# Exploring the Links Between Household Chores, Learning, and Mathematics Performance in Zambia

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## Declarations

**Conflicts of interest.** We have no known conflicts of interest to disclose.

**Ethical approval and consent.** This study was approved by the Human Subjects Committee of the Yale University Institutional Review Board (Protocol #0410000155). The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Written and signed informed consents were collected from all participants; informed consent for children's participation was received from their parents/caregivers.

**Author contributions.** All authors contributed to the study conception, design and writing of this manuscript. Original material preparation and data collection were performed by the Learning Disabilities Project Team led by Elena Grigorenko. Mathematics item coding for this study was carried out by David Bolden, Joe Pirozzolo and Mei Tan; data analyses were carried out by Joe Pirozzolo and Nan Li. The first draft of the manuscript was written by Mei Tan, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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**Abstract**

In Zambia, as well as many other African and non-Western cultures, the extent and kind of children's chores may contribute to their learning, yet often also conflict with their schooling. In the moderation analysis we present in this manuscript, we aimed to explore the interactive effects of schooling and chores on children's mathematics performance at different levels of math knowledge and computational skill, taking into account how the assessment questions were presented. The sample consisted of 1,535 children (719 girls) living in rural and peri-urban communities in Zambia who were administered the Zambia Achievement Test (ZAT). We categorized the 60 items of the ZAT by their targeted content knowledge, sizes of the numbers involved, and forms of representation. Our results showed that chores supported the development of very basic mathematics skills and knowledge in children who had less schooling, but also significantly lowered the performance of students who were in school once their school attendance rose above certain levels. Moreover, this interaction between chores and school attendance was observed predominantly in girls, with a lesser effect of chores on boys.

*Keywords*: informal labor, school attendance, mathematics, Zambia, sub-Saharan Africa

*Highlights:*

- In our sample of Zambian children, girls had higher levels of school attendance and carried out more chores.
- The amount of chores carried out by children moderates the relationship between their school attendance and mathematics performance.
- The moderating effect of chores on the relationship between their school attendance and mathematics performance varies by type of mathematics problem for boys and girls.

## Exploring the Links Between Household Chores, Learning, and Mathematics Performance in Zambia

It has been at least two decades since the effects of children's informal labor on their schooling came to the attention of international entities such as the World Bank; the situation of girls in sub-Saharan Africa has drawn particular attention (Fentiman et al., 1999; Odaga & Heneveld, 1995). These children are caught between cultural norms and expectations and family needs, and the imperative of education as a right to improve quality of life. This conflict may be mitigated somewhat by ascertaining what can be learnt by children outside of school, particularly in the domain of mathematics, in which skills and knowledge can be acquired to some extent in everyday activities (Carraher et al., 1985; Fentiman et al., 1999; Ginsburg et al., 1981b; Lave, 1988; Odaga & Heneveld, 1995). To explore this potential, working with a sample of youth recruited in rural and peri-urban parts of Eastern Province, Zambia, we examined the conditional effects of chores on the association between children's school attendance (a ratio of actual years of schooling over expected years of schooling) and the aggregated scores across different types of mathematics tasks. We hoped to better understand differences in the types of mathematical skills that children may develop when they have had more schooling versus less, and how mathematics learned in out-of-school activities, such as chores, may enhance or interfere with their learning in school. This inquiry adds to the existing body of work on children's acquisition of mathematics skills outside of school, but also contributes to the continuing conversation on the effect of informal labor, including chores, on children's academic progress in low resource settings. Understanding what children might gain from chores, as well as how chores may be detrimental to their academic development, should be considered in discussions of how families must balance children's work, play and schooling, and what forms of aid might help optimize this negotiation. Findings might also inform education policy-makers in low- and middle-income settings as they evaluate the factors underlying student academic achievement and set requirements and expectations for children's schooling.

Two relevant bodies of literature provide the basis for our inquiry and subsequent discussion: 1) children's natural acquisition of mathematical skills in out-of-school contexts, such as commerce and other daily chore or recreational activities; and 2) known gender differences in the assignment and effect of chores in sub-Saharan Africa. We also include information on what was known about chores and schooling in rural Eastern Province, Zambia around the time the data was collected from 2004-2005.

### Developing Mathematics Skills in Informal Settings

Several studies have examined the acquisition and mastery of mathematical operations and problem-solving strategies by adults and children in contexts outside of school, that is, in informal settings. We present a few examples here to illustrate how proficiency in mathematics may be gained without formal schooling.

Ginsburg and colleagues investigated the development of mental arithmetic strategies in unschooled Dioula adults in the Cote d'Ivoire (Ginsburg, 1997; Ginsburg et al., 1981a, 1981b). The Dioula are a Moslem ethnic group settled in several West African countries where their primary occupation historically has been commerce. Specifically, the researchers explored the mathematical strategies employed by schooled and unschooled Dioula children and adults and compared them to schooled Americans of comparable ages. They found that unschooled Dioula children did not perform as accurately as often as schooled Dioula and American children. For example, in a set of addition tasks, young unschooled Dioula children employed counting strategies on 21% of the problems and were correct only 59% of the time on average, versus schooled Dioula using counting strategies on 47% of addition problems getting 60% correct; American children used counting strategies 46% of the time with 81% accuracy. Yet once Dioula children reach adulthood, they were found to be just as accurate as those who attended school, using both memorized math facts and grouping strategies to solve problems (Ginsburg et al., 1981b).

