00 (0.03)	0.879
3=Most days	-0.04 (0.05)	0.606
Collecting fire wood: 1=Never (Ref.)		
2=Some days	-0.10 (0.09)	0.783
3=Most days	-0.07 (0.06)	0.942
Taking care of livestock: 1=Never (Ref.)		
2=Some days	-0.03 (0.03)	0.888
3=Most days	-0.08 (0.05)	0.178
Helping in a family business: 1=Never (Ref.)		
2=Some days	0.02 (0.03)	0.690
3=Most days	0.04 (0.04)	0.367
Number of homework in a week for all subjects	-0.02 (0.01)	0.439
Someone at home/ school helps with homework	-0.03 (0.04)	0.773
How often teacher corrects homework: 1-5	0.00 (0.01)	0.547
Number of lessons missed in a week for all subjects	-0.01 (0.01)	0.421
Student had extra lessons in mathematics	0.08 (0.06)	0.138
Student had extra lessons in social studies	-0.08 (0.07)	0.651

Note. Std. Err. = Standard Error (in parentheses)

Substituting the remaining student-level predictors into the Level-1 model (4.29a) yielded:

$$Y_{ij} = \beta_0 + \beta_1 s21_{ij} + \beta_2 s22a_{ij} + \beta_3 s23a_{ij} + \beta_4 s27_{ij} + \beta_5 s313x_{ij} + \beta_6 s36c_{ij} + \beta_7 s314a_{ij} + \beta_8 s314b_{ij} + \beta_9 s314e_{ij} + \beta_{10} s314l_{ij} + \beta_{11} s58x_{ij} + \beta_{12} s61x_{ij} + u_j + e_{ij} \quad (4.29a)$$

Where s21= Sex of student; s22a= Student age in years; s23a= Student's years in current school; s27= Number of times student spoke English in last 7 days;

s313x= Student's SES; s36c= Number of siblings; s314a= Looking after younger relatives; s314b= Looking after elderly relatives; s314e= House cleaning; s314l= Gardening/working in a vegetable garden; s58x= Number of times student has repeated classes; s61x= Student keeps negative company (standardized items).

4.6.4.3 The (Level-2) School Characteristics Random Intercept Model for Objective 3

Level-2 school characteristics were modelled as predictors of student total KCPE score plus a random school-level error. There was a variance of 64.52% that lay at Level-2 that needed to be explained by modelling the Level-2 school characteristics predictors that were significantly correlated with the outcome variable. Model-2 was an extension of models 4.29 and model 4.29a specified as:

$$Y_{ijk} = \beta_0 + \beta_1 a_{1ij} + \beta_2 a_{2ij} + \beta_3 d_{3j} + \beta_4 d_{4j} + \cdots + \beta_{lj} d_{lj} + u_j + e_{ij} \quad (4.30)$$

Assuming that; $u_j \sim N(0, \sigma_u^2)$

$e_{ij} \sim N(0, \sigma_e^2)$

Where:

Y_{ij} is the total KCPE score for student

i $(i = 1, \dots, 1824)$ nested within school j, $(j = 1, \dots, 61)$;

β_0 is the mean score across all schools;

d_{lj} are $l = 1, \dots, L$ school characteristics predictors of academic achievement;

β_{lj} are the corresponding Level-2 coefficients that indicate the direction and strength of association between each school characteristics predictor, d_l and the outcome under school j;

u_j is the effect of school j; and

e_{ij} is the student level residual error term.

The school, effects and the student level residual errors were assumed independent and normally distributed with zero means and constant variances.

The two-step selection process for predictors described in section 4.4.3.2 was employed for screening the school characteristics predictors Objective 3. The predictors summarized in Table 4.31 did not return significant effects on the outcome variable at the 5% significance level and were consequently dropped and not considered in the final school characteristics model as their presence in this and subsequent models would add little explanatory value (Leckie, 2010; Raudenbush & Bryk, 2002).

Table 4.31 Non-significant Variables Dropped from the School Characteristics-only Model (Objective 3)

Variable label	Est. (Std. Err.)	*p*
School has store room	0.16 (.09)	0.085
School has piped water	0.16 (.11)	0.124
School has a computer	0.11 (0.14)	0.447
School has a feeding programme	0.16 (0.13)	0.219
Mean teacher years in current school	0.04 (0.04)	0.353
Male teacher	0.07 (.06)	0.249
Masters	0.09 (0.16)	0.584
Untrained teacher	0.05 (0.04)	0.187
P1	0.04 (0.03)	0.147
S1/Diploma	0.01 (0.04)	0.750
ATS	0.03 (0.04)	0.330
Has been teaching subject in C8 since 2014 began	0.04 (0.02)	0.072

Note. Std. Err. = Standard Error (in parentheses)

Since HLM is additive by level, the 8 school characteristics predictors were brought into Model-2 and specified as:

$$Y_{ij} = \beta_0 + \beta_1 s21_{ij} + \beta_2 s22a_{ij} + \beta_3 s23a_{ij} + \beta_4 s27_{ij} + \beta_5 s313x_{ij} + \beta_6 s36c_{ij} + \beta_7 s314a_{ij} + \beta_8 s314b_{ij} + \beta_9 s314e_{ij} + \beta_{10} s314l_{ij} + \beta_{11} s58x_{ij} + \beta_{12} s61x_{ij} + \beta_{13} h16_j + \beta_{14} h24a_j + \beta_{15} h218z_j + \beta_{16} h227z_j + \beta_{17} h49a_j + \beta_{18} h432_j + \beta_{19} h487_j + \beta_{20} h5122_j + u_j + e_{ij} \quad (4.30a)$$

h16= Sub-County; h24a= Boarding status at class 8; h218z= Mean parental contribution 0-10 scale; h227= Mean community school participation: 0-10 scale; h49a= Mean teacher years since first employment; h432= Number of female teachers; h487= Number of graduate teachers; h5122= Students not allowed to borrow school books and take home.

Table 4.32 summarizes the output from the final school (Level-2) model.

Table 4.32 Two Level Random Intercept School Characteristics Model (Level-2), Objective 3

Fixed Effect Variable label	Model 1 (Student)		Model 2 (School Characteristics)	
	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*
Sex of student (Ref: 1=Female)	-0.30 (0.03)	<.001	-0.30 (0.03)	<.001
Student's age in years	-0.09 (0.01)	<.001	-0.09 (0.01)	<.001
Student's years in current school	-0.02 (0.01)	<.001	-0.02 (0.00)	<.001
Number of times student spoke English in last 7 days	0.03 (0.01)	<.001	0.03 (0.01)	<.001
Student's Wealth Index (3 Tertiles): 1=High (Ref.)				
2=Middle	-0.04 (0.03)	0.210	-0.03 (0.03)	0.292
3=Low	-0.13 (0.04)	<.001	-0.13 (0.04)	<.001
Number of siblings	-0.02 (0.01)	0.003	-0.02 (0.01)	0.006
Looking after younger relatives: 1=Never (Ref.)				
2=Some days	-0.03 (0.03)	0.327	-0.02 (0.03)	0.585
3=Most days	-0.13 (0.04)	0.005	-0.12 (0.04)	0.009
Looking after elderly relatives: 1=Never (Ref.)				
2=Some days	-0.04 (0.03)	0.149	-0.04 (0.03)	0.155
3=Most days	-0.11 (0.05)	0.017	-0.10 (0.05)	0.022
House cleaning				
2=Some days	0.10 (0.05)	0.051	0.10 (0.05)	0.044
3=Most days	0.19 (0.05)	<.001	0.19 (0.05)	<.001
Gardening/working in a vegetable garden: 1=Never (Ref.)				
2=Some days	0.08 (0.04)	0.039	0.08 (0.04)	0.033
3=Most days	0.06 (0.04)	0.132	0.07 (0.04)	0.113
Number of times student has repeated classes	-0.08 (0.02)	<.001	-0.09 (0.02)	<.001
Student keeps negative company (standardized score)	-0.23 (0.03)	<.001	-0.23 (0.03)	<.001
Sub-County (Ref: 1=Kuria East)			-0.79 (0.09)	<.001
School's boarding status at Class 8: 1=Day (Ref)				
2=Boarding			0.46 (0.21)	0.034
3=Day and boarding			0.46 (0.17)	0.006
Mean parental contribution 0-10 scale			0.06 (0.02)	0.004
Mean community school participation: 0-10 scale			0.04 (0.02)	0.013
Mean teacher years since first employment			-0.02 (0.01)	0.015
Female Teacher			0.04 (0.01)	<.001
Graduate Teacher			0.07 (0.02)	0.001
Students disallowed from borrowing library books to take home			-0.14 (0.04)	0.001
Intercept	1.63 (0.20)	<.001	1.40 (0.25)	<.001

(continued)

Table 4.32 Two Level Random Intercept School Characteristics Model (Level-2), Objective 3 (continued)

Fixed Effect Variable label	Model 1 (Student)		Model 2 (School Characteristics)	
	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*
Random Effect	*Variance Component*		*Variance Component*	
Student (Level-1), e_{ij}	0.2827 (0.01)		0.2812 (0.0095)	
School (Level-2), u_j	0.5659 (0.11)		0.0788 (0.02)	
Variance Explained %				
Student (Level-1), σ^2_e	0.0695		0.0710	
School (Level-2), σ^2_u	0.0741		0.5657	
Model Fit Statistics				
Deviance	3117		2994	
Akaike Information Criterion (AIC)	3157		3052	
Bayesian Information Criterion (BIC)	3267		3212	
Likelihood Ratio test vs. OLS Regression	chibar2 (01) = 1490	<.001	chibar2 (01) = 304	<.001
Likelihood Ratio test (Preceding Model vs. Next)	χ^2 (17) = 392	<.001	χ^2 (11) = 139	<.001

Note. N= 1824; Est. = Estimate; Std. Err. = Standard Error (in parentheses); AIC and BIC statistics = smaller-is-better fit; OLS=Ordinary Least Squares

Controlling for student-level covariates in Model-1, school characteristics had a huge effect on a student's total KCPE score. The intercept in Model-2 was 1.40 (*SE*=0.25, *p*<.001) with all school characteristics returning statistically significant coefficients. Three of the eight school-level covariates had coefficients that surpassed the ≥0.10 threshold for flagging as predictors of academic achievement in KCPE. Schools in Kuria East scored -0.79 (*SE*=0.09, *p*=<.001) standard deviation units below what schools in Mumias scored. Boarding schools and boarding/day scored 0.46 standard deviation units above what day schools scored. Students in schools that disallowed their borrowing of school books and materials for further study away from school scored -0.14 (*SE*=0.04, *p*=0.001) below what their colleagues in alternative schools scored.

In the final model, the following Level-1 covariates were flagged as predictors of student academic achievement with coefficients meeting the ≥0.10 threshold: Female student -0.30 (*SE*=0.03, *p*<.001); Students in the lowest wealth index -0.13 (*SE*=0.04, *p*<.001); looking after younger and old relatives most of the days -0.12 (*SE*=0.04, *p*=0.009) and -0.10 (*SE*=0.05, *p*=0.022) respectively; House cleaning for some and most of the days -0.10 (*SE*=0.05, *p*=0.044) and -0.19 (*SE*=0.05, *p*<.001) respectively; and students who kept negative company -23 (*SE*=0.03, *p*<.001).

The random part of the model saw a huge reduction in the school-level variance component. After running the final model, the proportion of variance at student-level (e_{ij}) dropped to 0.2812 from 0.3516 in the null model while that at the school-level (u_j) dropped from 0.6393 in the null model to 0.0788 in Model-3.

Student-level variables explained 0.0710 (7.10%) of 0.3548 (35.48%) available for explanation in the null model. This translated to just 20.01% of explained variance at student-level leaving up to 79.99% unexplained suggesting the other student-level variables outside these models could be holding onto much of this variation. School-level covariates explained 0.5657 (56.57%) of 0.6452 (64.52%) available for explanation in the null model. This translated to 87.68%% of explained variance at school-level leaving just about 12.32% unexplained suggesting the school-level variables estimated in the models explained a huge chunk of the variation available for explanation at school -level. The two levels explained 0.6367 (63.67%) of the variation in student academic achievement.

