**Executive Functions and Motivation Uniquely Predict Children's
Academic Development in Côte d'Ivoire**

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This study's design, hypotheses, and analysis plan were preregistered. Additionally, all data, analysis code, and research materials are available. See the following website for this information: https://osf.io/y9emz/?view_only=5656570cce1b4c27896f01807612ee36

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Abstract

The role of executive function skills and motivation in supporting children's academic achievement is well-documented, but the vast majority of evidence is from high-income countries. Classrooms in low- and middle-income countries tend to be large, teacher-driven, and lecture-focused, which may provide extra challenges for children to stay engaged in the learning process. Based in self-regulated learning theory, we tested the contributions of executive functions and motivation for children's literacy and numeracy skills over one school year. Our preregistered study of 2,500 primary school students in Cote d'Ivoire used cross-lagged models with a robust set of demographic covariates. Executive functions were directly assessed and children reported on their levels of motivation for schooling. Findings indicated unique effects of executive functions and motivation for changes in children's literacy and numeracy skills over the school year. Overall, these results provide evidence for the importance of non-academic skills for children's learning in a low- and middle-income context. Implications include improving the quality of primary school experiences to promote opportunities to practice self-regulation skills and increase motivation for learning.

Keywords: executive function, motivation, sub-Saharan Africa, self-regulated learning, academic achievement

Executive Functions and Motivation Uniquely Predict Children's Academic Development in Côte d'Ivoire

Non-academic skills such as self-regulation, persistence, and motivation, are important for children's classroom learning and academic achievement. Self-regulated learning theory emphasizes that children need both the *ability* and the *motivation* to engage in learning (Garner, 2009; Knouse et al., 2014; Zimmerman, 1990). Executive functions (EFs) are under the broad umbrella of self-regulation skills and allow children to regulate their attention and behaviors (Diamond, 2013). EFs are implicated in the direct acquisition of math and reading skills (Cartwright, 2012; Kroesbergen et al., 2009) and also support children's learning-related behaviors in the classroom (Nelson et al., 2017). Separately, prior research in high-income countries has shown that aspects of children's motivation uniquely contribute to adaptive classroom behaviors and achievement, over and above EFs (Finch & Obradović, 2017; Howse et al., 2003; Sulik et al., 2020).

The vast majority of studies examining the role of non-academic skills for children's learning have been conducted in high-income countries. Whether these skills have the same importance across diverse contexts, including classrooms in sub-Saharan Africa where learning levels and educational quality are low, is not known, though a few studies suggest they may be important aspects of children's learning in low-income country contexts (Chiu & Xihua, 2008; von Suchodoletz et al., 2015; Wolf & McCoy, 2019). The current study examines the unique contributions of EFs and motivation skills for children's academic achievement in a sample of primary school students in Côte d'Ivoire.

Self-Regulated Learning: The Intersection between EFs and Motivation for Children's School Success

Self-regulated learning theory emphasizes the active role of students in their learning through their efforts to control their own cognition, motivation, and behavior (Pintrich, 2000; Schunk & Zimmerman, 2012; Zimmerman, 2008). This theory highlights that learning requires both the ability to engage with learning material and the will to do so (Hofmann et al., 2012; Wolters, 2003). A longstanding body of research has linked self-regulated learning to academic success for children in primary school classrooms in high-income countries (Dignath & Büttner, 2008; Zimmerman, 1990). Recent evidence suggests that self-regulated learning may also be an important predictor of achievement in low- and middle-income contexts. In Western China, a composite measure of responsible decision making, social awareness, self-management, and relationships skills were associated with reading, math, and science achievement in fourth and fifth grade students (Wang et al., 2019).

Executive Functions and Learning

Executive functions (EFs) are a set of higher-order cognitive skills that allow children to regulate their attention and behavior (Diamond, 2013). There is strong evidence in high-income countries for the role of EFs for academic achievement via two pathways. First, EFs are linked to the direct acquisition of mathematics and reading skills (Cartwright, 2012; Kroesbergen et al., 2009). Second, EFs contribute to adaptive classroom behaviors that support learning, such as staying on task, perseverance, and managing assignments (Finch & Obradović, 2017; Nelson et al., 2017). There is some recent evidence from low- and middle-income contexts that EFs are linked to preschool children's academic outcomes, and just one study focusing on the link between EFs and academic achievement in primary school. In Kosovo, a lower middle-income

region in southeastern Europe, preschoolers' EFs were associated with children's vocabulary and math skills (von Suchodoletz et al., 2015). A cross-sectional study of preschoolers in Kenya demonstrated that a battery of EF tasks was to both pre-literacy and pre-numeracy skills in children (Willoughby et al., 2019). Finally, Ghanaian children's EFs were associated with growth in both literacy and numeracy skills in the first two years of primary school, after controlling for children's social-emotional skills such as emotion identification and peer social skills (Wolf & McCoy, 2019). Together, these studies indicate that EFs are consequential for early literacy and mathematics achievement for younger children in low- and middle-income country contexts.