Carraher, Carraher, and Schliemann (1985) similarly carried out informal and formal mathematical activities with five children in Recife, Brazil, ages 9–15 years old ($M = 11.2$), who had limited schooling. All were from very poor backgrounds and worked on street corners as vendors. Although four of the five children had received formal instruction on mathematical operations and word problems in school, in the course of their work as vendors all had to solve many math problems, usually without the aid of paper and pencil. The informal test activities included 63 "situations" in which the researcher posed as a customer. However, after an answer was reached for each item, the testers asked the child to explain his or her method for solving the problem. The formal test that followed, less than a week after the informal test, included 38 mathematical operation problems and 61 word problems based on the items successfully solved by the child during the informal test (i.e., either the same mathematical problem in a slightly different form, or the inverse of the question). It was established that context-embedded problems were much more easily solved than those without a context. In the informal test, the children solved 98.2% of the "situational" problems correctly. In the formal test, children correctly solved 73.7% of the items that provided some descriptive context. In contrast, only 36.8% of the items consisting of mathematical operations with no context were solved correctly. Children appeared to solve the more formally presented test items using school-learned methods (i.e., algorithmic procedures) and the informally presented items using strategies learned on the job. These studies illustrate how individuals may learn mathematics in different social contexts for learning (Reed & Lave, 1979), informal and formal, and how context may influence the different numerative systems and strategies developed for problem-solving. They also illustrate how being able to perform mathematics in one context does not necessarily enhance success in another.

**Chores and Gender in sub-Saharan Africa**

It has been observed that in many cultures, the types of chores assigned, the hours spent doing chores, as well as whether or not chores are carried out in addition to going to school differ between boys and girls. For example, in Madagascar, women and girls spend more time fetching water than do men and boys (Boone et al., 2011). This phenomenon has also been observed in a nationally collected Household Budget Survey ($n$ = 807,843) conducted in Kenya (Agesa & Agesa, 2019). In a Tanzanian case study including 57 households (mothers/female guardians) and 114 children, both mothers and children reported that more girls (aged 10–17) than boys of the same age engaged in collecting wood and fetching water, and that they spent more average hours than boys doing these necessary household tasks and that these hours often took place during the week (DeGraff et al., 2017). Gendered chore assignments are often culturally driven, as such social norms are perpetuated through the tradition of modeling and emulation in play and daily work; as one anthropologist noted, Maasai community members in southern Kenya would laugh if a boy carried firewood back home (Tian, 2019). There is also an economic aspect to such practices. In a study of the effects of unconditional cash transfers on households conducted in Lesotho, baseline data showed that boys in both primary and secondary school (ages 6–17) were much more likely to spend time engaging in crop and livestock (i.e., income-generating) activities than girls; they were also more likely to miss school and repeat grades. Girls, on the other hand, spent more time per day engaging in household chores than boys (Sebastian et al., 2016). Across low- and middle-income countries (LMIC) in general, girls are more likely than boys to work inside the home doing household chores, childcare, and elder care (Putnick & Bornstein, 2016; Webbink et al., 2012).

**Schooling, Chores and Gender in Zambia**

A broad literature has attested to the fact, almost unequivocally, that all forms of child labor, including housework, negatively affect children's school attendance and their ultimate level of academic attainment (Beegle et al., 2009; Heady, 2003; Webbink et al., 2012). In Zambia, the quality of schooling remains variable, as is children's ability to attend school regularly. According to the 2001-2002 Demographic Health Survey, the net primary school attendance rate in Zambia was 78% in urban areas, and 61% in rural areas (Central Statistical Office/Zambia et al., 2003); in 2007, attendance rates of 87% and 76% for urban and rural areas, respectively, were reported (Central Statistical Office/Zambia et al., 2009). In Eastern Province specifically, the attendance rate was 74%. In terms of sex and geographical location, in rural areas, 27% of females and 18% of males had no formal educational experience; in contrast, only 9% of females and 6% of males in urban areas had no formal educational experience. In the age group of 10–14 year-olds countrywide, 6% of children, including both males and females, had never attended school (Central Statistical Office/Zambia et al., 2009).

The reasons for missing school are partially economic. In times of financial difficulty, paying for school uniforms or school fees (particularly at the secondary level) is often prohibitive for families that are primarily subsistence farmers. A second set of reasons for missing or devoting less time to school, as described above, are likely cultural. In many countries around the world, children's participation in household activities is simply a given as part of the culture. This is the case in several regions of sub-Saharan Africa. Sporadic or infrequent school attendance may also be caused by difficulty in getting to school due to flooding (Zambia has a distinct rainy season) or long distances (Reich et al., 2013). Thus, among Zambian children in both urban and rural settings, one can expect to find children who attend school regularly, those who attend sporadically, and those who have never attended school at all.

## The Current Study

In this study, we aimed to examine the moderating effect of chores on the associations between school attendance and performance on different types of mathematics for boys and girls separately. We hypothesized that chores would strengthen the association between school attendance and mathematics performance on certain problem types: simple computations in addition and subtraction; items involving smaller numbers; and problems that mirror some of their everyday chores, presented as simple story problems and/or illustrated with familiar objects, such as mangoes and chickens. Conversely, we expected that chores would attenuate the association of school attendance with mathematics performance on other problems involving more academic information or procedures such as abstract symbols (e.g., equations), or concepts (e.g., numerical series).

# Methods

## Participants

The participants were part of a larger epidemiological survey study ($n$ = 1,665) focusing on learning disabilities, conducted in 2004–2005; the description of this larger sample is given in detail in Reich et al (2013). For the evaluation of mathematics performance, our analyses were restricted to the responses of 1,623 participants who completed the mathematics portion of the Zambian Achievement Test (Reich et al., 2013; Stemler et al., 2009). To evaluate the moderating effect of chores on the relationship between school attendance and mathematics performance by gender, our analyses were further restricted to the 1,535 participants (816 boys and 719 girls) for whom gender was reported.