Deviance, AIC and BIC estimates reduced from 3117, 3157 and 3267 in Model-1 to 2994, 3052 and 3212 in Model-2 respectively. This indicated that adjusting for covariates in Model-2 improved the overall model fit compared with preceding models. Model-2 was also deemed better than the single level Ordinary Least Squares linear regression, *LR:* $chibar2\ (01) = 304, p =< .001$. Similarly, another *LR* test shows that Model-4 was better than Model-2 in fitting the data, $\chi^2(11) = 139, p =< .001$

4.6.4.4 The School (Level-2) Random Slopes Model for Objective 3

Models 4.30 and 4.30a specified a random intercept and fixed coefficients which constrained the slopes and assumed that the slopes were constant at Model-2. An exploratory random slope model was considered for the sex of student (s21) specified as:

$$Y_{ij} = \beta_0 + \beta_1 s21_{ij} + \beta_2 s22a_{ij} + \beta_3 s23a_{ij} + \beta_4 s27_{ij} + \beta_5 s313x_{ij} + \beta_6 s36c_{ij} + \beta_7 s314a_{ij} + \beta_8 s314b_{ij} + \beta_9 s314e_{ij} + \beta_{10} s314l_{ij} + \beta_{11} s58x_{ij} + \beta_{12} s61x_{ij} + \beta_{13} h16_j + \beta_{14} h24a_j + \beta_{15} h218z_j + \beta_{16} h227z_j + \beta_{17} h49a_j + \beta_{18} h432_j + \beta_{19} h487_j + \beta_{20} h5122_j + u_{0j} + u_{1j} s21_{ij} + e_{ij} \tag{4.31}$$

A description of these variables was given under models 4.29a and 4.30a.

After running the model, the results suggested that the slope variance for sex of the student was not statistically significant, ($\sigma^2_{u1} = 0.01, SE = 0.01$), meaning that the slopes for Male and Female students did not differ statistically across the schools. The *LR* test did not find that this random slopes model was better than the random intercept model (Model-2), $\chi^2(2) = 1.70, p$ =0.427. Consequently, the researcher reverted back to Model-2 as the final model for Objective 3.

4.6.4.5 Testing $H_0$3 under Objective 3

The null hypothesis for Objective 3 stated that there was no statistically significant relationship between school characteristic variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties.

Several tests for this hypothesis involving the 8 school characteristics predictors at school-level in Model-2 were done. First a post-estimation significance test using the Wald test of simple and composite linear hypotheses for each of 8 predictors returned statistically significant results for each confirming their effect on students' academic achievement in the KCPE examination;

. test h16

(1) [s17f]h16 = 0 chi2(1) = 78.03 Prob > chi2 = 0.0000

. test 2.h24a

(1) [s17f]2.h24a = 0 chi2(1) = 4.51 Prob > chi2 = 0.0336

. test 3.h24a

(1) [s17f]3.h24a = 0 chi2(1) = 7.43 Prob > chi2 = 0.0064

. test h218z

(1) [s17f]h218z = 0 chi2(1) = 8.28 Prob > chi2 = 0.0040

. test h227z

(1) [s17f]h227z = 0 chi2(1) = 6.14 Prob > chi2 = 0.0132

. test h49a

(1)	[s17f]h49a = 0	chi2(1) =	5.91	Prob > chi2 =	0.0151
. test	h432				
(1)	[s17f]h432 = 0	chi2(1) =	20.27	Prob > chi2 =	0.0000
. test	h487				
(1)	[s17f]h487 = 0	chi2(1) =	11.35	Prob > chi2 =	0.0008
. test	h5122				
(1)	[s17f]h5122 = 0	chi2(1) =	10.58	Prob > chi2 =	0.0011

Secondly, a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-1 nested in Model-2 was done. As earlier noted, the LR ratio test statistic is calculated as two times the difference in the log likelihood values for the two models assuming that Model 1 is nested in Model 2. The values for the Model-1 nested in Model-2 were -1558 and -1497 respectively and were calculated as

$$LR = 2 * (-1497 \ - (-1558\ )) = 122 \tag{4.32}$$

With 11 degrees of freedom at $\alpha = .05$, the critical value for a chi-square distribution is 19.68. With $\chi^2 = 122, p < .001$, there was sufficient evidence to suggest that school characteristics had a statistically significant effect on student academic achievement in the KCPE examination.

Thirdly, adjusting for student-level covariates in Model-1, school characteristics in Model-2 accounted for $0.4931\ (49.31\%)$ of the variance available for explanation across the two models calculated as

$$(0.6367 - 0.1436) = 0.4931 * 100 = 49.31\%. \quad (4.33)$$

With these three pieces of evidence, there was overwhelming and sufficient evidence to reject the null hypothesis. The conclusion is that adjusting for student level covariates in Model-1, the 8 school-level covariates specified in Model-2 had a statistically significant effect on student academic achievement in the KCPE examination by accounting for 49.31% of the total 63.67% of the variation explained by the two-levels.

4.6.4.6 Model Diagnostics

Three post-estimation diagnostic tests were run to check the fit of the models. Two of these tests have already been presented in 4.6.4.5: The post-estimation significance test using the Wald test of simple and composite linear hypotheses of the 8 independent variables and a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-1 nested in Model-2. The third important post estimation test was the generation of standardized residuals to see if they followed a standard normal distribution, as they should in any good-fitting model. Figure 4.9 presents a graph for quantiles of normal distribution (qnorm) showing that indeed the residuals were normally distributed.

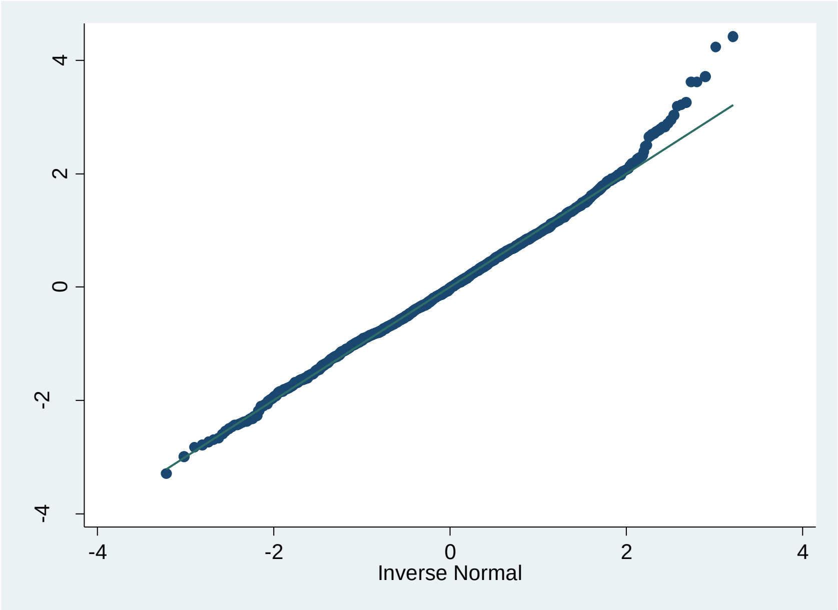

Figure 4.9 Quantiles of Normal Distribution for the Residuals (Objective 3)

4.6.4.7 The Two-Level Comparative Random Intercept School (Level-3) Model

The researcher also fitted a two-level random intercept model comparing between the two Sub-Counties to determine any differences in the behaviour and effect of predictors and covariates. Table 4.33 presents the results.

Table 4.33 Comparative Two-Level Random Intercept School Model (Level-2), Objective 3

Fixed Effect Variable label	0= Mumias Sub-County (*N*= 1068)		1= Kuria East Sub-County (*N*= 756)	
	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*
Sex of student (Ref: 1=Female)	-0.31 (0.03)	<.001	-0.30 (0.05)	<.001
Student's age in years	-0.11 (0.01)	<.001	-0.06 (0.02)	0.001
Student's years in current school	-0.02 (0.01)	0.001	-0.02 (0.01)	0.009
Number of times student spoke English in last 7 days	0.02 (0.01)	0.016	0.05 (0.01)	0.001
Student's Wealth Index (3 Tertiles): 1=High (Ref.)				
2=Middle	-0.08 (0.04)	0.043	0.01 (0.05)	0.818
3=Low	-0.21 (0.05)	<.001	-0.05 (0.06)	0.350
Number of siblings	-0.02 (0.01)	0.004	-0.01 (0.01)	0.359

(continued)

Table 4.34 Comparative Two-Level Random Intercept School Model (Level-2), Objective 3 (continued)

Fixed Effect Variable label	0= Mumias Sub-County (*N*= 1068)		1= Kuria East Sub-County (*N*= 756)	
	Est. (Std. Err.)	*p*	Est. (Std. Err.)	*p*
Looking after younger relatives: 1=Never (Ref.)				
2=Some days	-0.01 (0.04)	0.247	0.01 (0.06)	0.918
3=Most days	-0.05 (0.05)	0.375	-0.22 (0.08)	0.004
Looking after elderly relatives: 1=Never (Ref.)				
2=Some days	-0.05 (0.04)	0.171	-0.02 (0.05)	0.668
3=Most days	-0.09 (0.06)	0.098	-0.10 (0.07)	0.182
House cleaning				
2=Some days	0.12 (0.06)	0.046	0.07 (0.09)	0.436
3=Most days	0.23 (0.06)	<.001	0.13 (0.09)	0.157
Gardening/working in a vegetable garden: 1=Never (Ref.)				
2=Some days	0.07 (0.04)	0.107	0.10 (0.06)	0.088
3=Most days	-0.01 (0.05)	0.884	0.17 (0.070)	0.013
Number of times student has repeated classes	-0.11 (0.02)	<.001	-0.06 (0.03)	0.079
Student keeps negative company (standardized score)	-0.14 (0.04)	<.001	-0.31 (0.04)	<.001
School's boarding status at Class 8: 1=Day (Ref)				
2=Boarding	0.24 (0.23)	0.292	0.76 (0.45)	0.092
3=Day and boarding	0.35 (0.17)	0.046	0.58 (0.37)	0.118
Mean parental contribution 0-10 scale	0.05 (0.03)	0.041	0.06 (0.04)	0.142
Mean community school participation: 0-10 scale	0.06 (0.02)	0.003	0.03 (0.03)	0.348
Mean teacher years since first employment	-0.02 (0.01)	0.033	-0.02 (0.02)	0.165
Female Teacher	0.04 (0.01)	<.001	0.02 (0.03)	0.329
Graduate Teacher	0.08 (0.02)	<.001	0.08 (0.05)	0.140
Students disallowed from borrowing library books to take home	-0.13 (0.05)	0.013	-0.17 (0.08)	0.026
Intercept	1.72 (0.28)	<.001	0.15 (0.48)	0.746

Note. N= 1824; Est. = Estimate; Std. Err. = Standard Error (in parentheses)

In this comparative model, student sex and keeping of negative company were flagged as a predictors of student academic achievement in both Sub-Counties with the later having more adverse effects in Kuria East compared with Mumias. Looking after younger relatives most of the days was a predictor in Kuria East while the number of times a student had repeated classes was flagged as a predictor in Mumias but not in Kuria East. A day and boarding component at Class 8 had larger positive effects for

Mumias only. Disallowing students from borrowing school books and other materials for private study away from school was also flagged as a predictor of student academic achievement in both Sub-Counties.

4.6.5 Discussion of the Findings Under Objective 3.

In Objective 3, eight school-level characteristics were modelled as predictors of student academic achievement in the KCPE examination while controlling for student-level covariates. The results suggest a large statistically significant effect of these eight school-level predictors on student academic achievement in KCPE examination by accounting for 49.31% of the 63.67% variance explained by the two-levels and two models. However, given the ≥0.10 for flagging as predictors, only school location in the Sub-Counties (h16) with -0.79 (*SE*=0.09, *p*<.001); Boarding schools with 0.46 (*SE*=0.21, *p*=0.034); Day and boarding schools with 0.46 (*SE*=0.17, *p*=0.034); and students disallowed from borrowing library books to take home with -0.14 (*SE*=0.04, *p*=0.001) can be declared predictors of student academic achievement in the KCPE examination.

The positive effect of a boarding component at Class 8 a is probably indicative of the availability of more time that could be channelled to improving student academic outcomes since the students are at school throughout the length of the school term. While it is practically impossible to turn each school into boarding, or with a boarding component, day schools should probably maximally harness the time they have with the students without missing lessons or engaging students in non-core-curriculum activities during school time. Indeed in one of the day schools while collecting data, the researcher saw some select school girls being engaged in preparing teachers' break tea and lunch in a very smoky kitchen during class time. These day-scholars probably have little time to study when they go back to their homes and so better use of school time would probably be advantageous to them.