Motivation for Learning

A separate literature has emphasized the role of motivation for learning. Motivation provides the will to initiate and sustain goal-directed activities (Schunk & Zimmerman, 2012) and is necessary for cognitive engagement in the classroom (McLaughlin et al., 2005). In high-income countries, children with higher motivation are more likely to demonstrate academic success as indexed by achievement test scores and school grades (Corpus & Wormington, 2014; Taylor et al., 2014). In a sample of adolescents across 41 countries, including low-income and middle-income countries, students' motivation was consistently associated with higher mathematics achievement (Chiu & Xihua, 2008). Evidence from Nigerian and Kenyan secondary schools show that cooperative learning environments, which are more likely to promote student motivation, are linked to higher mathematics and science achievement than competitive learning environments (Kolawole, 2008; Wachanga & Mwangi, 2004).

Unique Contributions of EFs and Motivation

There is theoretical and empirical evidence that EFs and motivation are likely to have unique contributions for children's school achievement. EFs would support children's abilities to focus in the classroom, keep track of assignments, and track their learning. In contrast, children's motivation would provide them with the will to engage in these adaptive classroom behaviors. However, the two are rarely studied together. A handful of studies do lend support to the unique contributions of EFs and motivation for children's academic success in the United States. For example, in a small sample of kindergarteners, both teacher report of students' motivation and directly-assessed EFs were associated with children's reading scores (Howse et al., 2003). Further, in a racially and socioeconomically-diverse sample of elementary school students, EFs and an aspect of motivation—challenge preference—were uniquely associated with children's adaptive classroom behaviors and academic achievement (Finch & Obradović, 2017; Sulik et al., 2020).

These issues have not yet been studied in a sub-Saharan African context, where classrooms are structured differently than in the United States, with teacher-driven and whole-group instruction being the norm (Lerkkanen et al., 2016). While some evidence has established that EFs are related to preschoolers' learning in sub-Saharan African contexts (e.g., Wolf & McCoy, 2019), the role of EF and motivation, and the interplay between EFs and motivation during primary school, is unknown. Given that most classrooms in the region are not optimally designed for student engagement or learning (Perry et al., 2002), children's abilities to self-regulate and their motivation to do so may be particularly important for their learning in such classrooms.

Primary School Education in Sub-Saharan Africa

While enrollment in primary school has increased dramatically in sub-Saharan Africa, the quality of classrooms remains low and learning levels are among the lowest globally (Angrist et al., 2021; Bashir et al., 2018). Classrooms face significant resource constraints: only a third of classrooms in sub-Saharan Africa have electricity, a fifth have access to toilets, and two to three students commonly share one textbook (Mbiti, 2016). Typically, classrooms are much larger compared to high-income countries and rates of teacher absences are high (UNESCO, 2012). Classrooms tend to be lecture-driven, rigid, and teacher-dominated with few opportunities for students to actively engage with learning material. When not lecturing, teachers ask a series of pre-planned questions and rarely interact with the substance of students' responses (Metto & Makewa, 2014)

Given the lack of effective teaching practices, most students who attend primary school in sub-Saharan Africa do not acquire basic academic skills. In 2017, representative surveys from seven sub-Saharan African countries, representing close to 40 percent of the region's total population, found that three-quarters of second graders could not count beyond 80, and 40% could not do a one-digit addition problem (Bold et al., 2017). Further, primary school attendance is not even supporting basic literacy skills for children – in fourth grade, 40% of children could not read a single letter, 70% could not read a single word, and 90% could not read a paragraph (Bold et al., 2017).