**Assessments**

***Zambian Achievement Test (ZAT)***

The ZAT is an assessment developed by a research group at Yale University and colleagues at the University of Zambia (UNZA; Stemler et al., 2009). It is based on the curricula of Zambia and is designed to be administered individually to children in primary school. The version used in this study had four subtests, including Reading Recognition, Reading Comprehension, Pseudoword Reading, and Mathematics; the current study focused on the mathematics subtest only (ZAT-M).

The ZAT-M has 60 multiple-choice items that increase in difficulty and cover a variety of mathematical concepts such as number recognition, counting, arithmetic, geometry, and measurement (units and conversion). Each problem is presented both visually and read out loud. Given a multiple choice array of four answers, children point to their choice, which is then recorded by the test administrator. For example, an item presents four boxed quadrants; each contains four, five, one and three flowers, respectively. The administrator indicates the boxes and says, "Which box shows three flowers? Point to the picture of three flowers." In another item, 1 + 5 is presented, vertically arranged. The four answer choices below are 4, 6, 10, and 16. The administrator says, "What does one plus five equal? Find the answer to the problem down here [indicates the 4 boxed choices]. Point to it." All items are scored as correct (1) or incorrect (0). No partial credit is given and omitted items are coded as incorrect.

***Classification of Mathematics Questions***

We coded test items according to three characteristics: (1) content, (2) number size, and (3) form of representation used (see Table 1 for the coding scheme). Based on common content categories of mathematical knowledge (Martinez & Martinez, 2007), we categorized the 60 items into three basic content areas: early math knowledge, operations, and abstract mathematics. Early math knowledge included: (a) numeral matching, such as

"Point to number that matches the one at the top of the page"; (b) basic vocabulary, such as "biggest," "longest," "circle"; (c) numeral recognition—"Which number here is the number 8?"; number to quantity matching—"Which box shows three flowers?"; and counting. Operations included addition, subtraction, multiplication, and division. Abstract math included knowledge of clocks and calendar, geometry, measurement, number patterns, and part-whole concepts such as fractions and percentages. Based on the number size we generated two groups: simple numbers (numbers < 20; 17 items) and complex numbers (numbers ≥ 20, fractions and decimals; 32 items). Regarding form of representation, two groups of items were formulated: abstract/symbolic (31 items) and concrete (14 items) visuals. The item coding was carried out by the first, third and fourth authors independently. The raters' agreement was 80%, 85%, and 90% in terms of content, number size, and form of representation, respectively. The coding team discussed all discrepancies, and consensus was reached on the classifications for all items.

***Assessment of Chores***

Interviews with a sample of Zambian adults currently residing in the region of the study were carried out to ascertain a list of chores commonly carried out by children. We then assessed the number of chores by asking children the following questions: (1) What are your responsibilities at home? and (2) What are your responsibilities away from home? The response choices were: (a) serve food to elders; (b) look after children; (c) look after a sick person; (d) sell goods; and (e) prepare meals. As these chores require interpersonal communication, analytical ability, and academic skills (i.e., reading, mathematics), they were thought to be among the more complex chores in daily rural Zambian life. Caring for a sick person, for example, requires skilled social interactions, assessment of the level of sickness, and making decisions. Washing dishes, in contrast, generally requires only routine, repetitive actions. Children responded to each chore question with Yes (1) or No (0). The chore composites were obtained by summing the five item responses with higher scores indicating more complicated chores children involved.

***School Attendance***

To reflect the number of years a child had attended school with respect to the expected years of attendance based on their age (with expected attendance of grade 1 at age 7), we created a ratio composed of their actual years of schooling divided by the expected years of schooling. This ratio ranged from 0 to 1.

***Covariates***

We calculated the age for each child using the child's date of birth according to the Head of Household or wife. We determined the socioeconomic status (SES) of each household using items on the Home Environment

Survey (Reich et al., 2013) that reported household assets and amenities. Twelve indicators (vehicle, more than 50 cattle, a caregiver educated above secondary school level, a brick house, refrigerator, motorbike, stove, English spoken at home, television, meat eaten more than twice a month, a toilet, drinking clean water (i.e. tap or bottled) were weighted according to rankings by a sample of people living in the study area. We calculated the SES index as the fraction of a household's summed indicators over the total possible.

**Data Analysis**

Child performance on each type of mathematics question was first computed under the item response theory (IRT) framework. Under the classical test theory (CTT) framework, each respondent's observed score is typically the unweighted sum of the individual's responses to a test (De Ayala, 2013). IRT, in contrast, allows an examination of item performance (e.g., difficulty), taking item characteristics (e.g., difficulty) and response patterns into account while calculating the respondent's score. We used a two-parameter logistic IRT (2PL) model to calibrate the responses to each type of mathematics question. The estimated item parameters for the 2PL model included discrimination (i.e., slope) and difficulty (i.e., location). One important assumption for IRT is unidimensionality. To evaluate this assumption, we fitted the data for each type of mathematics question to an ordered-categorical confirmatory factor analysis (CFA) model, which was carried out with the lavaan package (Rosseel, 2012) in the R program (R Core Team, 2014). After establishing unidimensionality, the MIRT package (Chalmers, 2012) in the R program was employed to perform the IRT analyses. We screened the estimated item parameters and item characteristics curves (ICCs) to identify potential problematic items. Specifically, items with extreme values of discrimination (> +4 or < –4) and difficulty (> +4 or < –4) were excluded (Wirth & Edwards, 2007). Then, we re-evaluated the unidimensionality assumption with the remaining items, again using the ordered-categorical CFA for each type of mathematics question. The remaining items were re-calibrated, and the expected *a priori* (EAP) estimation was used to compute each respondent's mathematics score for each type of mathematics question. These scores were used for the following moderation analyses. Marginal reliability was presented for the evaluation of internal consistency of each type of mathematics question.