Curiously, Class 8 female teachers were predicted to have a statistically significant positive effect of up to 0.04 standard deviation units on student academic scores in KCPE examination above what would be the effect of their male colleagues. There is insufficient evidence in this dataset to suggest any claims as to whether female teachers are better at content delivery or student handling than their male counterparts. This is certainly an area for further research.

The results also suggest that a one year increase in a Class 8 teacher's mean years since employment had a negative effect on a student's academic score in the KCPE examination by up to -0.02 standard deviation units. It would be expected that with advances in age, teachers become more experienced and therefore better at delivery of the curriculum with better learning outcomes for students. But this is the opposite for this sample of teachers. It could probably be argued that as teachers advance in age, natural 'tear and ware' sets in and they probably get tired and bored at the routine curriculum delivery with each successive year. And they probably begin thinking more about their retirement than the mechanics of curriculum implementation and improving student learning outcomes. If this is plausible, then school administrators should probably make careful decisions on who should be allocated lessons in Class 8. By extension, the Teachers' Service Commission should probably consider reviewing downwards the teachers' retirement age. Currently, teachers retire after attaining 60 years up from 55 a couple of years ago. Older teachers appear to be less fruitful and could be involved in non-candidate classes and other areas of schooling outcomes. With an untrained teacher as the lowest cadre, a graduate teacher had a positive effect on a student's KCPE scores by up to 0.07 standard deviation units above the effect of an untrained teacher. It should however be noted that these cadres are largely promotional in the sense that while a teacher may enter service as a P1 (Primary 1), that teacher could end up as ATS as a function of service longevity or productivity measures. Never the less, higher cadre teachers on the professional scale were predicted to have more positive effect on student scores.

With FPE capitation, it is expected that schools would use part of the funds to purchase instructional materials including text books. But a policy brief from SACMEQ III data collected in 2007 involving 4,436 Standard 6 pupils in 193 primary schools in all eight regions in Kenya reported that one in every five pupils did not have all the three basic learning materials needed for effective participation in classroom activities. Further, at least four in every five pupils did not have sole use of mathematics textbooks and that most of the pupils without these mathematics textbooks were in public schools (Southern and Eastern Africa Consortium for Measuring Education Quality, 2011). The finding in this thesis is that students in schools disallowing their borrowing of school and library books to take them home for further reading scored up to -0.14 standard deviation units below what students in alternative schools scored. Purchasing and keeping such textbooks under lock and key only to be used within the school precincts may end up being counter-productive. In any case, newer editions of those textbooks will be published and those under lock and key in book stores will be rendered less helpful or outdated. Schools disallowing borrowing are probably keen on stemming book losses and tare and ware. But of what good will it be if neat books were locked away from constant student reach, denying them a chance for private study with the same to improve their knowledge acquisition?

These results support those of Hungi and Thuku (2010) who found that female students scored lower than their male counterparts in Maths and Reading and that school-level variables accounted for 18.9% of the total 34.2% variance explained by the three-level model in Maths and 27% of 41% in reading (see also Ejakait et. al., 2011). Hungi and Thuku (2010) also found that younger students achieved better scores compared with their older colleagues, a finding whose coefficient is statistically significant in this thesis. The negative effect of class repetition supports the finding of Hungi and Thuku as was the positive effect of speaking English outside the school precincts.

This results also support the findings of Legewie and DiPrete (2012) who used a quasi-experimental research design to estimate the gender difference in the causal effect of peer socioeconomic status as an important school resource on test scores using 4372 cases from the longitudinal German ELEMENT dataset for 4^{th} to 6^{th} graders within Berlin’s schools supplemented with the German PISA-I-Plus 2003 data. They found substantial variation in the gender gap in academic performance across schools and that this variation was related to average school performance (Legewie & DiPrete, 2012). They also found that boys were more sensitive to peer-SES composition as an important dimension of school quality related to the learning environment and that on average, boys did as well or better than girls in mathematics, and the male advantage was larger on the right tail of the distribution.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter presents a summary of the findings, conclusion, recommendations and suggestions for further research. The purpose of this study was to examine primary school-effects on student academic achievement using hierarchical linear models for analysis. The study set out to:

i) Examine the relationship between teacher-level variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties;

ii) Establish the relationship between non-teacher school-level resource inputs and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties;

iii) Determine the relationship between school-level characteristics and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties.

The corresponding null hypotheses were:

$H_0 1$: There is no statistically significant relationship between teacher-level variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties;

$H_0 2$: There is no statistically significant relationship between non-teacher school-level resource inputs and student academic achievement in the Kenya

Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties;

$H_0 3$: There is no statistically significant relationship between school-level characteristics and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties.

5.2 Summary of Findings

5.2.1 Objective 1: Examine the relationship between teacher-level variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties

Under the first objective, the study specified and fitted a three-level random slopes HLM with Students (Level-1) nested within Teachers (Level-2) who were in turn nested within Schools (Level-3) and modelled student academic achievement as a function of the three levels plus a random student-level error term.

Three teacher-level predictors were fitted in models 1 through 5 under Objective 1. These were Teacher's age in years (t22a), the number of in-service courses attended by teachers in their specific subject areas (t214) and the number of formal written tests in those specific subject areas (t227). The difference between Models 4 and 5 gave the net effect value of these three variables. The null hypothesis for Objective 1 stated that there was no statistically significant relationship between teacher-level variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties. Several tests for this hypothesis were done after fitting Model-5. First a post-estimation significance test using the Wald test of simple and composite linear hypotheses for each of the three variables returned significant results at 5% for two of the independent variables: t22a ($\chi^2(1) = 9.10, p = 0.003$) and t227 ($\chi^2(1) = 12.14, p < .001$). The test for t214 was not significant at 5%, ($\chi^2(1) = 3.79, p = 0.052$).

This test confirmed the observed effect of t22a and t227 on student academic achievement in the KCPE examination. Secondly, a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-4 (omitting the three teacher-level predictors) and Model-5 (including the three teacher-level predictors) was done. This was calculated as $LR = 2 * (-8695 - (-8707)) = 24$ and with 2 degrees of freedom at $\alpha = .05$, the critical value was 5.99. With χ^2=24, there was sufficient evidence suggesting that the three teacher-level independent variables in Model-5 made it a better model at fitting the hierarchical nature of the data than Model-4 where they were omitted. Thirdly, controlling for Level-1 and Level-3 covariates in Model-5, the proportion of variance explained by the three teacher-level predictors was 0.0105 (1.05%) as calculated in (4.18). A regression post estimation graph for quantiles of normal distribution (qnorm) showed that the standardized residuals were normally distributed.

With these pieces of evidence, there was sufficient evidence to reject the null hypothesis and conclude that two of the three teacher-level predictors (t22a and t227) indeed influenced student academic achievement in the KCPE examination. The researcher however argues that the three teacher variables may not be flagged as predictors of student academic achievement in the KCPE examination given that each had lower than the 0.10 cut-off for standardized regression coefficients discussed earlier.

5.2.2 Objective 2: Establish the relationship between non-teacher school-level resource inputs and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties

Under the second objective, the study specified and fitted a two-level random slopes HLM with Students (Level-1) nested within Schools (Level-2) and modelled student academic achievement as a function of the two levels plus a random student-level error term.

Three non-teacher school-level resource input variables were modelled as predictors of student academic achievement in the KCPE examination. These were: School has piped water (h31e); School has a typewriter (h31i); and School has a lunch-meal feeding programme (h32). A post-estimation significance test using the Wald test of simple and composite linear hypotheses of the three variables after fitting Model-4 returned statistically significant results for h31e, $(\chi^2(1) = 4.99, p = 0.025)$, and h32, $(\chi^2(1) = 5.06, p = 0.025)$. The effect of typewriter ownership (h31i) was not statistically significant $(\chi^2(1) = 3.30, p = 0.069)$.

Secondly, a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-2 (omitting the non-teacher school-level resource inputs) nested in Model-4 (final model with the non-teacher school-level resource inputs included) was done. This calculated as $LR = 2 * (-1519 - (-1540)) = 42$ and with 4 degrees of freedom at $\alpha = .05$, the critical value for a chi-square distribution was 9.49. With $\chi^2 = 42, p < .001$, there was sufficient evidence to suggest that the non-teacher school-level resource inputs had a statistically significant effect on student academic achievement in the KCPE examination at the 5% significance level.

Thirdly, adjusting for student-level covariates in Model-1 and other non-teacher school characteristics in Model-4, the three non-teacher school-level resource inputs accounted for 2.71% of the 51.07% of the explained variance by the two levels as calculated in equation (4.26). As already noted, lunch-meal programmes and piped water into schools surpassed the ≥0.10 threshold standardized regression coefficients with 0.30 (*SE*=0.13, *p*=0.025) and 0.25 (*SE*=0.11, *p*=0.025) respectively, thus being flagged as predictors of student academic achievement in KCPE. A regression post estimation graph for quantiles of normal distribution (qnorm) showed that the standardized residuals were normally distributed.

With these pieces of evidence, there was sufficient evidence to reject the null hypothesis. The conclusion was that controlling for student level covariates in Model-1 and other non-teacher school-level covariates in Model-4, two of the three non-teacher school-level resource inputs (h31e and h32) had statistically significant effect on student academic achievement in the KCPE examination.

5.2.3 Objective 3: Determine the relationship between school-level characteristics and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties

Under the third objective, the study specified and fitted a two-level random intercept HLM with Students (Level-1) nested within Schools (Level-2) and modelled student academic achievement as a function of the two levels plus a random student-level error term. The null hypothesis for Objective 3 stated that there was no statistically significant relationship between school characteristic variables and student academic achievement in the Kenya Certificate of Primary Education examination in Mumias and Kuria East Sub-Counties.

Eight school-level characteristics were modelled as predictors of student academic achievement in the KCPE examination. These were: Kuria East Sub-County (h16); School's boarding status at Class 8 (h24a); Mean parental contribution 0-10 scale (h218z); Mean community school participation: 0-10 scale (h227z); Mean teacher years since first employment (h49a); Female Teacher (h432); Graduate Teacher (h487); and Students disallowed from borrowing library books to take home (h5122).

Several tests for the hypothesis under Objective 3 were done. First a post-estimation significance test using the Wald test of simple and composite linear hypotheses for each of 8 predictors returned statistically significant results for each confirming their effect on students' academic achievement in the KCPE examination. The test for h16 returned $\chi^2(1) = 78.03, p < .001$ meaning that a chi-square test with one degree of freedom has a critical value of 3.84 at α .05 and with a calculated value of 78.08 which is way above this critical value of 3.84, the test is statistically significant at α .01 leading to a rejection of the null hypothesis of no effect from h16. Even if alpha were to be adjusted to .025, .01 or .001, the respective critical values would be 5.02, 6.63, and 10.83 respectively which are individually below the calculated value of 78.03. For boarding schools, the result was $\chi^2(1) = 4.51, p = 0.034$; for day and boarding schools, $\chi^2(1) = 7.43, p = 0.006$); for h218z $\chi^2(1) = 8.28, p = 0.004$; for h227 $\chi^2(1) = 6.14, p = 0.013$; for h49a $\chi^2(1) = 5.91, p = 0.015$; for h432 $\chi^2(1) = 20.27, p < .001$; for h487 $\chi^2(1) = 11.35, p = 0.001$ and for h5122 $\chi^2(1) = 10.58, p = 0.001$.

Secondly, a Likelihood Ratio test comparing the convergence iteration log likelihood values for Model-1 nested in Model-2 was calculated as $LR = 2 * (-1497 - (-1558\ )) = 122$. With 11 degrees of freedom at $\alpha = .05$, the critical value for a chi-square distribution was 19.68. With $\chi^2 = 122, p < .001$, there was sufficient evidence to conclude that school characteristics had a statistically significant effect on student academic achievement in the KCPE examination.

Thirdly, adjusting for student-level covariates in Model-1, school-level characteristics in Model-2 accounted for 0.4931 (49.31%) of the variance available for explanation across the two models calculated as $(0.6367 - 0.1436) = 0.4931 * 100 = 49.31\%$. Three of the eight independent variables were flagged as predictors of student academic achievement in the KCPE examination for surpassing the 0.10 threshold for standardized regression coefficients as discussed earlier. These were: Kuria East Sub-County (h16); School's boarding status at Class 8 (h24a); and Students disallowed from borrowing library books to take home (h5122).

A regression post estimation graph for quantiles of normal distribution (qnorm) showed that the standardized residuals were normally distributed.

