Why the Household Matters: The Correlation between Educational Assets and Math Score for Kenyan students

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Abstract

There has long been debate about the relative importance of resources at school versus at home for student learning outcomes. The 2015 Uwezo dataset [1], an East African assessment of child literacy and numeracy, offers unique and critical insight into the effects of family resources on important “gateway” skills for engineering and STEM study like numeracy by collecting data at the household level. Research around what educational researchers call “the Heyneman-Loxley effect” [2] has found that in lower income countries, school resources are more important than family resources for educational achievement. Further research has shown that family effects have increased in all countries and are still significant in their contributions to educational achievement. Thus, to contribute to this conversation on the importance of family versus school effects, this paper examines two aspects of the family effect: educational assets available at home and socioeconomic status. Previous findings for other datasets have shown that the availability of home resources (such as educational resources and physical assets) and household wealth correlated with higher academic achievement. However, the Uwezo assessment specifically collects data from households, not schools, allowing for the sampling of all youth ages 6-16 including out of school youth and recording the assets available to children in their home. Utilizing nested models to allow for comparison of the relative contribution of each set of variables, this study estimates four models analyzing the correlation of family education assets with student numeracy and then adding individual demographics, educational attainment, and socioeconomic status with each subsequent model. The first regression model showed that education assets were positively associated with increased likelihood of higher math scores. With the addition of other factors, the correlation of educational assets with math scores remained significant ($p < 0.05$). Individual demographic factors added in model 2 also remained significant throughout other models and supported previous research regarding the importance of these factors for predicting numeracy. Educational attainment ordinal variables were added in model 3, including school type and current enrollment status. Compared with students who were not attending school, those who attended public school were less likely to be numerate while those attending private school were more likely to be numerate. Students who completed their elementary education had a significantly higher likelihood of numeracy than students who had never enrolled in school. However, students still enrolled any grade of school were not significantly different from those students who had never enrolled which may be related to the low average grade of enrollment. Model four added an ordinal variable for

economic status with the likelihood of numeracy increasing for each subsequent level of SES when compared with the lowest value of SES. Overall, this analysis supports the significance of family effects (specifically family educational assets and household wealth), which remain significant with the addition of individual demographics and educational attainment. Household educational assets need to be examined further to understand what (if any) interventions could be implemented at the household level to benefit students. Further research should investigate how educational resources can be best utilized to strengthen student numeracy skills across the globe and examine how other types of family resources (nutritional, vocational, etc.) affect numeracy.

Objective

Within educational research, a lengthy debate analogous to the nature versus nurture discussion takes place around whether family life or school life is more impactful in relation to student's academic achievement. In the U.S., this debate was put forward by the Coleman Report, which stated that academic achievement was influenced the background and social context created by the home and neighborhood that cannot be separated from the influence of schooling [3]. Worldwide, the Heyneman-Loxley effect was proposed, that low-income countries show larger school effects than family effects on academic outcomes, hypothesized to be due to the high disparity of school resources between schools [1]. However, further research on more recent data shows the family effects for all nations are larger than previously reported [4]. Whichever effects are larger, researchers on the practical end of this debate are examining what factors within both school and family life are most influential to create interventions that help students towards their academic goals. This paper contributes to the engineering education field's understanding of this line of inquiry by examining the correlation between student mathematical test scores and household educational resources for Kenyan students examining the data using a multilevel approach to account for regional differences.

Literature Review

This study utilizes the 2015 Uwezo dataset, an East African assessment of child literacy and numeracy collecting critical insight on family assets and attainment at the household level [1]. The data collection accomplishes this by shifting the focus from enrollment rates and infrastructure to identifying actual learning levels of students [5]. Previous studies on this dataset have demonstrated home resource factors having large impacts in students' academic achievement such as the mother's education [6] and the parent's level of school completed [7]. Other additional factors such as household wealth have also been found to be correlated to higher academic achievement [6], just as Sumra et. al. [7] showed how the combination of factors related to education and location of the student (based on region) could predict the likelihood of student success [7].

Household educational assets are important to examine because they are directly linked to student educational success. For girls, wealth related household educational assets such as liquid assets and total net worth have a stronger correlation to their academic performance compared to their male colleagues [8], [9]. One household asset is the language spoken at home, as a substantial amount of instruction and many exams in Kenya are given in English [1], [10]. Students in Kenya learn both English and Swahili while in school, but outside of school, they have additional support in their mother tongue based on whatever language is spoken at home. Another key educational asset is the highest level of parent education in the household, as it directly and consistently shows a positive correlation to a child's academic achievement [11]. Physical assets

such as tv, radio, and computer access were accounted for in our aggregate educational asset variable, for they have proven to directly affect student educational outcomes [12].