The educational picture in Côte d'Ivoire is representative of sub-Saharan Africa. The government has been successful at increasing enrollment at the primary school level over the past 10 years (UNESCO, 2019). However, while Côte d'Ivoire's government spends more than other countries in the region on education (UNESCO, 2019), very few students demonstrate

minimum learning achievement. The most recent PASEC data, which focuses on Francophone countries in West Africa, rates Côte d'Ivoire among the bottom 30 countries globally (Angrist et al., 2021), with large inequalities between urban and rural regions (PASEC, 2020). Even among children attending primary school, the average fifth grader can only read a few words (Jasińska et al., 2018). This is partly due to poor teacher motivation and performance, and in rural areas very large class sizes and little ongoing professional development and training for teachers (World Bank, 2018). Further, both Ivorian civil wars (in 2002 and 2011) significantly impacted children's education in lasting ways, with both the destruction of school infrastructure and long periods of children being out school. Estimates suggest that, on average, children in school during the civil wars had almost one year of schooling loss (Dabalen & Paul, 2014).

Disadvantaged Subgroups of Children in Sub-Saharan Africa

There are specific groups of children who are particularly marginalized in sub-Saharan Africa and show the lowest rates of school attendance and achievement. Children's sex is a key determinant for schooling outcomes in sub-Saharan Africa, with girls being disadvantaged. Parent engagement may vary by child sex due to greater opportunity costs of schooling for girls (e.g., larger involvement of girls in household or care work), lower perceived returns to girls' education, and widespread gender bias in social norms and aspirations (Alderman & King, 1998). Current school enrollment rates in Côte d'Ivoire are 86.0%, with disparities between males and females at 89.8 and 82.1%, respectively (UNESCO UIS, 2018). Further, inter-generational educational transmission is particularly salient in sub-Saharan Africa (Azomahou & Yitbarek, 2016; Pufall et al., 2016), such that children whose parents have low levels of educational attainment tend to have lower educational attainment themselves.

For these marginalized children, EFs and motivation may be more strongly linked to their

academic achievement, based on studies demonstrating self-regulation skills as protective factors for disadvantaged students in high-income countries (King & Mrug, 2018; Liew et al., 2010; Obradović, 2010). For example, using a nationally-representative sample of American kindergarteners, Liu (2019) found that a composite measure of self-regulation, persistence, interpersonal skills, and motivation served as a protective factor for the academic achievement of children from low-socioeconomic status homes. In contrast, research on students from the United States demonstrated that the positive association between motivation and reading achievement was significant for gifted readers but non-significant for poor readers (McGeown et al., 2012). This suggests that the benefits of motivation for achievement might actually be limited to more advantaged students. However, these questions have not been explored in sub-Saharan Africa where children's school experiences differ greatly and where children from marginalized groups may not have the same access to schooling as their peers from more advantaged backgrounds.

Current Study

This pre-registered study investigates whether EFs and motivation uniquely contribute to growth in literacy and mathematics skills for primary school students in Côte d'Ivoire. The participants are in second and fourth grade, which mark an important transitional period into middle childhood where children are increasingly expected to self-regulate their behaviors and monitor their own progress and behaviors (Felton & Akos, 2011). Children's EFs are directly assessed using two widely used tasks, children report on their own intrinsic and extrinsic motivation, and academic achievement is measured using standardized tasks adapted to capture children's literacy and numerical skills in the region. Based on previous empirical and theoretical evidence (Hofmann et al., 2012; Sulik et al., 2020; Wolters, 2003), we hypothesized that there would be unique benefits of both EFs and motivation for children's literacy and numeracy

achievement in the spring, after controlling for lagged measures of achievement in the fall. Finally, we ran exploratory analyses to test whether the links between EFs, motivation, and academic achievement differ by gender and by parental educational attainment.

Method

Participants and Procedure

We preregistered our hypotheses and statistical analyses at the Open Science framework (https://osf.io/y9emz/?view_only=5656570cce1b4c27896f01807612ee36). Data for this study come from the Eduq+ intervention study conducted in 100 schools in the Aboisso and Bouaflé regions of Côte d'Ivoire. This school-randomized control trial examined impacts of a text-message based intervention to parents and teachers related to educational engagement and improvement. A list of all of the schools in the two regions was obtained from the regional education offices. Fifty public schools within each region ($N = 385$ total in Aboisso, 612 in Bouaflé) were selected by the district education office to participate in the study. Schools were randomly assigned to (i) receive one of five variations of the Eduq+ intervention administered to parents and / or teachers ($N = 50$), or (ii) a control group ($N = 50$). See BLINDED for more details on the intervention. Data was collected over one school year in the fall (October-November 2018; start of the school year) and the spring (May 2019; end of the school year).

In each school, the class rosters of CP2 (equivalent to second grade) and CE2 (equivalent to fourth grade) were obtained. Twenty-five children were selected per school to participate in the assessments: 13 children were randomly chosen from the CP2 roster, and 12 children randomly chosen from the CE2 roster and data collected in the schools in the fall (beginning) and spring (end) of the school year. In total, data was collected on 2,500 children at baseline. In the spring, achievement data was collected on 2,246 (89.8%) of those children. The study was

approved by the XXX at the University of XXX (XXX IRB #XXX).