With these pieces of evidence, there was overwhelming and sufficient evidence to reject the null hypothesis. The conclusion is that adjusting for student level covariates in Model-1, the 8 school-level independent variables specified in Model-2 had a statistically significant effect on student academic achievement in the KCPE examination.

5.3 Conclusion

1. Fitting a random slopes three-level HLM with Students (Level-1) nested within Teachers (Level-2) who were in turn nested within Schools (Level-3), Two of the

three teacher predictors: Class 8 teacher's age in years and the number of formal written tests in the teachers’ subject areas were found to significantly affect student academic scores in the KCPE examination.

2. Fitting a two-level random intercept model with Students (Level-1) nested within Schools (Level-2), there was sufficient evidence to suggest that the two of the three non-teacher school-level input predictors: School has piped water and school has a lunch-meal feeding programme had statistically significant effect on student academic scores in the KCPE examination.
3. Estimating a two-level random intercept model with Students (Level-1) nested within Schools (Level-2), there was sufficient evidence to suggest that the eight school-level characteristics predictors modelled in Objective 3 had statistically significant effect on student academic subjects’ scores in the KCPE examination. These were: Kuria East Sub-County (h16); School's boarding status at Class 8 (h24a); Mean parental contribution 0-10 scale (h218z); Mean community school participation: 0-10 scale (h227z); Mean teacher years since first employment (h49a); Female Teacher (h432); Graduate Teacher (h487); and Students disallowed from borrowing library books to take home (h5122).

5.4 Recommendations

From the findings, the following recommendations are suggested

1. Objective 1
    1.1. That school administrators should probably make careful decisions on who should be allocated lessons in Class 8. The results from this study are robust enough and suggest that a one-year increase in a Class 8 teacher’s age has a negative effect on a student’s academic scores in the KCPE examination.

Consequently, the Teachers' Service Commission should probably consider reviewing downwards the teachers' retirement age. Currently, teachers retire after attaining 60 years up from 55 a couple of years ago. Older teachers appear to be less fruitful and could be involved in non-candidate classes and other areas of schooling outcome.

1.2. Exposure of candidates to many varied test items was also found to have a statistically significant effect on student academic achievement in the KCPE examination. It is therefore recommended that coverage of syllabus content be carefully tempered with a productive testing regime for sufficient exposure of the candidates to final examination-like items. For instance, a student who has written several English compositions and has had them marked, revision done and guidance given, is more likely to score highly in the final KCPE English composition examination than one who has never written any test before sitting that same KCPE final examination.

2. Objective 2

2.1. Electricity was significantly associated with enhancing student academic achievement. It is crucial for supporting students who wish to use early morning and evenings for further study for day schools and certainly crucial for boarding schools. It also supports other functions within the school such running computers, borehole pumps, and multimedia-aided learning among others. It is therefore recommended that the few primary schools remaining to be connected to the national are connected.

2.2. Piped water into the school was also significantly associated with enhancing student academic achievement. This is an area where most primary schools are in dire need. It is recommended that resources at Sub-County (Constituency) and County levels in the Mumias and Kuria East be specifically set aside for institutional water drilling or connection to main lines as appropriate.

3. Objective 3

    3.1. The effect of where the school is located was found to have an effect on student academic achievement. Schools and students in Kuria East Sub-County comparatively performed lower than those in Mumias Sub-County. It is recommended that education administrators and stakeholders in Kuria East Sub-County should study this thesis and pick out relevant variables of interest for adjustment in curriculum delivery as a starting point. Other variables outside this thesis should also be identified through stake-holder forums and necessary adjustments made in order to improve education standards in the sub-County.

    3.2. A boarding component at Class 8 was found to have a positive effects on student academic achievement in the KCPE examination. This probably boils down to availability of more time that could be channelled to improving student academic outcomes. While it is practically impossible to turn each school into boarding, day schools should probably harness maximally the time they have with the students without missing lessons or engaging students in non-core-curriculum activities. These day-scholars probably have little time to study when they go back to their homes and so better use of school time would probably be advantageous to them.

    3.3. Schools are also encouraged to allow students borrow school and library books to aid in their further study while at home. The results show that student scores were lower for schools that disallowed this borrowing of school books.

3.4. While class repetition has been disallowed and automatic class progression encouraged, the practice is still going on. If teachers and school administrators are asked whether there was repetition in their schools, they would probably deny. But when students are asked in the absence of the teachers or school administrators, they acknowledge that it is happening. This study collected repetition data from Class 8 students and those who had repeated classes, whether once, twice, thrice, or more were found to score lower than those who had never repeated at all. School administrators and teachers should therefore find innovative ways of helping slow learners other than asking them to repeat as the results suggest that this is not advantageous and productive after all. In fact, an extra one year a school beyond the normal number of years was predicted to have negative effects on student academic achievement in the KCPE examination.

3.5. Class 8 female teachers were predicted to have a more positive and statistically significant positive effect compared with their male counterparts. While this calls for further research, it is recommended that in the short term, school administrators need to consider the staffing of Class 8 with some caution.

4. Recommendations from student-level control variables

4.1. The gender gap in academic achievement is still large with female students scoring lower than their male colleagues. Strong girl-centred mentorship programmes involving female role models who have succeeded in academic-driven fields are recommended to help boost academic performance among female students. Similar programmes have worked in performing arts and music in Kenya and could probably help narrow the gap in education as well.

4.2. A large and growing body of literature (including this study) continues to show the linkages between the students' wealth status (index) and academic achievement. With students from the low wealth index tertile achieving lower than the upper two tertiles, lifting households and students in the lowest wealth tertile out of their status is a long-term undertaking often involving actions at local and macro level. But the results suggest that short term measures be considered. These could include identifying students in the lowest wealth tertile and making practical interventions aimed at boosting their academic scores. These actions can be at household level, school level, community level and could be escalated all the way to national level.

5.5 Suggestion for Further Research

For further research, it is suggested this study be replicated with a sufficient number of private schools (at least 20) to enable comparative hierarchical linear modelling between public and private primary schools. Even if all the private schools in the two Sub-counties were included in this study's sample, the 20 school-threshold would still not have been met to permit robust hierarchical linear modelling. This study has modelled the dichotomy between a top 5% performing Sub-County (Mumias) and that at the bottom 5% (Kuria East). A modelling of the private-public dichotomy would add value to knowledge, literature and debate on student academic achievement.

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APPENDICES

APPENDIX A. HEAD TEACHER QUESTIONNAIRE

MASENO UNIVERSITY
DEPARTMENT OF EDUCATION FOUNDATIONS AND MANAGEMENT
HEAD TEACHER/SCHOOL QUESTIONNIARE
THIS QUESTIONNAIRE SHOULD BE ADMINISTERED TO THE HEAD TEACHER OF THE SAMPLED SCHOOL

DIFFERENTIALS IN STUDENT ACADEMIC ACHIEVEMENT: A HIERARCHICAL LINEAR MODELLING OF PRIMARY SCHOOL EFFECTS IN MUMIAS AND KURIA EAST DISTRICT.

SECTION 1: BACKGROUND INFORMATION

1.1 QUESTIONNAIRE ID (e.g. 09 FOR QUESTIONNAIRE NUMBER 09) [ ][ ]

1.2 START TIME [24 CLOCK HH:MM:SS] [ ][ ][ ][ ][ ][ ]

1.3 DATE OF INTERVIEW (DD/MM/YYYY) [ ][ ][ ][ ][ ][ ][ ][ ]

1.4 FULL NAME OF SCHOOL ______________________________

1.5 CURRENT KENYA NATIONAL EXAMINATION INDEX FOR THE SCHOOL [ ][ ][ ][ ][ ][ ][ ][ ]

1.6 FI: IN WHICH DISTRICT IS THE SCHOOL LOCATED? 1=KURIA EAST; 2=MUMIAS [ ]

1.7 INTRODUCTION AND CONSENT

Good morning/afternoon/evening sir/madam. My name is Epari Ejakait. I am a postgraduate student at Maseno University carrying out research on the contribution of schools to student academic achievemnt in the KCPE examination. Your school was randomly sampled to participate in the study and I visit you today to seek your consent to collect data concerning teaching, learning, enrolment, staffing, infrastructure and management. These data are are for academic purposes only. If you you give consent for this interview, your responses will be held with utmost confidentiality and will only be available to members of the research team. The study will not cause any disadvantage to you, your teachers, your students or your school in general. If you accept that they participate in this research, you will be doing so professionally and voluntarily and there will not be any monetary returns. Any benefits of the research will largely be to contribute to research knowledge and evidence in order to improve policy and the teaching and learning processes in our schools. You are free to ask questions as we proceed and you are also at liberty not to respond to questions you do not feel comfortable answering. This interview will take about 30 minutes.

1.8 Would you like your school to participate in this study? 1=YES; 2=NO [ ]

[IF 1=YES, THANK THE RESPONDENT AND PROCEED TO SECTION 2.0]

1.9 Kindly let me know the reason why you would not wish to participate in this research [ ]

1=TOO BUSY/DO NOT HAVE TIME; 2=TIRED OF RESEARCH; 3=RESEARCH NOT BENEFICIAL;
4=NOT INTERESTED; 6=OTHER (specify) ______________________________

[CHECK 1.8: IF 2=NO, THANK THE RESPONDENT, AND SKIP TO SECTION 6.0]

SECTION 2: SCHOOL CHARACTERISTICS

2.1 What was the school's overall KCPE mean score in 2013? [INCLUDE DECIMALS IF APPLICABLE] [ ]

2.2 In 2013, what was the school's KCPE mean score in the following subjects

(A) ENGLISH [ ]
(B) KISWAHILI [ ]
(C) MATHEMATICS [ ]
(D) SCIENCE [ ]
(E) SOCIAL STUDIES AND RELIGION [ ]

2.3 Who is the **main** sponsor of your school? 11=GOVERNMENT (E.G. D.E.B); 12=RELIGIOUS ORGANISATION; [ ][ ]

13=PRIVATE INDIVIDUAL(S); 14=COMMUNITY; 15=PRIVATE ORGANISATION; 16=NGO/CBO
96=OTHER (specify) ______________________________

2.4 What is the date of this school's establishment? (DD/MM/YYYY) [ ][ ][ ][ ][ ][ ]

[ENTER 01 FOR DD AND 07 FOR MM RESPECTIVELY IF DATE AND MONTH ARE UNKNOWN]

2.5 The following are some problems that schools may have to deal with among students. On a scale of **0-10** where **0=NOT A PROBLEM AT ALL** and **10=A VERY SEVERE PROBLEM**, rate the severity of the following problems.

[WRITE 00 IF NOT A PROBLEM AT ALL]

- A PUPILS ARRIVING LATE AT SCHOOL
- B PUPIL ABSENTEEISM (i.e. UNREPORTED ABSENCE)
- C PUPILS SKIPPING CLASSES
- D PUPILS DROPPING OUT OF SCHOOL
- E NOISE MAKING AND DISTURBANCE IN CLASS BY PUPILS
- F CHEATING BY PUPILS
- G USE OF ABUSIVE LANGUAGE BY PUPILS
- H VANDALISM BY PUPILS
- I THEFT BY PUPILS
- J INTIMIDATION OR BULLYING OF PUPILS BY PUPILS
- K SEXUAL HARASSMENT OF PUPILS BY OTHER PUPILS
- L DRUG ABUSE BY PUPILS
- M ALCOHOL ABUSE OR POSSESSION BY PUPILS
- N FIGHTS AMONG PUPILS

2.6 The following are some problems that schools may have to deal with among teachers. On a scale of **0-10** where **0=NOT A PROBLEM AT ALL** and **10=A VERY SEVERE PROBLEM**, rate the severity of the following problems.