As stated above, several other variables have been found to be significant within this dataset in relation to academic performance [6], [7]. Gender has been a persistent component of the education conversation, as connections found in gender-based studies have helped defined other ties to positive educational performance [13]. Total academic achievement plays a part in student ability to perform well in mathematical content [14]. Preschool attendance is an important variable to consider in mathematics, as previous large-scale studies have shown that students typically benefit from preschool attendance at around the 4th grade level, but not so much in other subjects [15]. School type attended, whether public or private, is significant as its impact varies across the world over different contexts [16].

Understanding the relationship between these various household educational assets, student demographics, schooling, SES, and students' numeracy has the potential to help us adapt and minimize the gaps present in current educational system. Specifically, this paper aims to answer the following research questions:

1. To what extent are educational assets correlated to student's numeracy?
2. To what extent are individual demographics, schooling, and social economic status (SES) correlated to student's numeracy?

Method/Approach

This paper performs a multilevel ordinal regression on the Uwezo dataset to determine if a correlation is present between math score and household educational assets. The Uwezo dataset was previously gathered through multi-stage sampling, including levels of district, enumeration area, household, and individual. All districts in Kenya were included in the dataset, and thirty enumeration areas were selected from each district based on probability proportion equal to size (PPS) [17]. Twenty households were selected in each enumeration area. The total number of students surveyed was 190,470.

Every N/20th household was selected, where N is the total number of households [18]. Data from each household were collected, and every child between the ages of 6-16 in the household completed a literacy and numeracy test. This paper will focus on the numeracy data collected, consisting of seven ordinal factor levels, including non-numerate, numbers, counting, addition, subtraction, multiplication, and division in that order. The tests were administered at the subtraction level (denoted as 5 in the data set), and students could only move up or down a singular level at a time. Additional data collected for each child included demographic information, in-school status, and preschool attendance.

Data for several individuals was incomplete or otherwise coded in a way that led to missing data. To account for this, several steps were taken to recode variables and impute data. First, all data for individuals under the age of six was eliminated, for they did not complete the numeracy test. Several variables such as grade and school type did not account for individuals who were not in school. A grade variable for those in school and a last grade completed variable for dropout students were combined into a single variable that reflected the last grade completed for all students. Additionally, those individuals who had never attended school were coded as a "-1" in grade. For school type, those who had never enrolled or dropped out were coded into a "'no school'" factor. Once this data cleaning had been completed, multiple imputation was implemented to deal with any remaining missingness [19].

The outcome variable, math score, was ordinal and thus ordinal regression was performed. The independent variable of interest, educational assets, was created as a combined scale score using various household assets including the parent's highest level of education, whether English was the home language, and noting which physical assets (tv, radio, computer) were present in the household. Additionally, clustered errors by enumeration area were chosen to account for regional differences. Clustering was not done at the household level as the small number of respondents in each household presents difficulties statistically. The variables included in the regression included the focal variable of educational assets and control variables related to SES, demographics such as age and last grade completed, and educational variables such as whether a student attended preschool and the kind of school they were currently attending (out of school, public, or private). This paper acknowledges that many household educational assets are directly tied to household wealth. By controlling for wealth in the final model, this paper will examine if these assets contribute on their own to student numeracy and inform further interventions to increase household educational assets for families with low SES.

Table 1. Kenya 2015 Descriptive Statistics

Summary Statistics	Min	Max	Mean	SD
Math Score	1	7	5.25	2.09
Educational Assets	0	5	1.23	0.91
Age	1	16	8.21	4.36
Gender (1-Male, 2-Female)	1	2	1.50	0.50
Last Grade Completed	-1	13	2.01	3.24
Preschool Attendance	1	2	1.10	0.30
School Type	1	3	1.68	0.62
School Enrollment	1	5	3.30	1.13
SES	1	5	3.01	1.41

From the descriptive statistics summary, the average score students received hovers around the Subtraction – Multiplication range (mean of 5.25). The data show that the majority of households had few household educational assets. The last grade completed having a somewhat low mean given the max grade emphasizes that many students may have never been enrolled in the first place, hence being coded as -1.