Transparency and Openness

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study, and we follow Journal Article Reporting Standards (JARS; Appelbaum et al., 2018). All data, analysis code, and research materials will be available at https://osf.io/y9emz/?view_only=5656570cce1b4c27896f01807612ee36. These materials and documentation allow for independent replication of the results presented in this paper. Data were cleaned using Stata, version 15.1 (StataCorp, 2017) and analyses were conducted using Mplus, version 8.6 (Muthén & Muthén, 2021). This study's design and its analyses were preregistered at the Open Science Framework and can be accessed at this link:

https://osf.io/y9emz/?view_only=5656570cce1b4c27896f01807612ee36). Our small deviations from the pre-registered analyses are specified below in the Analytic Plan.

Measures

All items were translated from English to French and back translated to English. Assessments were then piloted with 40 children to ensure their suitability for use in this context. Only items that were deemed appropriate were included in the assessment.

Literacy. Literacy in French was assessed using eight tasks measuring pre-literacy and literacy domains from two sources. Using the Early Grade Reading Assessment (RTI International, 2009b), domains included letter-sound identification, nonword decoding, and word reading. Four additional adapted subtasks from EGRA were used and included phonological awareness, phoneme segmentation, synonyms and antonyms (Jasińska et al., 2018). Finally, one additional measure of phonological awareness from the International Development and Early Learning Assessment (IDELA) (Pisani et al., 2018) was also included. The percent correct for

each domain was computed, and the score for each domain averaged to create a total score ($M = 0.23$, $SD = 0.19$, $range = 0 - 0.92$, $\alpha = 0.85$).

Numeracy. Numeracy was assessed using eight tasks measuring. Four tasks from the Early Grade Math Assessment (RTI International, 2009a) and included number identification, quantity discrimination, addition, subtraction, and missing number pattern identification. In addition, four tasks from the IDELA (Pisani et al., 2018) were used which included number knowledge, one-to-one correspondence, shape identification, and sorting abilities based on color and shape. The percent correct for each domain was computed, and the score for each domain averaged to create a total score ($M = 0.50$, $SD = 0.22$, $range = 0 - 0.93$, $\alpha = .86$).

Executive functions. Children's executive functions were measured using two tasks: Hearts and Flowers (Davidson et al., 2006) and the Forward Digit Span (Carlson, 2005).

Hearts and Flowers. The Hearts and Flowers task is a measure of inhibitory control and cognitive flexibility. When children viewed a "heart" or congruent trial, they were told to press the button on the same side as the heart. When children viewed "flower" or incongruent trials, they were told to press the button on the opposite side of the flower. After practice trials, children completed 11 mixed "heart and flower" trials. We created a composite measure of inhibitory control and cognitive flexibility using the percent of correct responses on the mixed block, where children are asked to sort both hearts and flowers.

Forward Digit Span. The Forward Digit Span task was used to measure children's working memory, since the Backward Digit Span Task was too challenging for this population. Children were visually shown 13 sets of numbers ranging from two to seven digits and asked to write down the numbers they saw in the same order after each set was presented ($\alpha = .79$). We created a composite measure of working memory using the total span, which is measured by the

longest span for which at least two test trials were repeated correctly, plus 0.5 if one longer sequence was correctly repeated at the next level (Noël, 2009).

Motivation. Children's motivation was measured using 9 items from the Elementary School Motivation Scale (Guay et al., 2005). Items focused on children's motivation for schooling and answered on a 5-point scale with 1 = *always no* and 5 = *always yes*. Items included intrinsic motivation (e.g., "I like going to school") and extrinsic motivation (e.g., "I go to school to please my parents or teacher").

Factor analysis of motivation measure. We used exploratory factor analysis and confirmatory factor analysis to test the adequacy of a two-factor solution of the scale. The exploratory factor analysis results demonstrated that a two-factor solution was significantly better than a one-factor solution ($\chi^2(df = 8) = 241.199, p < .001$), with items 1 through 5 loading on Factor 1 and items 6 through 8 loading on Factor 2 (as indicated by loadings $> .40$). The follow-up confirmatory factor analysis demonstrated that model fit was excellent ($\chi^2(df = 12) = 22.902, p = .029, RMSEA = .019, CFI = .996, TLI = .988$) and provided strong support for the two-factor solution. See the Supplemental Materials (Table S1) for the factor loadings and item stems. Based on these results and our conceptual understandings of the items, we averaged across items 1 through 5 to create a composite measure of *intrinsic motivation* and across items 6 through 8 to create a composite measure of *extrinsic motivation*.