[WRITE 00 IF NOT A PROBLEM AT ALL]

- A TEACHERS ARIVING LATE AT SCHOOL
- B TEACHER ABSETEEISM (I.E. UNREPORTED ABSENCE)
- C TEACHERS SKIPPING CLASSES
- D INTIMIDATION OR BULLYING OF PUPILS BY TEACHERS
- F SEXUAL HARASSMENT OF PUPILS BY TEACHERS
- G USE OF ABUSIVE LANGUAGE BY TEACHERS
- H DRUG ABUSE BY TEACHERS
- I ALCOHOL ABUSE OR POSSESSION BY TEACHERS
- J INSUFFICIENT TESTING AND MARKING OF STUDENT WORK
- K POOR SYLLABUS COVERAGE

FI: CHECK 2.6B. IF 00, SKIP TO 2.8, OTHERWISE PROCEED WITH QUESTION 2.7

2.7 For whatever reason, how many teachers in total are absent from school today?

	(A) Female	**(B) Male**
1 TEACHERS EMPLOYED BY THE TSC		
2 TEACHERS EMPLOYED BY THE SCHOOL MANAGEMENT BOARD		

2.8 What do you think is the **MAIN** reason why teachers are absent?
11=DOMESTIC RESPONSIBILITIES; 12=LIVING FAR FROM THE SCHOOL;
13=PROBLEM WITH TRANSPORT; 14=ILLNESS; 15=UNION MEETINGS; 16=PAY RELATED;
17=TRAINING; 96=OTHER (specify) ____________________

2.9 What is the total enrolment of your school as of today?
A BOYS
B GIRLS

2.10 How many students are registered to sit for KCPE in your school later this year 2014?
A BOYS
B GIRLS

2.12 Can pupils borrow books from the school library to take away to their homes for homework and private study? [ ]
1=YES; 2=NO; 3=NO SCHOOL LIBRARY

2.13 How many toilets/latrines does your school have?
[FI: PLEASE WRITE THE NUMBER OF DOORS FOR EACH CATEGORY, IF ANSWER IS ZERO, WRITE '000']

		Flush Toilets	**Squat holes or pit hole**	**Other types of toilet/latrine**
A	BOYS			
B	GIRLS			
C	STAFF			

2.14 How many teachers in total do you have in this school employed by the Teachers Service Commission (TSC) including the head teacher?
A FEMALE [ ]
B MALE [ ]

2.15 How many teachers in total do you have in this school employed by the School Management Committee (School)?
[WRITE 00, IF THERE ARE NO SUCH TEACHERS]
A FEMALE [ ]
B MALE [ ]

2.16 How many teachers in your school attended any short course(s) on professional development last year 2013? [ ]
[IF 00, SKIP TO 2.16]

2.17 How many of the teachers who are teaching standard 8 this year 2014 attended any short course(s) on professional development in the **last one year (12 months)?** [ ]

2.18 Do parents and/or the community contribute to the school in any of the following ways? 1=YES; 2=NO

2.19 On a scale of **0-10** where **0=NO CONTRIBUTION AT ALL** and **10=A LOT OF CONTRIBUTION**, rate parenta and/ community contribution to the school in any of the following ways?
[WRITE 00 IF NO CONTRIBUTION AT ALL]

A BULDING OF SCHOOL FACILITIES SUCH AS CLASSROOMS, TEACHER HOUSES E.T.C [ ]
B MAINTENANCE OF SCHOOL FACILITIES SUCH AS CLASSROOMS, TEACHER HOUSES E.T.C [ ]
C CONSTRUCTION OR MAINTENANCE AND REPAIR OF FURNITURE, EQUIPMENT, E.T.C [ ]
D PURCHASE OF TEXTBOOKS [ ]
E PURCHASE OF STATIONARY [ ]
F PURCHASE OF OTHER SCHOOL SUPPLIES, MATERIALS AND OR EQUIPMENTS [ ]
G PAYMENT OF EXAMINATION FEES [ ]
H PAYMENT OF SALARIES FOR ADDITIONAL TEACHERS [ ]
I PAYMENT OF SALARIES FOR NON-TEACHING STAFF [ ]
J PAYMENT FOR EXTRA-CURRICULAR ACTIVITIES INCLUDING TRIPS [ ]
K PROVISION OF SCHOOL MEALS [ ]

2.20 How many times did a quality assuarance officer from the zonal/division/district or province visit your school last YEAR 2013? [ ]

2.21 What is the date of your first appointment as head teacher? (DD/MM/YYYY) D D M M Y Y Y Y

2.22 What is the date of your posting to this school as head teacher? (DD/MM/YYYY) D D M M Y Y Y Y

2.23 Some schools may have many streams at lower primary and fewer streams at upper primary. Overall for your school , how many streams do you have? [ ]

2.24 How many classrooms does your school have that are used for instruction/teaching in a typical school day? [ ]

2.25 As a Headteacher in this school, what would you say is the task on which you spend the **MOST** time?
11=DISCIPLINING LEARNERS; 12=LIAISING WITH PARENTS;
13=FINANCIAL MANAGEMENT (INCLUDING FUNDRAISING); 14=OVERSEEING TEACHING CURRICULUM;
15=COORDINATING SCHOOL BOARD, GOVERNING BODY;
16=ADMINISTRATION AND DEPARTMENTAL REPORTING; 17=SUPERVISING TEACHERS;
18=OFFICIAL MEETINGS; 96=OTHER (specify) ______

2.26 As a Headteacher in this school, what would you say is the task on which you spend the **LEAST** time?
11=DISCIPLINING LEARNERS; 12=LIAISING WITH PARENTS;
13=FINANCIAL MANAGEMENT (INCLUDING FUNDRAISING); 14=OVERSEEING TEACHING CURRICULUM;
15=COORDINATING SCHOOL BOARD, GOVERNING BODY;
16=ADMINISTRATION AND DEPARTMENTAL REPORTING; 17=SUPERVISING TEACHERS;
18=OFFICIAL MEETINGS; 96=OTHER (specify) ______

2.27 What do you think is the **MOST** pressing challenge you face in making this a good school?
11=DISCIPLINE; 12=LACK OF RESOURCES/FINANCES/POVERTY;
13=LACK OF PARENTAL/INVOLVEMENT; 14=BULLYING/FIGHTING; 15=SAFETY/SECURITY
16=TEACHER ABSENTEEISM; 17=LEARNER ABSENTEEISM; 18=LARGE CLASS SIZE;
19=INADEQUATE TEACHERS; 11=LEARNERS NOT DOING THEIR WORK;
12=TEACHERS NOT DOING JOBS/LACK OF GOOD TEACHING; 13=LANGUAGE;
14=LACK OF KNOWLEDGE/NO INTEREST; 15=NEW POLICIES/WORKLOAD/CANNOT COVER SYLLABUS;
16=LATENESS; 17=NO PROBLEM; 96=OTHER (specify) ______

2.28 On a scale of 0-10 where 0=VERY LITTLE OBSERVATION and 10=EXCELLENT OBSERVATION, rate your **overall** observation of the lessons in all subjects for the teachers who currently teach class 8

SECTION 3: NON-TEACHER RESOURCE INPUTS

3.1 Which of the following does your school have? 1=YES; 2=NO

A	SCHOOL LIBRARY	G	SCHOOL OWNED TELEPHONE
B	TEACHER /STAFF ROOM	H	SCHOOL GARDEN
C	STORE ROOM	I	TYPEWRITTER [Functional & used]
D	SPORTS AREA/FIELD	J	RADIO [Functional & used]
E	PIPED WATER/WATER TANK/BORE HOLE/SPRING	K	COMPUTER [Functional & used]
F	ELECTRICITY [connected]	L	FENCE/HEDGE AROUND SCH. BORDERS
M	SPORTS FIELD		

3.2 Does your school have a feeding programme, whether mid morning snack or a lunch meal? 1=YES; 2=NO
[IF 2=SKIP TO 3.5]

3.3 For the FIVE DAYS of the school week from **Monday to Friday**, indicate the number of days that this school feeding provided at your school 1=ONCE; 2=TWICE; 3=THRICE; 4=FOUR TIMES; 5=FIVE TIMES

3.4 Who pays for this feeding programme? 1=PARENTS; 2=GOVERNMENT; 3=WFP; 6=OTHER (SPECIFY)

3.5 Out of 100, about what percentage of learners in your school benefit from this school feeding?
[WRITE FOR EXAMPLE 040 FOR 40% AND 100 FOR 100%]

FOR PUBLIC SCHOOLS ONLY:
3.6 How much is the FPE capitation grant that the Ministry of Education gives to your school per pupil per year?
[GIVE THE AMOUNT IN KES, 0,000]

For last year 2013, how much (in KES) was a student in standard 8 required to pay for:
[WRITE 999 OR 9999 IF THE CHILD IS NOT REQUIRED TO PAY FOR THE ITEM AT THE SCHOOL]

Grade	Tuition	Construction Fund	Extra classes	Examination Fees	School meals	Other Items
Std 8						

3.7 **FOR PRIVATE SCHOOLS:** What is the annual total school fees levied per student in this school?
[GIVE IN KES, 000,000] Std 8

SECTION 4: TEACHER-RESOURCE INPUTS

4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8
LINE NUMBER	MAKE A LIST OF ALL THE TEACHERS WHO WERE AT THE SCHOOL BY THE END OF LAST YEAR 2013 BEFORE GOING TO QNS 4.3. BEGIN WITH THE HEAD TEACHER, DEUPTY, SENIOR TEACHER, THEN LIST THE REST OF THE TEACHERS EMPLOYED BY THE TSC AS WELL AS THOSE EMPLOYED BY THE SCHOOL. USE ADDITIONAL SHEETS OF PAGE 5-6 WHERE NECESSARY (TEACHERS ARE MORE THAN 10) AND ATTACH APPROPRIATELY	What is the sex of (NAME)? 1=FEMALE 2=MALE	What is the date of birth of (NAME)? RECORD THE ANSWER AS DD/MM/YYYY. IF DAY AND/OR MONTH ARE UNKNOWN, RECORD 01 AND 07 RESPECTIVELY IN THE CORRESPONDING BOXES. **D D M M Y Y Y Y**	What is (NAME'S) designation? 1=HEAD TEACHER 2=DH/ TEACHER 3=SENIOR TEACHER 4=TEACHER	Who is (NAME'S) employer? 1=TSC 2=SCHOOL	What is the highest level of education that (NAME) has completed/ attained? **USE CODE SHEET 4.7 (SEE BOTTOM)**	What is the highest level of professional training that (NAME) has completed/ attained? **USE CODE SHEET 4.8 (SEE BOTTOM)**
01							
02							
03							
04							
05							
06							

4.7 11=PRIMARY; 12=SECONDARY EDUCATION (FORM 2 KJSE); 13=SECONDARY EDUCATION (FORM 4 KCE/KCSE); 14=SECONDARY EDUCATION (FORM 6); 15=UNIVERSITY BACHELOR'S; 16=PGDE; 17=UNIVERSITY MASTER'S; 18=UNIVERSITY PhD; 96=OTHER (Specify)

4.8 11=UNTRAINED; 12=NACECE; 13=P2; 14=P1; 15=S1/DIPLOMA; 16=ATS; 17=GRADUATE; 18=SENIOR GRADUATE; 19=PRINCIPAL GRADUATE; 96=OTHER (Specify)

CONTINUATION OF SECTION 4 **HOUSEHOLD SCHEDULE (CONTINUED)**

	4.9	4.10	4.11	4.12	4.13	4.14
Line Number	What is the date of (NAME'S) first employment as a tecaher? RECORD THE ANSWER AS DD/MM/YYYY. IF DAY AND/OR MONTH ARE UNKNOWN, RECORD 01 AND 07 RESPECTIVELY IN THE CORRESPONDING BOXES. **D D M M Y Y Y Y**	What is the date of (NAME'S) first posting to this school? RECORD THE ANSWER AS DD/MM/YYYY. IF DAY AND/OR MONTH ARE UNKNOWN, RECORD 01 AND 07 RESPECTIVELY IN THE CORRESPONDING BOXES. **D D M M Y Y Y Y**	Is (NAME) currently teaching class 8 in 2014? 1=YES 2=NO **[IF 2, SKIP TO SECTION 5]**	What subject is (NAME) teaching class 8 currently in 2014? 11=ENGLISH 12=KISWAHILI 13=MATHS 14=SCIENCE 15=SOCIAL STUDIES 16=RELIGIOUS EDUCATION	Has (NAME) been teaching class 8 this subject since 2014 began? 1=YES 2=NO **[IF 1, SKIP TO SECTION 5]**	For about how many months has (NAME) been teaching this subject in class 8 this year 2014? **[THERE ARE APPROXIMATELY 3 MONTHS PER TERM]**
01						
02						
03						
04						
05						
06						

4.15 WAS ADDITIONAL SHEET USED? 1=YES; 2=NO

SECTION 5: COMMENTS, INTERVIEW RATING AND WIND UP

5.1 RECORD COMMENTS ABOUT THE INTERVIEW ________________________________

____

____

____

____

____

5.2 RATE THE INTERVIEW 1=VERY BAD; 2=BAD; 3=AVERAGE; 4=GOOD; 5=VERY GOOD [ ]

5.3 RESULT OF INTERVIEW [ ]
1=COMPLETED; 2= NO COMPETENT RESPONDENT AT SCHOOL;
3=SCHOOL CLOSED FOR EXTENDED PERIOD; 4=SCHOOL UNKNOWN;
6=OTHER(Specify); ________________________ 7=REFUSED ACCESS

5.4 RECORD END TIME [24 CLOCK HH:MM:SS] [| | | | |]

5.5 RESEARCH ASSISTANT' NAME ________________________________

5.6 RESEARCH ASSISTANT'S CODE [|]

5.7 RESEARCHER'S NAME (SUPERVISOR) SIGNATURE: BERNARD AKHARUNDA ________________

5.8 RESEARCHER'S CODE: [E | E]

SECTION 6: DATA ENTRY MANAGEMENT

6.1 DATA ENTRY CLERK'S NAME ________________________________

6.2 DATA ENTRY CLERK'S CODE [|]

6.3 RESEARCHER'S NAME (SUPERVISOR) AND SIGNATURE: BERNARD AKHARUNDA ________________

6.4 RESEARCHER'S CODE: [E | E]

APPENDIX B. CLASS 8 TEACHER QUESTIONNAIRE

MASENO UNIVERSITY
DEPARTMENT OF EDUCATION FOUNDATIONS AND MANAGEMENT
TEACHER QUESTIONNIARE
THIS QUESTIONNAIRE SHOULD BE ADMINISTERED TO TEACHERS WHO ARE CURRENTLY TEACHING CLASS IN THE SAMPLED SCHOOLS

DIFFERENTIALS IN STUDENT ACADEMIC ACHIEVEMENT: A HIERARCHICAL LINEAR MODELLING OF PRIMARY SCHOOL EFFECTS IN MUMIAS AND KURIA EAST DISTRICT.