To evaluate the moderating effect of chores on the association between school attendance and mathematics performance in different types of mathematics questions, a series of multiple linear regressions were carried out with Mplus (Version 7.4; Muthén & Muthén, 1998-2015) for boys and girls separately. Specifically, scores for each type of mathematics question were regressed on chores, school attendance, and the interaction between chores and school attendance with age and SES as covariates. Given the appearance of missing data in the predictors (1%–9% for boys and 1%–8% for girls), we specified the variances of the predictors in the model to be estimated so that full information maximum likelihood (FIML) could be performed to handle the missing data. To follow-up a significant interaction, we utilized a percentile bootstrap confidence interval approach (BOOTSTRAP = 5,000 in Mplus) to test simple slopes (Liu et al., 2017). The 95% bootstrap confidence interval for the simple slope was evaluated to determine whether the simple slope was statistically different from 0. The following values for chores were selected to test the simple slope of mathematics scores with school attendance: 0, 1, 2, 3, 4, and 5.

## Results

### IRT Calibration of Mathematics Performance

Table 2 presents the number of items and the marginal reliability for each type of mathematics question after excluding items with extreme values on the item discrimination and difficulty parameters. Results showed that few problematic items were identified for each type of mathematics question. The model fit indices of the one-factor CFA model for each type of mathematics question after exclusion supported the unidimensionality assumption for IRT (see Table S1 for the model fit indices). After the exclusions, the marginal reliability was acceptable for all domains (0.64–0.80) except for abstract math (0.59). The relatively lower marginal reliability of abstract math may be a consequence of being represented by fewer items compared to other types of mathematics questions.

### Descriptive Statistics

Table 3 shows the gender differences for all predictors. Girls had higher levels of school attendance (0.43 versus 0.37) and carried out more chores (2.92 versus 2.42) than boys; boys were older than girls (11.86 versus 11.55). According to Cohen (1992), the effect sizes of gender differences in school attendance and chores were small and moderate, respectively. No gender differences were found for SES.

Table 4 presents the Pearson correlation coefficients between all studied variables for boys and girls. We found that the correlation coefficients between school attendance and mathematics scores and between chores and mathematics scores are comparable for boys and girls: the correlation coefficients between school attendance and mathematics scores ranged between 0.19–0.31 and 0.20–0.36 for boys and girls, respectively; and between chores and mathematics scores ranged between 0.09–0.18 and 0.10–0.18 for boys and girls, respectively.

### Moderation Analysis

The results for the multiple regressions testing chores as a moderator of the relationship between school attendance and mathematics scores are shown in Table 5. Controlling for age and SES, for boys, the interaction between school attendance and chores was significantly and complexly associated with one type of mathematics performance—early math; for girls, the interaction was significantly associated with four types of mathematics performance—early math, abstract math, simple numbers, and concrete visual. We followed these significant interactions with simple slope analyses (Aiken & West, 1991), which reflect the relationship between school attendance and mathematics scores at different levels of chores (0, 1, 2, 3, 4, 5). For boys, the association between school attendance and mathematics scores on early math was significantly positive when chores were equal to 0, 1, 2, and 3 (Figure 1). For girls, the association between school attendance and mathematics scores on early math was significantly positive when chores were equal to 0, 1, 2, 3, and 4; the same pattern of simple slopes were also observed for simple numbers and concrete visual items; the association between school attendance and mathematics scores on abstract math was significantly positive when chores were equal to 0, 1, 2, and 3 (Figure 2). For all plots, we specified age to the average (11.86 for boys and 11.55 for girls) and SES to the average (0.69 for boys and 0.78 for girls). Results suggested that chores weakened the association between school attendance and mathematics scores across several types of mathematics questions but to different degrees. The significant, unstandardized regression coefficients are presented in Table 6. Taking early math as an example, for girls, the magnitude of the association between school attendance and mathematics scores was stronger for girls who carried out fewer chores ($B = 1.42$ when chores = 0) than those who carried out more chores ($B = 0.78$ when chores = 4). For boys, the unstandardized regression coefficient was 1.00 when chores were equal to 0 and 0.48 when chores were equal to 3.

Additionally, the simple slopes representing the association between school attendance and mathematics scores intersected at certain levels of school attendance across different types of mathematics questions. In general, results indicated that girls with less chores tended to perform worse on early math, abstract math, simple numbers, and concrete visual questions than girls with more chores when school attendance was below a certain level, whereas girls with less chores tended to perform better on these types of mathematics problems than those with more chores when school attendance was above a certain level. For example, among girls aged 11.55 years living at an average SES, when school attendance was equal to 0, the expected scores on early math items were –0.59 for no chores and –0.26 for 1 chore type; when school attendance was equal to 0.4, the expected scores were –0.02 for no chores and –0.03 for 1 chore type; when school attendance was equal to 1, the expected scores were 0.83 for no chores and 0.30 for 1 chore type. Obviously, these estimated values are heterogeneous; their statistical significance cannot be computed and their meaning needs to be further explored. However, it is clear that the connection between chores and math skills is, at least in this sample, more complex than what has been previously reflected in the literature. For girls, the transition points of school attendance at which less chores resulted in poorer mathematics scores than more chores, and less chores resulted in better mathematics scores than more chores, were approximately at 0.40, 0.60, 0.35, and 0.40 for early math, abstract math, simple number, and concrete visual item types, respectively; for boys, the transition point for early math was around 0.50.