Covariates. Child gender (1 = *male*) and age were drawn from the baseline survey. In addition, include a dummy indicator for region, and a set of five dummy variables for whether children's schools were randomly assigned to one of the treatment conditions. Parent education and household income were collected via surveys with children's parents. More specifically, parents reported their monthly income in CFA. The mid-point of each income category was used,

ranging from 5,000 CFA/month (equivalent to \$9 USD) to 350,000 CFA/month (equivalent to \$634 USD). Parents' education was coded as the highest level attended and transformed to represent years of schooling (0 = no schooling, 40%; 3 = some primary school, 21%; 5 = completed primary school, 9%; 7 = some lower secondary school, 9%; 9 = completed lower secondary, 5%; 10 = some upper secondary school, 4%; 12 = completed upper secondary school, 1%; 13 = some bachelor's degree coursework, 2%, 14 = bachelor's degree, 2%; 15 = some post-graduate coursework, 2%; and 16 = post-graduate degree, 2%). Finally, we used lagged measures of literacy and numeracy in the model drawn from the fall semester of school.

Analytic Plan

Analyses were conducted using Mplus, Version 7.3 (Muthén & Muthén, 2021). To account for missing data, we used full information maximum likelihood estimation (FIML). FIML is a model based approach that estimates parameters and standard errors from the observed data of each individual case (Nicholson et al., 2017) and only drops cases when information is missing on all data points (there were no such cases in the current study). FIML is less biased and more reliable compared with listwise or pairwise deletion (Enders & Bandalos, 2001) and commonly employed in path analyses (Nicholson et al., 2017). Model fit was evaluated using the Comparative Fit Index (CFI), Tucker Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and the chi-square test. Values above 0.95 indicate excellent fit for the CFI and TLI. The cut-offs of 0.01, 0.05, and 0.08 have been used to indicate excellent, good, and mediocre fit, respectively, using the RMSEA (MacCallum et al., 2002).

The main model utilized path analyses with observed composite variables for EFs, intrinsic motivation, and extrinsic motivation measured in the fall as predictors and literacy and numeracy in the spring as outcomes. Specifically, scores on the Hearts and Flowers and Forward

Digit Span tasks were standardized and averaged to create a composite EF variable ($r = .31$). Originally, in our pre-registered analyses, we had planned to utilize reflexive latent variables for EFs and motivation. However, after reviewing recent evidence that reflexive latent variables can cause biased and variable parameter estimates when not correctly specified and that reflexive latent variables may not be appropriate for measuring EF ability (Camerota et al., 2020; Rhemtulla et al., 2020), we explored the use of composite variables. Our EF measures are designed to capture different aspects of the overall EF construct (inhibitory control and cognitive flexibility on the Hearts and Flowers task and working memory on the Digit Span task), which causes issues when employing a reflexive latent variable that only utilizes variance shared by the two tasks (Bagozzi, 2007). Similarly, our two motivation variables are believed to reflect related, but different aspects of children's motivation to complete their schooling. The use of a reflexive latent variable can also overestimate pathways in SEM models, which we saw in our original analyses using reflexive latent variables (Rhemtulla et al., 2020; see the Supplemental Materials). Together, this information led us to use a composite score for our EF variable and specify the two motivation variables as separate, observed variables in our model.

We had also planned to include a measure of growth mindset to load onto the latent motivation variable. First, we learned that the two open-ended questions had not been administered, and so the score would rely on the three Likert-scale type questions. However, once we analyzed the data, we found that the average scores on the three growth mindset questions was negatively with intrinsic motivation ($r = -.05, p = .022$) and uncorrelated with extrinsic motivation ($r = .02, p = .368$), so we omitted this measure from our analyses, as it did not fit with our conceptual model of children's "will" to pursue academic work. These were the only deviations we made from our pre-registered analyses.

We use lagged models, controlling for literacy and numeracy in the fall, to reduce selection bias. Controlling for lagged scores in addition to a range of family and child demographic covariates adjusts for unobserved or omitted variables associated with the lagged outcome. This approach is recommended given that measures of each outcome are repeated exactly in the two waves (NICHD ECCRN & Duncan, 2003). We estimated covariate effects (child age, region, child gender, treatment status, parental education, and household income) on EFs, intrinsic motivation, extrinsic motivation, literacy (fall and spring), and numeracy (fall and spring). We also allowed for covariation between EFs and the two motivation measures, literacy and numeracy in the fall, and literacy and numeracy in the spring. Whenever EFs, motivation, or both EFs and motivation showed significant effects for children's academic growth, exploratory analyses were conducted to examine whether associations in the model operated similarly for males and females and for children of parents with no formal education and some formal education using multiple group analyses.