SECTION 1: BACKGROUND INFORMATION

1.1 QUESTIONNAIRE ID (e.g. 0009 FOR QUESTIONNAIRE NUMBER 9) ☐☐☐☐

1.2 START TIME [24 HOUR CLOCK HH:MM:SS] ☐☐☐☐☐☐

1.3 DATE OF INTERVIEW (DD/MM/YYYY) ☐☐☐☐☐☐☐☐

1.4 FULL NAME OF SCHOOL ________________________________

1.5 CURRENT KENYA NATIONAL EXAMINATION INDEX FOR THE SCHOOL ☐☐☐☐☐☐☐☐
FIRST 2 DIGITS=COUNTY (e.g KAKAMEGA); NEXT 3=DISTRICT (KHWISERO) AND NEXTT 3=SCHOOL

1.6 TEACHER'S NAME ________________________________

1.7 TEACHER ID [SCHOOL KNEC ID + TWO DIGITS FOR THE TEACHER] ☐☐☐☐☐☐☐☐☐☐
01=TEACHER OF ENGLISH; 02=KISWAHILI TEACHER; 03=MATHS TEACHER; 04=SCIENCE TEACHER; 05=SSR
IF SAY THE SCHOOL KNEC INDEX =37617201, THEN THE TEACHER OF ENGLISH WILL BE 3761720**01**
KISWAHILI=3761720**02;** MATHS=3761720**0**3; SCIENCE=3761720**04** AND SOCIAL STUDIES=3761720**05;**
RELIGIOUS EDUCATION =3761720**06**

1.8 IN WHICH DISTRICT IS THE SCHOOL LOCATED? 1=KURIA EAST; 2=MUMIAS ☐

1.9 INTRODUCTION AND CONSENT

Good morning/afternoon/evening sir/madam. My name is Epari Ejakait. I am a postgraduate student at Maseno University carrying out research on the contribution of schools to student academic achievemnt in the KCPE examination. Your school was randomly sampled to participate in the study and I visit you today to seek your consent to collect data because you are one of the teachers currently teaching standard 8 in 2014. I seek data on curriculum implementation as well as your professional and academic achievements. The data will be used for academic purposes only. Your responses will be held with utmost confidentiality and will only be available to me. Summary statistics will be used and no names of schools or respondents will be made known. The study will not cause any disadvantage to you, or your school. If you accept to participate in this research, you will be doing so professionally and voluntarily and there will not be any monetary returns. Any benefits of the research will largely be to contribute to research knowledge and evidence in order to improve policy and the teaching and learning processes in our schools. You are free to ask questions as we proceed and you are also at liberty not to respond to questions you do not feel comfortable answering. This interview will take about 30 minutes.

1.10 Would you like your school to participate in this study? 1=YES; 2=NO ☐

[IF 1=YES, THANK THE RESPONDENT AND PROCEED TO SECTION 2.0]

1.11 Kindly let me know the reason why you would not wish to participate in this research ☐
1=TOO BUSY/DO NOT HAVE TIME; 2=TIRED OF RESEARCH; 3=RESEARCH NOT BENEFICIAL;
4=NOT INTERESTED; 6=OTHER (specify) ________________
[CHECK 1.10: IF 2=NO, THANK THE RESPONDENT, AND SKIP TO SECTION 6.0]

SECTION 2: SOME QUESTIONS ABOUT YOUR ACDEMIC AND PROFESSIONAL TRAINING

FI:CHECK 1.6. (TEACHER;S NAME): IF THIS TEACHER IS LISTED IN THE HEAD TEACHER QUESTIONNAIRE SECTION 4 THEN CHECK AND TRANSFER THE DATA TO THIS FORM AS APPROPRIATE

2.1 **CHECK 4.3** AND INDICATE SEX OF TEACHER 1=FEMALE; 2=MALE ☐

2.2 **CHECK 4.4:** CONFIRM AND INDICATE TEACHER'S DATE OF BIRTH D D M M Y Y Y Y ☐☐☐☐☐☐☐☐
[IF DAY AND/OR MONTH ARE UNKNOWN, RECORD 01 AND 07 RESPECTIVELY IN THE CORRESPONDING BOXES]

2.3 **CHECK 4.6:** CONFIRM AND INDICATE THE TEACHER'S EMPLOYER
1=TEACHERS SERVICE COMMISSION; 2=SCHOOL ☐

2.4 **CHECK 4.7:** CONFIRM AND INDICATE HIGHEST LEVEL OF FORMAL EDUCATION THE TEACHER HAS COMPLETED/ATTAINED

11=PRIMARY; 12=SECONDARY EDUCATION (FORM 2 KJSE);
13=SECONDARY EDUCATION (FORM 4 KCE/KCSE); 14=SECONDARY EDUCATION (FORM 6);
15=UNIVERSITY BACHELOR'S; 16=PGDE; 17=UNIVERSITY MASTER'S; 18=UNIVERSITY PhD;
96=OTHER (Specify) ______

2.5 **CHECK 4.8:** CONFIRM AND INDICATE THE TEACHER'S HIGHEST PROFESSIONAL TRAINING COMPLETED/ATTAINED

11=UNTRAINED; 12=NACECE; 13=P3; 14=P2; 15=P1; 16=S1/DIPLOMA; 17=ATS;
18=GRADUATE; 96=OTHER (Specify) ______

2.6 **CHECK 4.9:** CONFIRM AND INDICATE THE TEACHER'S FIRST DATE OF EMPLOYMENT
[IF DAY AND/OR MONTH ARE UNKNOWN, RECORD 01 AND 07 RESPECTIVELY IN THE CORRESPONDING BOXES] D D M M Y Y Y Y

2.7 **CHECK 4.10:** CONFIRM AND INDICATE THE THE TEACHER'S FIRST DATE OF POSTING TO THIS SCHOOL
[IF DAY AND/OR MONTH ARE UNKNOWN, RECORD 01 AND 07 RESPECTIVELY IN THE CORRESPONDING BOXES] D D M M Y Y Y Y

2.8 **CHECK 4.12:** CONFIRM AND INDICATE THE SUBJECT THAT THE TEACHER IS CURRENTLY TEACHING IN CLASS 8 IN 2014

11=ENGLISH; 12=KISWAHILI; 13=MATHS; 14=SCIENCE; 15=SOCIAL STUDIES;
16=RELIGIOUS EDUCATION

2.9 **CHECK 4.13:** CONFIRM AND INDICATE WHETHER TEACHER HAS BEEN TEACHING CLASS 8 SINCE THE BEGINNING OF THE YEAR 2014 1=YES; 2=NO

2.10 **CHECK 4.14:** CONFIRM AND INDICATE THE NUMBER OF MONTHS THAT THE TEACHER HAS TAUGHT THIS SUBJECT IN CLASS 8 SO FAR IN 2014

2.11 How many years of **professional teacher training** have you received altogether?

2.12 How many years of formal education acquisition have you received all together, i.e. **primary+secondary+ college+and/or university**
[INCLUDE YEARS FOR WHICH YOU REPEATED ANY CLASS, IF ANY e.g. IN THE 8.4.4. SYSTEM, IF YOU REPEATED ONE CLASS IN PRIMARY SCHOOL, THEN YOUR TOTAL YEARS WOULD BE 9]

2.13 On a scale of 1-10 where 1=VERY INADEQUATE and 10=VERY ADEQUATE, rate your adequacy and preparation in teaching (NAME OF SUBJECT IN 2.8) curriculum in class 8?

2.14 For the whole of last year 2013, how many **in-service** teacher training short courses did you attend that were specific to (SUBJECT NAMED IN 2.8)? [FI: WRITE e.g. 04 FOR 4, 00 FOR 0 etc.]

2.15 How many days altogether did you attend this **in-service?**

2.16 How many **complete years** have you been teaching (SUBJECT NAMED IN 2.8)?

2.17 How many streams of class 8 do you teach (SUBJECT NAMED IN 2.8)
1=ONE; 2=TWO; 3=THREE; 4=MORE THAN THREE

2.18 In total, how many lessons of (SUBJECT NAMED IN 2.8) do you teach in class 8 in a week?

2.19 About how many times has the school Head teacher attended your class 8 to see you teach (SUBJECT NAMED IN 2.8) since the year 2014 began? **[WRITE 00 IF THIS HAS NOT HAPPENED]**

2.20 About how many times has the Deputy Head Teacher/HOD/Senior teacher/ in this school attended your class 8 to see you teach (SUBJECT NAMED IN 2.8) since the year 2014 began?

2.21 How many times has a curriculum or subject advisor of (SUBJECT NAMED IN 2.8) from the Zonal/ Division/District or province visited you in your class 8 since this year 2014 began?
[IF 00=NEVER, SKIP TO 2.23]

2.22 Which of the following activities did the curriculum or subject advisor for (SUBJECT NAMED IN 2.8) undertake if s/he visited? 1=YES; 2=NO

A LOOKED AT LEARNERS WORK IN CLASS
B CHECKED MY FILES AND RECORDS
C DISCUSSED MY TEACHING AND AREAS OF IMPROVEMENT
D SUGGESTED ATTENDING A TRAINING SESSION
E EXPLAINED CURRICULUM CONTENTS
F RECOMMENDED NEW TEACHING MATERIALS OR METHODS
G GAVE ME NEW MATERIALS AND TEXTBOOKS
H OTHER(SPECIFY)____________________

2.23 Do you frequently face the following problems in your class 8 as you teach (SUBJECT NAMED IN 2.8)
[FI: READ OUT THE OPTIONS ONE AT A TIME AND CODE APPROPRIATELY] 1=YES; 2=NO

A PUPIL INDISCIPLINE
B LACK OF TEACHING AND LEARNING MATERIALS
C LACK OF PARENTAL/ FAMILY INVOLVEMENT
D LEARNER ABSENTEEISM
E CLASS SIZE IS TOO BIG
F LEARNERS NOT DOING THEIR WORK
G LANGUAGE PROBLEMS
H LACK OF INTERESTT BY PUPILS
I NEW POLICIES/WORK LOAD/CANNOT COVER THE SYLLABUS

2.24 Is there an education resource center which serves your school? 1=YES; 2=NO

2.25 Have you visited the education resource center at any time since this year 2014 began? 1=YES; 2=NO
[IF 2, SKIP TO 2.27]

2.26 What reasons made you visit the education resource center? 1=YES, MENTIONED; 2=NOT MENTIONED
[FI: PROBE AND CODE APPROPRIATELY]

A BORROW TEACHING/LEARNING MATERIALS
B MAKE TEACHING/LEARNING MATERIALS
C ATTEND TRAINING COURSES
D EXCHANGE IDEAS WITH TEACHERS FROM OTHER SCHOOLS
E SEEK ADVICE FROM THE STAFF OF THE RESOURCE CENTER
F OTHER(SPECIFY)____________________

2.27 Excluding end of term examination, how many formal written tests have you given your class 8 students in (SUBJECT NAMED IN 2.8) since the year 2014 began?