Results

Looking at the results collected in Table 2, the regression shows that educational assets are positively associated with increased likelihood of a higher math score. The second regression shows the addition of individual level variables and the third shows the addition of educational level variables. As individual variables were added into the regression, a positive correlation between educational assets and numeracy remains robust and displays only a slight upward bias, despite the significant predictive power of the controls. When educational variables were added to the regression, educational assets strengthened its positive relationship slightly. The other three individual variables changed slightly as well, with the age and grade variables having a positive increase in strength. Lastly, due to the regression being multilinear ordinal, a proper R^2 value could not be obtained. Therefore, pseudo R-squared values were obtained for each added level of regression by utilizing the nagelkerke package in r [20]. Our final model showed a notable amount of variance in numeracy explained (46%).

Table 2. Regression Analysis Showing Variable's Correlation to Numeracy

Outcome: Math Score	Model 1 Only Educational Assets	Model 2 Individual Control Variables	Model 3 Educational Attainment Variables	Model 4 Social Economic Status
Educational Assets	0.277 (0.0062)	0.271 (0.0065)	0.299 (0.0090)	0.180 (0.0129)
Age		-0.106 (0.0019)	0.285 (0.0032)	0.303 (0.0035
Gender (1-Male, 2-Female)		0.084 (0.0091)	0.145 (0.0121)	0.159 (0.0130)
Last Grade Completed		0.451 (0.0030)	0.529 (0.0043)	0.512 (0.0046)
Preschool			1.005 (0.0468)	0.868 (0.0506)
School Type: Public			-0.444 (0.0290)	-0.407 (0.0314)
School Type: Private			0.174 (0.0336)	0.213 (0.0359)

Dropout			-0.172 (0.0090)	-0.322 (0.0775)
Enrolled			1.760 (0.0708)	1.618 (0.0432)
Completed-Not Enrolled			2.846 (0.0388)	2.467 (0.2325)
Wealth Quartile 2				0.137 (0.0233)
Wealth Quartile 3				0.182 (0.0256)
Wealth Quartile 4				0.345 (0.0279)
Wealth Quartile 5				0.505 (0.0372)
Constant	0.308	0.348	1.161	1.08
Pseudo R-squared	0.313	0.454	0.215	0.460

Throughout the addition of important individual- and school-level controls, the independent variables of interest remained significant. Educational assets remained significant predictors of the student's test score, and other factors in the model also were important predictors of student outcomes, including individual variables such as gender, age, and last grade completed and educational variables such as the type of school attended or whether preschool was attended.

Discussion and Significance

From the data, we can tell that home educational assets play a role in student success within numeracy. While components under the created educational assets variable did prove significant, obtaining additional data beyond what is included in Uwezo on other educational assets such as available school supplies and other educational resources at the household level will allow for more understanding on what might benefit the students' development of numeracy, which serves as a gateway skill across engineering and STEM disciplines. As English as the language at home did remain significant, as supported by other studies [1], [10], programs supporting English language acquisition at home may also help improve numeracy scores. Likewise, another area where additional data could be collected is the amount of time each child spends with the household member with the highest level of education.

Re-visiting other tested variables, we saw that previous grade was significant for numeracy, which also aligns with prior studies [14]. The preschool variable was significant, as similar studies have reported when examining the impact of preschool education on student achievement [15]. The public versus private school impact debate

seems to follow statistical trends, as public schooling proved to show a strong negative correlation, while private schooling showed strong positive correlation to numeracy following previous studies highlighting each type of schooling in Kenya's educational system [10].

Overall, the results of this study show that educational resources in the home have a strong, positive, and consistent weight in determining student numeracy.

Implications

This paper adds to the ongoing research connecting student performance and family effects specifically focusing on numeracy. This analysis confirms that student demographics, school variables, and socioeconomic status impact student performance in ways similar to previous studies. Considering the debate between family and school effects, this paper contributes to the understanding of family effects through identifying one specific component of family effects: household educational assets. These household educational assets remain significant to student academic performance at all numeracy levels regardless of other controls. With this understanding, further research should investigate how these resources can be utilized and encouraged within the household to strengthen numeracy skills and how to best supplement or complement home household assets within the classroom. Additionally, future research should examine whether the effect of educational assets extends to other educational contexts focusing on numeracy across the globe.

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