## Discussion

In this study, we examined the moderating effect of chores on the association between level of schooling and performance on different types of mathematics questions for boys and girls separately. Two points bear discussion here: First, in this rural African context, school attendance promotes mathematics learning, however, the magnitude of its effect varies regarding certain aspects of children's mathematics knowledge and application as a function of the chores that the children do; second, this occurs in a gendered fashion, where the moderating effect of chores is apparent across more math question types for girls than for boys. This may be because girls' and boys' chores are assigned differentially both by kind and in number, and may therefore present different math- and time-related demands. That is, while the benefits of informal learning environments for mathematics knowledge and skill development may be widely acknowledged, this is contingent upon specific contextual factors such as school attendance.

Regarding the first point, the results of this study illustrate that household chores that children are commonly assigned, even those not particularly intensively dealing with numbers (e.g., involving caregiving of a child or sick person, food preparation or serving as opposed to selling or precise measuring), can have a beneficial effect on children's basic mathematics knowledge and problem-solving skills. The acquisition of such mathematics knowledge and skills through everyday household activities has been documented (Brenner, 1998; Guberman, 2004). There is a trade-off exhibited in our data, however, such that as school attendance increases, children who do more chores than others tend to do more poorly on certain types of mathematics questions, even though they did better than those who did fewer chores with lower schooling. This trade-off effect, then, is exerted at different levels of school attendance depending upon the mathematics question type. For example, with regard to early math skills, working with numbers less than 20, and problems that are presented using recognizable illustrations, the dampening effects of chores become apparent for girls when their school attendance is above the average level, when age and

SES are average. When more advanced skills are required, such as measurement, the recognition of number patterns, and understanding of part-whole concepts, the weakening effect of chores is only observed after school attendance is above the average level. These topics may require more schooling for children with few chores to master; children who carry out chores on a regular basis may learn them earlier and benefit from them as other children with fewer chores catch up. This shift in effects, from beneficial to detrimental, may reflect the influence of several potential factors, as the relationship between children's informal labor and schooling is complex. For example, as the number of chore types increases (as reflected, for example, by our chore score), the intensity of these chores' demands on children's time and mental resources may not be linear, depending upon the complexity of the chores and how they are distributed throughout the day (Holgado et al., 2014). When a child takes on both home chores and schooling, according to a study of children's time allocation in Tanzania, what is often sacrificed is leisure or "free" time (Hedges et al., 2018). This may include time for study, sleep, or mental regeneration. Thus, both the time and mental demands of doing many chores may erase the benefits of what could be a learning experience when they are combined with schooling.

Regarding the second point of discussion, gender differences in the distribution and effects of chores on mathematics learning, our findings echo those found in other studies conducted in sub-Saharan Africa, which document girls' higher odds of enrollment in school (Hedges et al., 2018), as well as the more common occurrence of girls combining domestic chore activities with schooling (Hedges et al., 2018). Thus, girls exhibit both the positive and, when combined with expected or close to the expected years of schooling, negative effects of chores on their mathematics performance in four types of math items. Boys, who carry out significantly fewer chores and attend school less, appear to only benefit from chores on very basic math skills and knowledge. Overall, they benefit less but are also harmed less academically by the quantity of chores that they do; that is, chores have little effect on their mathematics learning on most types of mathematics questions. Our study illustrates the larger effect of doing many chores while attending school, and that this effect is experienced more by girls, likely because they have higher school attendance, but also tend to do more household chores than boys. Thus, it is most important to decrease girls' chores as they attend school more, to optimize their academic achievement. Such trade-offs are illustrated in the larger literature on forms of child labor in low- and middle-income countries, which probe in more detail the balance between children's work and schooling that many families negotiate and that influence their decision-making.

Weaknesses of our study include the operationalization of the chore score. First, most studies examining chores in sub-Saharan Africa include farming- and livestock-related activities, which boys commonly engage in. Our list of chores, based on the report of Zambian adults living in the study area, is likely abbreviated due to the adults' narrower than anticipated interpretation of the term "chore." The inclusion of agricultural and pastoral chores might have increased boys' chore scores significantly. In addition, respondents' report on the amount of time spent on chores, rather than just engagement in the activity, would have provided more information regarding the impact of chores. Also, school attendance was reported by parents and not obtained from school records, so may not be precise in all cases.

**Conclusion**

This work contributes to a larger literature currently addressing decision-making issues families and government policy-makers must consider regarding children's labor, which includes unpaid work within the household (i.e., chores), its benefits to learning and to the health of the household, and its potential negative effects on children's school enrollment and ultimate academic achievement, which could benefit the family in the long term (Putnick & Bornstein, 2016). In recent studies carried out in other regions of the world, children attending school and doing chores have exhibited mixed results in school achievement, with some studies reporting little to no effect of chores on achievement, such as in China (He, 2016), and others finding negative or mixed results (in Zambia, in Kakumbi et al., 2016; in South Africa, in Pillay, 2017). Across these and many other studies, such mixed results indicate what many researchers have pointed out: that chores are only part of a larger complex picture of household life that affect a child's academic progress (DeGraff et al., 2017; Sebastian et al., 2016).