2.28 How many approved pupil textbooks used for syllabus coverage do you have in (SUBJECT NAMED IN 2.8) for the class 8 that you currently teach in 2014?

2.29 The following are the Ministry of Education recommended text books from **the orange** book for the class 8 curriculum. Indicate the **MAIN TEXTBOOK** that you use for covering the class 8 syllabus for (SUBJECT NAMED IN 2.8)

11 ENGLISH **[INDICATE ONLY ONE MAIN TEXTBOOK USED]** 1-YES; 2=NO

A

B

C

D OTHER MAIN TEXTBOOK NOT LISTED IN THE ORANGE BOOK

12 KISWAHILI **[INDICATE ONLY ONE MAIN TEXTBOOK USED]** 1-YES; 2=NO

A

B

C

D OTHER MAIN TEXTBOOK NOT LISTED IN THE ORANGE BOOK

13 MATHS **[INDICATE ONLY ONE MAIN TEXTBOOK USED]** 1-YES; 2=NO

A

B

C

D OTHER MAIN TEXTBOOK NOT LISTED IN THE ORANGE BOOK

14 SCIENCE **[INDICATE ONLY ONE MAIN TEXTBOOK USED]** 1-YES; 2=NO

A

B

C

D OTHER MAIN TEXTBOOK NOT LISTED IN THE ORANGE BOOK

15 SOCIAL STUDIES **[INDICATE ONLY ONE MAIN TEXTBOOK USED]** 1-YES; 2=NO

A

B

C

D OTHER MAIN TEXTBOOK NOT LISTED IN THE ORANGE BOOK

16 RELIGIOUS EDUCATION **[INDICATE ONLY ONE MAIN TEXTBOOK USED]** 1-YES; 2=NO

A

B

C

D OTHER MAIN TEXTBOOK NOT LISTED IN THE ORANGE BOOK

2.30 What is the **textbook page** of the work that you covered in the last lesson in class 8 in your subject before this interview?

2.31 Do you have additional books at student level to aid in your teaching of (SUBJECT NAMED IN 2.8) besides the approved textbooks? 1=YES; 2=NO

[IF 2, SKIP TO 2.33]

2.32 How many such books do you have?

2.33 What is the enrolment of the class 8 that you are currently teaching (SUBJECT NAMED IN 2.8)?

2.34 How many of the following do you have in your classroom or teaching area as you teach (SUBJECT NAMED IN 2.8)? **[FI: WRITE '00' IF NONE]**

A SITTING PLACES FOR PUPILS (ON CHAIRS OR ON BENCHES)

B WRITING PLACES FOR PUPILS (ON DESKS OR TABLES)

2.35 Which of the following are available in your classroom or teaching area? 1=YES, 2=NO

[FI: PROBE AND CODE APPROPRIATELY]

A A USABLE WRITING BOARD (BLACK, WHITE, GREEN)

B CHALK (OR OTHER MARKERS)

C A WALL CHART OF ANY KIND

D A CUPBOARD OR LOCKER

E ONE OR MORE BOOKSHELVES

F A CLASSROOM LIBRARY, BOOK CORNER OR BOOK BOX

G A TEACHER'S TABLE

H A TEACHER'S CHAIR

3.0 SOME QUESTIONS ABOUT YOUR PLACE OF ABODE/HOME

3.1 Which of the following things do you have **access** to in the place (home) where you stay **during the school week?** **1=YES; 2=NO**

[FI: READ OUT THE OPTIONS TO THE RESPONDENT. INCLUDE ITEMS CURRENTLY BROKEN BUT CAN BE REPAIRED]

A DAILY NEWSPAPER

B WEEKLY OR MONTHLY MAGAZINE

C RADIO

D TV SET

E VIDEO CASSETTE RECORDER (VCR)/DVD

F CD PLAYER

G TELEPHONE/MOBILE PHONE

H REFRIGERATOR/FREEZER

I CAR

J MOTORCYCLE

K BICYCLE

L PIPED WATER

M ELECTRICITY, GENERATOR, SOLAR

N TABLE TO WRITE ON

O TOILET IN THE HOUSE

3.2 Approximately how many of the following livestock do you own in the place where you stay **during the school week** [FI: PLEASE WRITE THE NUMBER IN THE BOXES FOR EACH ITEM e.g. 0012 FOR 12]

A Cattle
B Sheep
C Goats
D Donkeys
E Pigs
F Poultry

3.3 What is the **main source of lighting** by which you can read in the place (home) where you stay **during the school week?** 11=FIRE; 12=CANDLE; 13=PARAFFIN OR OIL LAMP; 14=GAS LAMP;
15=ELECTRIC LIGHTING, SOLAR, GENERATOR; 16=THERE IS NO LIGHTING
96=OTHER (Specify) ____________

SECTION 4: COMMENTS, INTERVIEW RATING AND WIND UP

4.1 RECORD COMMENTS ABOUT THE INTERVIEW ____________

4.2 RATE THE INTERVIEW 1=VERY BAD; 2=BAD; 3=AVERAGE; 4=GOOD; 5=VERY GOOD

4.3 RESULT OF INTERVIEW
1=COMPLETED; 2= NO COMPETENT RESPONDENT AT SCHOOL;
3=SCHOOL CLOSED FOR EXTENDED PERIOD; 4=SCHOOL UNKNOWN;
6=OTHER(Specify); ____________ 7=REFUSED ACCESS

4.4 RECORD END TIME [24 CLOCK HH:MM:SS]

4.5 NAME OF RESEARCH ASSISTANT ____________

4.6 RESEARCH ASSISTANT'S CODE

4.7 RESEARCHER'S NAME (SUPERVISOR) SIGNATURE: BERNARD AKHARUNDA ____________

4.8 RESEARCHER'S CODE: E E

SECTION 5: DATA ENTRY MANAGEMENT

5.1 DATA ENTRY CLERK'S NAME ____________

5.2 DATA ENTRY CLERK'S CODE

5.3 RESEARCHER'S NAME (SUPERVISOR) AND SIGNATURE: BERNARD AKHARUNDA ____________

5.4 RESEARCHER'S CODE: E E

APPENDIX C. CLASS 8 STUDENT QUESTIONNAIRE

MASENO UNIVERSITY
DEPARTMENT OF EDUCATION FOUNDATIONS AND MANAGEMENT
CLASS 8 STUDENT QUESTIONNAIRE
THIS QUESTIONNAIRE SHOULD BE ADMINISTERED TO THE RANDOMLY SAMPLED STD 8 STREAM IN THE SAMPLED SCHOOL

SECTION 1: BACKGROUND INFORMATION

1.1 QUESTIONNAIRE ID

1.2 START TIME (24 HR CLOCK; HH:MM:SS)

1.3 DATE OF INTERVIEW (DD/MM/YYYY)

1.4 FIELD INTERVIEWER'S (FI) CODE

1.5 FULL NAME OF PUPIL AS REGISTERED WITH KNEC ____________________

1.6 PUPIL'S KNEC INDEX NUMBER FOR 2014 KCPE

1.7 PUPIL'S SCORE IN KCPE **[MARKS TO BE EXTRACTED AFTER EXAM RESULTS ARE RELEASED]**

A ENGLISH
B KISWAHILI
C MATHEMATICS
D SCIENCE
E SOCIAL STUDIES & RELIGION (SSR)
F TOTAL

1.8 FULL NAME OF SCHOOL ____________________

1.9 CURRENT KNEC INDEX FOR THE SCHOOL

1.10 IN WHICH DISTRICT IS THE SCHOOL LOCATED? 1=KURIA EAST; 2=MUMIAS

1.11 INTRODUCTION AND CONSENT FROM HEAD TEACHER

HEAD TEACHER CONSENT

Good morning/afternoon/evening sir/madam. My name is Epari Ejakait. I am a postgraduate student at Maseno University carrying out research on the contribution of schools to student academic achievemnt in the KCPE examination. Your school was randomly sampled to participate in the study and I visit you today to seek your consent to collect data concerning teaching, learning, enrolment, staffing, infrastructure and management. These data are are for academic purposes only. Summary statistics will be used and no names of schools or respondents will be made known. I have the necessry research permints and letters of introduction from relevant offices (SHOW HEAD TEACHER THE DOCUMENTS) and now seek your permission to collect data from a sample of your class 8 pupils. The pupils will be guided in filling out the questionnaires.

The responses from the pupils will be held with utmost confidentiality and will only be available to me. Their responses will not cause any disadvantage to them, you or your school. If you accept that they participate in this research, you will be doing so professionally and voluntarily and there will not be any monetary returns. Any benefits of the research will be policy oriented intended to improve the teaching learning process. The pupils will be free to ask questions as we proceed. They may also refuse to respond to questions they do not feel comfortable answering. This interview will take about 30 minutes.

1.12 Would you like your class 8 students to participate in the study? 1=YES; 2=NO

[IF 1=YES, THANK REPONDENT AND PROCEED WITH INTERVIEW AT SECTION 2.0]

1.13 Kindly let me know the reason why you would not wish your class six pupils to participate in this research

1=TOO BUSY/DO NOT HAVE TIME; 2=TIRED OF RESEARCH; 3=RESEARCH NOT BENEFICIAL; 4=NOT INTERESTED; 6=OTHER (specify) ____________________

FI: FROM THIS SECTION FORWARD, GUIDE THE STUDENTS TO COMPLETE THE QUESTIONNAIRE

SECTION 2: SOME QUESTIONS ABOUT YOU THE STUDENT

2.1 Are you a boy or a girl? (WRITE 1 IF GIRL AND 2 IF BOY] 1=GIRL; 2=BOY

2.2 What is the date of your birth? (DD/MM/YYYY)

2.3 Which year did you join this school (excluding pre-primary)? DD/MM/YYYY

2.4 Did you attend pre-school (nursery school) before you joined Standard 1? 1=YES; 2=NO

2.5 Was this pre-school Government/Public or Private? 1=PUBLIC; 2=PRIVATE

2.6 Do you speak English outside school? 1=NEVER; 2=SOMETIMES; 3=ALL TIMES

2.7 In the last **one week** (7days), how many times did you read books, magazines or newspapers while at home or during your free time in boarding school?

SECTION 3: SOME QUESTIONS ABOUT THE PLACE WHERE YOU STAY DURING THE SCHOOL WEEK

3.1 Where do you stay during the school week?
11=IN MY BIOLOGICAL PARENTS' HOME; 12=IN MY LEGAL GUARDIANS' HOME;
13=WITH MY SIBLINGS; 14=WITH OTHER RELATIVES; 15=WITH UNRELATED FAMILY;
16=IN A BOARDING SCHOOL ACCOMODATION/HOSTEL;
17=SOMEWHERE BY MYSELF; 18=WITH OTHER AGEMATE CHILDREN;
96=OTHER(specify) ________

3.2 Is your biological **Mother** alive or has passed on (dead)? 1=ALIVE; 2=PASSED ON

3.3 What is the **Highest level** of education that your Mother has completed? **(or female guardian if mother is not there)**
11=DID NOT GO TO SCHOOL; 12=SOME PRIMARY EDUCATION;
13=COMPLETED PRIMARY EDUCATION; 14=SOME SECONDARY EDUCATION
15=COMPLETED SECONDARY EDUCATION;
16=COMPLETED SOME TRAINING AFTER SECONDARY EDUCATION (E.G. TEACHER TRAINING)
17=COMPLETED UNIVERSITY EDUCATION; 96=OTHER (specify) ________
98=I DON'T KNOW; 99=I DO NOT HAVE A MOTHER OR FEMALE GUARDIAN

3.4 Is your biological **Father** alive or has passed on (dead)? 1=ALIVE; 2=PASSED ON

3.5 What is the **Highest level** of education that your Father has completed? **(or male guardian if father is not there)**
11=DID NOT GO TO SCHOOL; 12=SOME PRIMARY EDUCATION;
13=COMPLETED PRIMARY EDUCATION; 14=SOME SECONDARY EDUCATION
15=COMPLETED SECONDARY EDUCATION;
16=COMPLETED SOME TRAINING AFTER SECONDARY EDUCATION (E.G. TEACHER TRAINING)
17=COMPLETED UNIVERSITY EDUCATION; 96=OTHER (specify) ________
98=I DON'T KNOW; 99=I DO NOT HAVE A FATHER OR MALE GUARDIAN