Results

Descriptive Statistics and Bivariate Correlations

Descriptive statistics for all study variables are presented in Table 1. Overall, children reported relatively high intrinsic and extrinsic motivation (intrinsic $M = 4.556$, $SD = 0.693$; extrinsic $M = 4.378$, $SD = 0.759$; range: 1 – 5). On average, children responded correctly to 28.5% of the literacy items ($SD = 21.5\%$) and 57.6% of the numeracy items ($SD = 21.4\%$) in the fall. Scores were slightly lower in the spring – children responded to 23.1% of the literacy items ($SD = 19.0\%$) and 50.2% of the numeracy items ($SD = 22.2\%$), on average. Children were 8.6 years old, on average, with 90% of the sample falling between the ages of 6 and 12. Parents reported relatively low levels of education ($M = 4.1$ years, $SD = 4.6$ years) and household income

($M = 77,851$ CFA/month, equivalent to \$141 USD/month; $SD = 90,212$ CFA/month, equivalent to \$163 USD/month). For comparison, the international benchmark for poverty is \$1.90/day (\$57/month), so families with three or more household members would be living in poverty at the average household income level of this sample.

Path Analysis Model

The main model was a path analysis with composite variables for EFs, intrinsic motivation, and extrinsic motivation predicting spring literacy and numeracy skills. Fit statistics indicated good model fit (CFI = 0.996; TLI = 0.982; RMSEA = 0.031, 90% confidence interval [0.022, 0.039]; SRMR = 0.011). All standardized path coefficients for the primary pathways of interest are presented in Table 3 and displayed in Figure 1. All standardized path coefficients for covariate pathways are presented in Table 4.

As expected, there was significant longitudinal continuity between literacy at fall and spring ($\beta = 0.607, p < .001$) and numeracy at fall and spring ($\beta = 0.468, p < .001$). Intrinsic motivation, extrinsic motivation, and EFs uniquely contributed to spring literacy skills ($\beta = 0.052, p < .001$; $\beta = 0.045, p = .001$; $\beta = 0.210, p < .001$, respectively) and spring numeracy skills ($\beta = 0.043, p < .001$; $\beta = 0.055, p < .001$; $\beta = 0.253, p < .001$, respectively). The standardized effects were approximately 4 to 5 times larger for EFs compared to the motivation measures.

There were also some notable covariate effects on the study variables. Child age was a significant predictor of literacy skills ($\beta = 0.342, p < .001$), numeracy ($\beta = 0.441, p < .001$), EFs ($\beta = 0.346, p < .001$), and intrinsic motivation ($\beta = 0.064, p = .002$). Boys had significantly higher numeracy scores in the fall than girls ($\beta = 0.060, p = .001$), but there were no other significant effects of gender on literacy ($\beta = -0.006, p = .741$), EFs ($\beta = 0.018, p = .332$), or

motivation (intrinsic: $\beta = -0.018$, $p = .372$; extrinsic: ($\beta = -0.004$, $p = .841$). Parental education and household income were significant predictors of children's literacy in the fall ($\beta = 0.212$, $p < .001$; $\beta = 0.071$, $p = .001$; respectively), numeracy in the fall ($\beta = 0.139$, $p < .001$; $\beta = 0.069$, $p < .001$; respectively), and EFs ($\beta = 0.108$, $p < .001$; $\beta = 0.049$, $p = .025$; respectively). Parental education also had a significant main effect on children's intrinsic motivation ($\beta = 0.083$, $p < .001$, but was not associated with their extrinsic motivation ($\beta = 0.018$, $p = .405$).

Exploratory Analyses

Multiple group analyses tested gender and parental education differences in the hypothesized path analytic model. We found unique effects of motivation and EFs for both girls' and boys' academic skills, suggesting that these pathways work similarly regardless of gender (see the Supplemental Materials, Figure S2). There was a slight difference in the predictive value of extrinsic motivation by gender, such that extrinsic motivation was significantly predictive of literacy skills for boys but not girls. However, EFs and intrinsic motivation significantly predicted literacy and numeracy skills for both boys and girls, still providing support for the unique contributions of motivation and EFs for academic achievement for both genders. Further, we did not find differences in the pathways for children whose parents have no formal education versus parents who have some formal education. For both groups, intrinsic motivation, extrinsic motivation, and EFs had unique and positive effects on literacy and numeracy skills (see the Supplemental Materials, Figure S3).