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**Table 1**

*Item Coding Scheme*

| Categories | |
|---|---|
| Content | Early math knowledge (18 items) |
| | Basic vocabulary, |
| | Symbol recognition, counting |
| | Addition/subtraction (17 items) |
| | Multiplication/division (12 items) |
| | Abstract math (13 items) |
| | Clocks and calendars |
| | Geometry |
| | Measurement |
| | Algebra/patterns |
| | Part-whole concepts such as proportions and percent |
| Number & digit types | Simple numbers (17 items) |
| | Numbers <= 20 |
| | Complex numbers (32 items) |
| | 2-digit numbers > 20 |
| | 3-4-digit numbers |
| | Fractions and decimals |
| Representations | Abstract/symbolic (31 items) |
| | Numerals and equations only |
| | Concrete visual (14 items) |
| | Familiar pictures |

*Note.* Content was scored according to the highest content level required to solve the problem. Number & digit type was scored for the highest level presented.

**Table 2**

*Number of Items and Marginal Reliability for Each Type of Mathematics*

| | # of items | Reliability |
|---|---|---|
| Early math | 17 | 0.73 |
| Addition & subtraction | 16 | 0.74 |
| Multiplication & division | 11 | 0.64 |
| Abstract math | 10 | 0.59 |
| Simple numbers | 17 | 0.79 |
| Complex numbers | 28 | 0.77 |
| Abstract/symbolic | 29 | 0.80 |
| Concrete visual | 14 | 0.76 |

**Table 3**

*Gender Differences for All Predictors*

| | Boys | Girls | Statistics |
|---|---|---|---|
| Age | 11.86 (3.15) | 11.55 (2.89) | *t* (1514) = 1.97, *p* = 0.05, *Cohen's d* = 0.10 |
| SES | 0.69 (1.17) | 0.78 (1.21) | *t* (1533) = –1.54, *p* = 0.12, *Cohen's d* = –0.08 |
| School attendance | 0.37 (0.30) | 0.43 (0.30) | *t* (1419) = –-3.33, *p* = 0.00, *Cohen's d* = –0.17 |
| Chores | 2.22 (1.33) | 2.92 (1.32) | *t* (1402) = – 9.90, *p* = 0.00, *Cohen's d* = –0.53 |

**Table 4**

*Correlations Between All Studied Variables for Boys and Girls*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Age | 1.00 | -0.11 | 0.12 | 0.40 | 0.36 | 0.29 | 0.24 | 0.26 | 0.33 | 0.29 | 0.27 | 0.33 |
| 2. SES | -0.11 | 1.00 | 0.38 | -0.02 | 0.15 | 0.06 | 0.03 | 0.06 | 0.14 | 0.01 | 0.03 | 0.12 |
| 3. School attendance | 0.03 | 0.35 | 1.00 | 0.17 | 0.36 | 0.26 | 0.25 | 0.20 | 0.34 | 0.23 | 0.26 | 0.29 |
| 4. Chores | 0.30 | 0.04 | 0.09 | 1.00 | 0.18 | 0.12 | 0.10 | 0.16 | 0.14 | 0.16 | 0.13 | 0.15 |
| 5. Early math | 0.39 | 0.17 | 0.29 | 0.17 | 1.00 | 0.67 | 0.52 | 0.56 | 0.78 | 0.62 | 0.61 | 0.90 |
| 6. Addition & subtraction | 0.32 | 0.15 | 0.26 | 0.14 | 0.67 | 1.00 | 0.62 | 0.66 | 0.86 | 0.82 | 0.85 | 0.78 |
| 7. Multiplication & division | 0.26 | 0.07 | 0.19 | 0.10 | 0.49 | 0.62 | 1.00 | 0.59 | 0.75 | 0.70 | 0.82 | 0.61 |
| 8. Abstract math | 0.28 | 0.13 | 0.24 | 0.09 | 0.57 | 0.68 | 0.59 | 1.00 | 0.71 | 0.79 | 0.79 | 0.62 |
| 9. Simple numbers | 0.35 | 0.16 | 0.31 | 0.18 | 0.79 | 0.86 | 0.73 | 0.73 | 1.00 | 0.68 | 0.83 | 0.85 |
| 10. Complex numbers | 0.33 | 0.11 | 0.22 | 0.11 | 0.61 | 0.85 | 0.72 | 0.78 | 0.70 | 1.00 | 0.89 | 0.66 |
| 11. Abstract/symbolic | 0.31 | 0.11 | 0.26 | 0.12 | 0.61 | 0.87 | 0.81 | 0.79 | 0.84 | 0.90 | 1.00 | 0.64 |
| 12. Concrete visual | 0.33 | 0.16 | 0.26 | 0.15 | 0.91 | 0.77 | 0.58 | 0.63 | 0.85 | 0.66 | 0.65 | 1.00 |

*Note.* Correlation coefficients are statistically significant at 0.05 when the correlation coefficients are greater than 0.10. Correlation coefficients for boys were in the lower diagonal. Correlation coefficients for girls are in the upper diagonal.