3.6 How many biological siblings (brothers and sisters) do you have?
[WRITE 00 IF YOU DO NOT HAVE]
A SISTERS
B BROTHERS

3.7 About how many books (including story books) are in the place where you stay during the school week (home or boarding school)? [WRITE 000 IF THERE ARE NO SUCH BOOKS]
[PRECEDE FIGURE WITH ZERO AS APPLICABLE]
[FI: GUIDE STUDENTS NOT TO COUNT NEWSPAPERS, MAGAZINES OR SCHOOL TEXT BOOKS]

3.8 What is the **main source of lighting** by which you can read in the place (home or boarding school) where you stay during the school week?
11=FIRE; 12=CANDLE; 13=PARAFFING OR OIL LAMP; 14=GAS LAMP;
15=ELECTRICITY, SOLAR, GENERATOR; 16=THERE IS NO LIGHTING

3.9 Which of the following things can be found in the place (home) where you stay **during the school week or holidays?** [FI: INCLUDE ALL ITEMS THAT ARE CURRENTLY BROKEN BUT THAT CAN BE REPAIRED] 1=YES; 2=NO

AA DAILY NEWSPAPER	☐	AQ ELECTRIC FAN	☐
AB WEEKLY OR MONTHLY MAGAZINE	☐	AR WASHING MACHINE	☐
AC CLOCK	☐	AS VACUUM CLEANER	☐
AD PIPED WATER	☐	AT COMPUTER/LAPTOP	☐
AE BORE HOLE	☐	AU INTERNET/MODEM	☐
AF TABLE TO WRITE ON	☐	AV RADIO	☐
AG BED	☐	AW TV SET	☐
AH PRIVATE STUDY AREA	☐	AX VIDEO TAPE/DISC PLAYER (VCR/DVD)	☐
AI BICYCLE	☐	AY AUDIO DISC PLAYER (CD)	☐
AJ DONKEY/HORSE CART	☐	ZZ AUDIO CASSETTE PLAYER	☐
AK CAR	☐	BA ORDINARY CAMERA FOR PHOTOS	☐
AL MOTORCYCLE	☐	BB DIGITAL CAMERA FOR PHOTOS	☐
AM TRACTOR	☐	BC VIDEO CAMERA	☐
AN ELECTRICITY, GENERATOR, SOLAR	☐	BD TELEPHONE/MOBILE PHONE	☐
A0 REFRIGERATOR/FREEZER	☐	BE TOILET IN THE HOUSE	☐
AP AIR CONDITIONER	☐		

3.10 Approximately how many of the following **livestock are owned by the household or place where you stay during the school week or during the holidays?** [PRECEDE FIGURE WITH ZERO AS APPLICABLE]

A	CATTLE	☐☐☐	E	PIGS	☐☐☐
B	SHEEP	☐☐☐	F	POULTRY	☐☐☐
C	GOATS	☐☐☐	G	CAMELS	☐☐☐
D	DONKEYS	☐☐☐	H	OTHER LIVESTOCK (specify) ______	☐☐☐

3.11 What is the **MAIN** make of the FLOOR of the **MAIN HOUSE** of the place that you call home and where you stay when not in school? ☐

[FI: EXPLAIN TO THE STUDENTS THE DIFFERENCE BETWEEN THE OPTIONS]

1=EARTH OR CLAY WITH OR WITHOUT COVERING; 2=CANVAS;
3=WOODEN PLANKS; 4=CEMENT; 5=CARPET/TILES (PLASTIC, CERAMIC OR WOODEN)
6=OTHER(specify) ______________________

3.12 What is the **MAIN** make of the **OUTSIDE WALLS** of the **MAIN HOUSE** of the place you call home and where you stay when not in school? ☐☐

[FI: EXPLAIN TO THE STUDENTS THE DIFFRENCES BETWEEN THE OPTIONS]

11=CARDBOARD/PLASTIC SHEETING/CANVAS; 12=REED/STICKS/GRASS THATCH
13=STONES/ MUDBRICKS; 14=METAL SHEETS/ ASBESTOS SHEETS;
15=WOOD (PLANKS OR TIMBER); 16=CUT STONE /CONCRETE BLOCKS/ BURNED BRICKS
96=OTHER (specify) ______________________

3.13 What is the **MAIN** make of the **ROOF** of the **MAIN HOUSE** of the place you call home and where you stay when not in school? ☐☐

[FI: EXPLAIN TO THE STUDENTS THE DIFFRENCES BETWEEN THE OPTIONS]

11=CARDBOARD/PLASTIC SHEETING/CANVAS; 12=GRASS THATCH AND MUD
13=IRON SHEETS/ ASBESTOS SHEETS; 14=CEMENT OR CONCRETE; 15=TILES
96=OTHER (specify) ______________________

3.14 How often do you do the following household tasks in the place you call home and where you stay during the school week? 1=NEVER; 2=SOME DAYS; 3=MOST DAYS

- A LOOKING AFTER YOUNGER RELATIVES
- B LOOKING AFTER ELDERLY RELATIVES
- C TAKING CARE OF SICK FAMILY MEMBERS AND RELATIVES
- D COOKING
- E HOUSE CLEANING
- F SWEEPING OUTSIDE THE HOUSE
- G WASHING AND IRONING CLOTHES
- H FETCHING WATER
- I CHOPPING FIRE WOOD
- J COLLECTING FIRE WOOD
- K SHOPPING
- L GARDENING/WORKING IN A VEGETABLE GARDEN
- M TAKING CARE OF LIVESTOCK
- N HELPING IN A FAMILY BUSINESS

SECTION 4: SOME QUESTIONS ABOUT YOUR HOMEWORK

4.1 Did any one in your home **frequently** read story books or books to you when you were young? 1=YES; 2=NO

4.2 In a typical school week from Monday to Friday, about how many times in the whole week do you have homework in the following subjects? [WRITE 0 IF YOU HAVE NO HOMEWORK]

A	ENGLISH	D	SCIENCE
B	KISWAHILI	E	SOCIAL STUDIES
C	MATHEMATICS	F	RELIGIOUS EDUCATION

4.3 Does anyone at home or in boarding school help you with your homework? 1=YES; 2=NO;

4.4 Who mostly helps you out with your homework in a typical school week (Monday to Friday?
1=FATHER/MALE GURDIAN; 2=MOTHER/FEMALE GUARDIAN; 3=SIBLING;
4=OTHER RELATIVE; 5=FELLOW STUDENTS IN BOARDING SCHOOL
6=OTHER (specify) ____________________

4.5 How many days does the person named in 4.4 help you with your homework in a typical school week?
1=ONE OF THE DAYS; 2=TWO OF THE DAYS; 3=THREE OF THE DAYS;
4=FOUR OF THE DAYS; 5=ALL THE FIVE DAYS INCLUDING WEEKENDS

4.3 For each of the following six subjects that you learn, indicate how often your teacher corrects your homework?
1=I DO NOT GET ANY HOMEWORK IN THE SUBJECT
2=MY TEACHER NEVER CORRECTS MY HOMEWORK IN THE SUBJECT
3=MY TEACHER SOMETIMES CORRECTS MY HOMEWORK IN THE SUBJECT
4=MY TEACHER CORRECTS MOST OF MY HOMEWORK IN THE SUBJECT
5=MY TEACHER ALWAYS CORRECTS MY HOMEWORK IN THE SUBJECT

A	ENGLISH	D	SCIENCE
B	KISWAHILI	E	SOCIAL STUDIES
C	MATHEMATICS	F	RELIGIOUS EDUCATION

SECTION 5: SOME QUESTIONS ABOUT YOUR SCHOOL

5.1 Now, think about last week from Monday to Friday. For the whole week, how many lessons did your class miss beacuase the subject teacher did not attend the lesson(s) in the following subjects?
[WRITE 0 IF YOUR CLASS DID NOT MISS ANY]

A	ENGLISH	D	SCIENCE
B	KISWAHILI	E	SOCIAL STUDIES
C	MATHEMATICS	F	RELIGIOUS EDUCATION

5.2 How often do learners hurt other learners in your school? 1=NEVER; 2=SOMETIMES; 3=OFTEN

5.3 How often do teachers hurt learners in your school? 1=NEVER; 2=SOMETIMES; 3=OFTEN

5.4 How often do outsiders hurt learners in your school? 1=NEVER; 2=SOMETIMES; 3=OFTEN

5.5 Now think about last term. Do you remember being absent at any time from school for a day so?
1-YES; 2=NO **[IF 2, SKIP TO 5.8]**

5.6 About how many days were you abent from school last term?

5.7 What was the **MAIN** reason for your absence?
1=I WAS ILL; 2=FAMILY REASONS (e.g. FUNERALS, WEDDINGS, ILLNESS etc); 3=I HAD TO WORK
4=BAD WEATHER OR FLOODS
5=I WAS NOT ALLOWED TO GO TO SCHOOL BECAUSE FEES WAS NOT PAID
6=OTHER REASONS (specify)

5.8 How many times have you repeated a grade since you started school in class one?
1=NEVER REPEATED; 2=ONCE; 3=TWICE; 4=THREE OR MORE TIMES **[IF 1, SKIP TO 5.10]**

5.9 **CIRCLE** the classes that you have ever repeated 1 2 3 4 5 6 7 8

5.10 Are you repeating standard 8 this year, 2014? 1=YES; 2=NO **[IF 2, SKIP TO 5.12]**

5.11 What was your total KCPE mark when you last sat for that exam?

5.12 Are you allowed to borrow library or school books and take them home with you?
1=YES; 2=NO; 9=THERE ARE NO LIBRARY BOOKS AT THE SCHOOL OR IN CLASS

5.13 What do you sit on in your classroom?
1=I SIT ON THE FLOOR; 2=I SIT ON A LOG, STONE, BOX, TIN etc;
3=I SIT ON A CHAIR, BENCH OR ON A SEAT AT A DESK
6=OTHER (specify) ____________

5.14 What writing place do you have in your classroom?
1=I HAVE NO SPECIAL PLACE TO WRITE
2=I WRITE ON THE CHAIR, BENCH, LOG, STONE, BOX OR TIN THAT I OTHERWISE SIT ON
3=I WRITE ON A DESK OR TABLE; 6=OTHER (specify) ____________

5.15 Since first term, have you taken any extra tuition outside school hours in the following subjects?
1=YES; 2=NO

A	ENGLISH	B	KISWAHILI	C	MATHEMATICS
D	SCIENCE	E	SOCIAL STUDIES	F	RELIGIOUS EDUCATION

SECTION 6: COMMENTS, INTERVIEW RATING AND WIND UP

6.1 RECORD COMMENTS ABOUT THE INTERVIEW ____________

6.2 RESEARCH ASSISTANT'S NAME AND CODE ____________

6.2 RECORD END TIME [FI: COMPLETE THIS ITEM] HH:MM:SS

6.3 RESEARCHER'S CODE **E** **E**

6.4 DATA ENTRY CLERK'S CODE

APPENDIX D. RESEARCH AUTHORIZATION AND PERMIT

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

NACOSTI/P/14/0177/2906

Date:

26th August, 2014

Epari Charles Ejakait
Maseno University
P.O. Private Bag
MASENO.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Differentials in student academic achievement: A hierarchical linear modelling of primary school effects in Mumias and Kuria East Districts,"*** I am pleased to inform you that you have been authorized to undertake research in **Kakamega and Migori Counties** for a period ending **31st August, 2015.**

You are advised to report to **the County Commissioners and the County Directors of Education, Kakamega and Migori Counties** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: SECRETARY/CEO

Copy to:

The County Commissioner
The County Director of Education
Kakamega County.

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

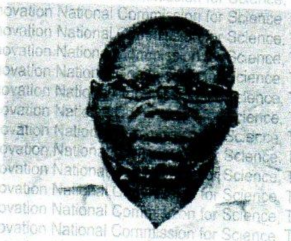
RESEARCH CLEARANCE PERMIT

Serial No. A 2992

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MR. EPARI CHARLES EJAKAIT
of MASENO UNIVERSITY, 0-80100 MOMBASA,has been permitted to conduct research in *Kakamega* , *Migori Counties*

Permit No : NACOSTI/P/14/0177/2906
Date Of Issue : 26th August,2014
Fee Recieved :Ksh 2,000



on the topic: *DIFFERENTIALS IN STUDENT ACADEMIC ACHIEVEMENT: A HIERARCHICAL LINEAR MODELLING OF PRIMARY SCHOOL EFFECTS IN MUMIAS AND KURIA EAST DISCTRICTS*

for the period ending:
31st August,2015

....
Applicant's Signature

....
for Secretary
National Commission for Science, Technology & Innovation