Discussion

This study was the first to apply the self-regulated learning model to primary school students in a low- and middle-income context. Results provide evidence that both EF skills and children's motivation play a unique role in the school success of second and fourth grade

students in Côte d'Ivoire. Our results demonstrate that self-regulated learning is important even in classroom contexts that are teacher-directed and where children have often limited autonomy over their learning process (Dembélé & Lefoka, 2007). Given low rates of academic achievement in the region, this study suggests that supporting children's self-regulation skills and their motivation to learn could be ways to improve their literacy and numeracy skills.

EFs and Motivation Support Learning in Côte d'Ivoire

Self-regulated learning theory highlights the shared importance of children's ability to regulate attention and behaviors and their will to do so in the classroom for successful learning and engagement. Indeed, our results show that both EFs and motivation uniquely contributed to students' literacy and numeracy skills in Ivoirian primary schools, though EFs were much stronger predictors of achievement than motivation. Our results align with previous research demonstrating that EF skills support academic learning during the school year. A recent meta-analysis of studies across primary school students in high-income countries demonstrated that direct assessments of EFs were linked to both reading and mathematics skills (Cortés Pascual et al., 2019). Further, a study in Kenya, another sub-Saharan African country, showed that pre-primary school students' EFs were significantly linked to pre-literacy and pre-numeracy skills measured concurrently (Willoughby et al., 2019). This is the first study, to our knowledge, to demonstrate that EFs are linked with *longitudinal changes* in academic skills in a low- and middle-income context. The fact that EFs remain a strong predictor of academic achievement in a low- and middle-income country provide further evidence of EFs as a universally beneficial set of skills for children across various cultural contexts (Obradović et al., 2019; Obradović & Willoughby, 2019).

In our sample, motivation had a unique, though smaller, effect on academic achievement,

which is in line with previous research in high-income countries (Howse et al., 2003; Sulik et al., 2020). However, we demonstrated significant effects of motivation on changes in both literacy and numeracy, whereas Sulik and colleagues (2020) only showed a significant effect of intrinsic motivation for mathematics and not literacy skills, when controlling for prior academic skills and EFs in a sample of American primary school students. This finding provides initial support for the hypothesis that motivation is particularly important for children in low- and middle-income countries, where classroom contexts are not particularly engaging and learning activities are not individualized.

The larger effect sizes for EFs, compared to motivation, may be due to the foundational nature of EFs for the learning process. EFs are linked to academic success through both the direct understanding of basic literacy and numerical skills (Cartwright, 2012; Kroesbergen et al., 2009) and through its contributions to adaptive classroom behaviors that allow children to focus and pay attention (Finch & Obradović, 2017; Nelson et al., 2017). Following the self-regulated learning model, children first need the ability to regulate their behaviors (EFs) before their interest in applying these self-regulation skills is beneficial to their engagement and learning. Our results support the notion that EFs underpin children's abilities to learn in an academic setting across different cultural contexts.

The Role of Socioeconomic Status and Gender for Non-Academic Skills and Achievement

In sub-Saharan Africa, and Cote d'Ivoire in particular, there are significant gender disparities in primary school enrollment and retention (UNESCO UIS, 2018). Disparities are particularly pronounced in low-income households, as the family economic situation and subjective well-being are more strongly linked to girls' likelihood of attending school compared to boys' (Koissy-Kpein, 2020). Similarly, parents who did not attend school themselves are

significantly more likely to be low-income and may prioritize children's financial contributions to the family over attending school. Lower levels of parental education are linked to lower rates of schooling and academic achievement for their children (Glick & Sahn, 2000; Pufall et al., 2016). Therefore, girls and children whose parents did not have any formal schooling are particularly disadvantaged in sub-Saharan Africa, compared to their peers.

Follow-up analyses demonstrated that there were not significant differences in the role of non-academic skills for achievement between disadvantaged subgroups of children and their more advantaged peers. In many ways, this is heartening. It suggests that efforts to support EFs and motivation in the classroom would benefit all students, regardless of their gender or family socioeconomic conditions. Further, there were few gender differences in children's non-academic skills or achievement. The only significant main effect of gender in the path analysis was for children's numeracy skills, such that boys had higher scores on the numeracy test than girls. However, these gender differences were not apparent for literacy scores, nor EFs or motivation.