**Table 5**

*Unstandardized Regression Coefficients for the Moderation Analyses*

| | Early math | Addition & subtraction | Multiplication & division | Abstract math | Simple numbers | Complex numbers | Abstract/ symbolic | Concrete visual |
|---|---|---|---|---|---|---|---|---|
| Boy | | | | | | | | |
| Age | 0.10*** | 0.09*** | 0.06*** | 0.07*** | 0.09*** | 0.09*** | 0.08*** | 0.09*** |
| SES | 0.09*** | 0.08** | 0.03 | 0.06* | 0.08** | 0.06* | 0.05 | 0.09*** |
| Attendance | 1.00*** | 0.82*** | 0.69*** | 0.58*** | 1.03*** | 0.69*** | 0.87*** | 0.85*** |
| Chores | 0.09* | 0.06 | 0.05 | 0.01 | 0.08* | 0.03 | 0.05 | 0.08 |
| Interaction | –0.17* | –0.10 | –0.12 | –0.04 | –0.13 | –0.09 | –0.10 | –0.13 |
| $R^2$ | 0.25 | 0.18 | 0.11 | 0.14 | 0.23 | 0.16 | 0.16 | 0.19 |
| Girl | | | | | | | | |
| Age | 0.10*** | 0.08*** | 0.06*** | 0.06*** | 0.09*** | 0.08*** | 0.07*** | 0.09*** |
| SES | 0.04 | 0.00 | -0.03 | 0.01 | 0.04 | –0.04 | –0.03 | 0.04 |
| Attendance | 1.42*** | 0.91*** | 0.74*** | 0.79*** | 1.42*** | 0.78*** | 0.89*** | 1.32*** |
| Chores | 0.08* | 0.02 | 0.00 | 0.09* | 0.07 | 0.04 | 0.02 | 0.09* |
| Interaction | –0.21*** | –0.10 | –0.04 | –0.15* | –0.22*** | –0.07 | –0.06 | –0.23*** |
| $R^2$ | 0.25 | 0.14 | 0.11 | 0.10 | 0.22 | 0.13 | 0.13 | 0.19 |

*Note*. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Interaction = Attendance*Chores.

**Table 6**

*Significant Simple Slopes for Boys and Girls*

| | Boys | | Girls | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Early math | | Early math | | Abstract math | | Simple numbers | | Concrete visual | |
| Chores | B | 95% CI | B | 95% CI | B | 95% CI | B | 95% CI | B | 95% CI |
| 0 | 1.00 | [0.70, 1.31] | 1.42 | [0.99, 1.89] | 0.79 | [0.38, 1.19] | 1.42 | [0.93, 1.92] | 1.32 | [0.86, 1.81] |
| 1 | 0.83 | [0.63, 1.03] | 1.20 | [0.88, 1.55] | 0.64 | [0.34, 0.94] | 1.21 | [0.85, 1.57] | 1.09 | [0.75, 1.45] |
| 2 | 0.65 | [0.48, 0.83] | 0.99 | [0.75, 1.24] | 0.49 | [0.27, 0.72] | 0.99 | [0.73, 1.26] | 0.85 | [0.60, 1.12] |
| 3 | 0.48 | [0.23, 0.75] | 0.78 | [0.55, 1.00] | 0.35 | [0.14, 0.57] | 0.78 | [0.53, 1.01] | 0.62 | [0.39, 0.86] |
| 4 | | | 0.56 | [0.27, 0.85] | | | 0.56 | [0.24, 0.76] | 0.39 | [0.08, 0.69] |

**Figure 1**

*Effect of School Attendance on Early Mathematics Scores at Different Levels of Chores for Boys*

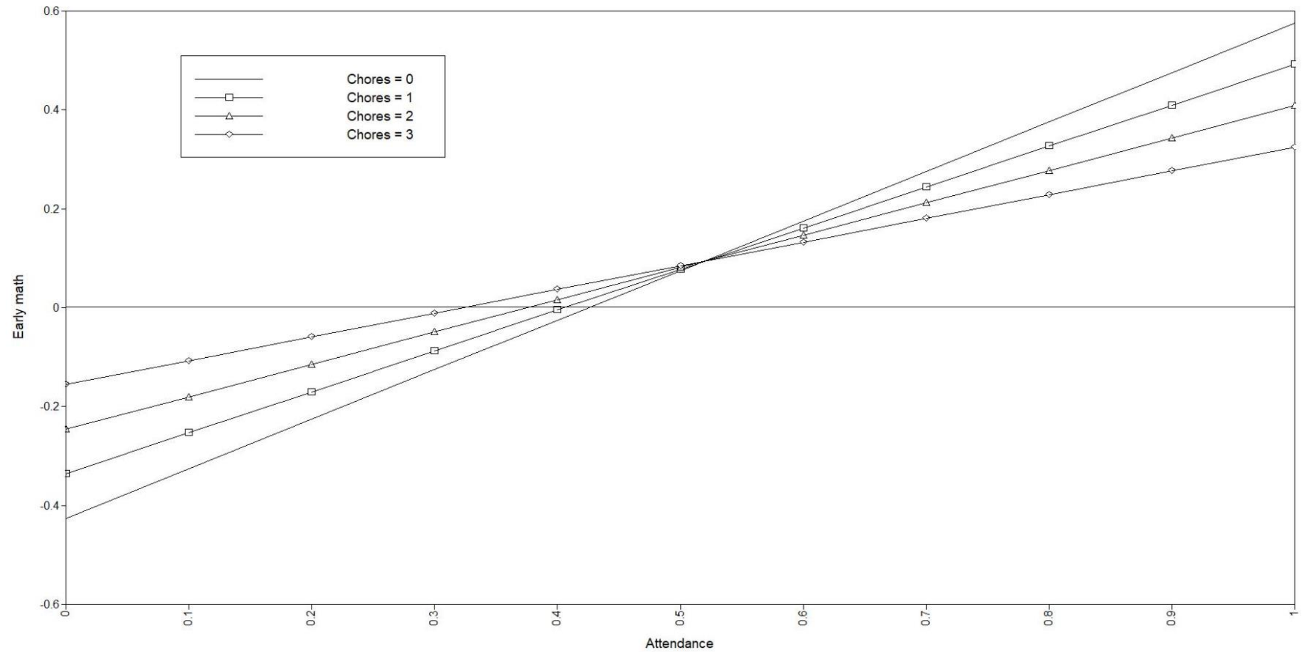
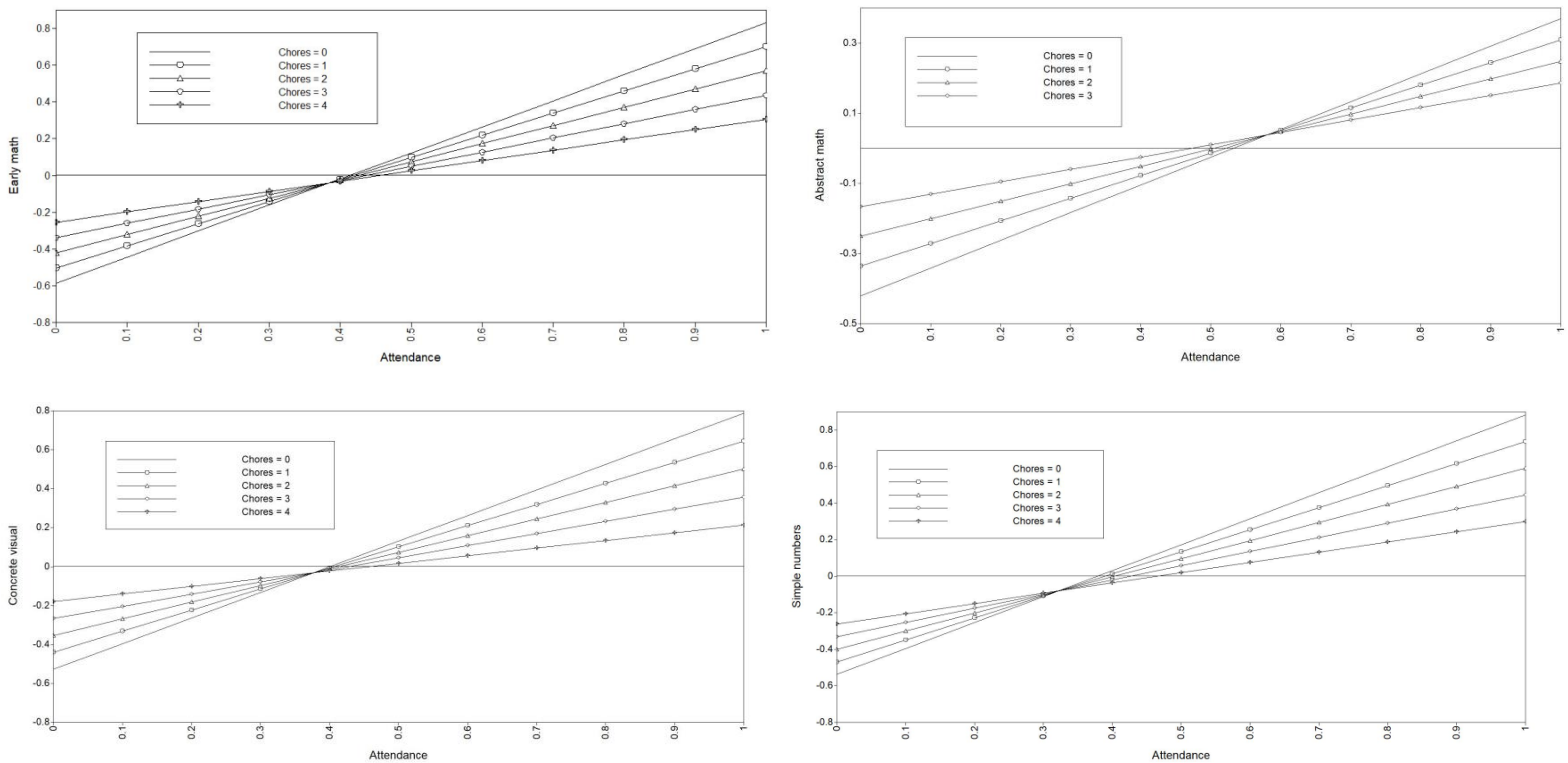


**Figure 2**

*Effect of School Attendance on Four Types of Mathematics Scores at Different Levels of Chores for Girls*




*Note*. For clarity, only significant simple slopes were plotted.

**Supplementary material**

**Table S1**

*Model Fit indices for One-factor CFA for Each Type of Mathematics*

| | $\chi^2$ | *df* | CFI | RMSEA [95% CI] |
|---|---|---|---|---|
| Early math | 481.581*** | 119 | 0.957 | 0.044 [0.040, 0.048] |
| Addition & subtraction | 540.307*** | 104 | 0.913 | 0.052 [0.047, 0.056] |
| Multiplication & division | 110.820*** | 44 | 0.962 | 0.031 [0.024, 0.038] |
| Abstract math | 98.400*** | 35 | 0.946 | 0.034 [0.026, 0.042] |
| Simple numbers | 355.469*** | 119 | 0.970 | 0.036 [0.031, 0.040] |
| Complex numbers | 970.495*** | 350 | 0.915 | 0.034 [0.032, 0.037] |
| Abstract/symbolic | 967.938*** | 377 | 0.938 | 0.032 [0.029, 0.034] |
| Concrete visual | 329.930*** | 77 | 0.973 | 0.046 [0.041, 0.051] |