In line with a growing body of research in low- and middle-income countries, measures of socioeconomic status were highly predictive of children's EFs and achievement (Obradović et al., 2019; Sania et al., 2019; Wolf & McCoy, 2017; Zuilkowski et al., 2019). We found much larger effects of parental education than household income (2 to 3 times larger) for children's EFs and achievement, providing evidence that in this context parental education may be a stronger measure of the types of household contexts that support self-regulation development. This is similar to a recent study of Chinese immigrant families in the United States demonstrating a significant effect of parental education, but not family income, on authoritative parenting and EFs (Chen et al., 2021). However in the current study, parental education and

household income were unique and significant predictors of EFs and achievement, suggesting that they each play a role in supporting children's self-regulation and school success. Similarly, in Zambia, wealth and parental education were indirectly linked to six-year-olds' EFs via home-based cognitive stimulation and access to early childhood education (McCoy, Zuilkowski, & Fink, 2015). Parental education was also a significant predictor of intrinsic motivation, suggesting that parents with higher levels of educational attainment may instill a stronger passion for learning in their children.

Implications for Children's Educational Experiences

Theoretically, the numerous interventions implemented in low-performing educational systems, including scripts for teachers, provision of learning materials, and coaching, influence students' learning outcomes via changes in teachers' classroom practices (Fleisch et al., 2016). There is growing evidence that making classrooms more activity-based and child-centered improves learning, EFs, and social-emotional development in sustained ways (Conn, 2017; Wolf, 2019; Wolf et al., 2019). Improving the quality of classrooms will likely provide more opportunities for children to practice and improve their EFs and increase their motivation towards learning. In high-income countries, teachers who offer choices, opportunities to control the challenge of activities, scaffold instruction, and make evaluation non-threatening and mastery-oriented, increase levels of self-regulated learning in their students (Perry et al., 2002). It is important to note that there may be significant barriers for teachers in sub-Saharan Africa to provide high-quality learning environments for their students. For example, teachers may be under-prepared and not have the necessary content knowledge about the subjects they are asked to teach. Many teachers in low-income settings are themselves living in poverty and experiencing stress and physical and mental health challenges that can undermine their abilities

to teach effectively (Schwartz et al., 2019). If educational interventions are to be effective, they need to address both student *and* teacher needs (Evans & Yuan, 2018).

Another opportunity to improve children's EFs is through access to high-quality early childhood education programs. In Cote d'Ivoire, very few children (5.7%) attend early childhood education programs, and nearly half of children experience both low levels of cognitive stimulation at home and do not attend early childhood education programs according to UNICEF's Multiple Indicator Cluster Survey program (McCoy et al., 2018). Attendance in early childhood education programs with individualized supports for students leads to more efficient primary school education, as these students are significantly less likely to have to repeat grades once they begin formal schooling (Gove, 2017). Increasing access to early childhood education may not only increase EFs and other important adaptive classroom behaviors, but may also support learning-related motivation by producing early academic experiences and success (McCoy et al., 2017; Obradović & Willoughby, 2019; Rao et al., 2012; Wolf et al., 2019).

Limitations and Conclusions

While this study provided initial evidence of the importance of non-academic skills for children's literacy and numeracy achievement in sub-Saharan Africa, there are some limitations that provide important avenues for future research. First, there may be a lack of generalizability outside of the schools and students in these two rural regions of Cote d'Ivoire. Sub-Saharan Africa is highly diverse and predictors of learning in one region may not be the same somewhere else. Second, we had sample attrition over the school year, which also limits generalizability to the sample of children who completed the spring achievement assessments and may have biased results. For example, it is plausible that these results may differ for children who dropped out during the year. Third, we only included two measures of children's EFs. Typically, larger

batteries of EF tasks are preferable, as they provide more coverage of the various aspects of EFs and allow for more precise measurement of EFs (Obradović & Willoughby, 2019). Finally, we used a self-report measure of children's motivation that may not capture children's actual behaviors when presented with choices in academic setting. There is a pressing need for scalable direct assessments of motivation that can be easily administered in classroom settings.

As governments around the world strive to provide high-quality education and learning opportunities to all children, building more evidence about which factors support learning will inform how to make these efforts more effective. This is particularly true to rural sub-Saharan African communities, where few such studies exist to date. Findings from this study provide evidence that non-academic skills are key predictors of growth in literacy and numeracy over the school year in Cote d'Ivoire. These skills may be particularly important given that classrooms are large, with few opportunities for students to engage with teachers and peers. Finally, improving the quality of classroom interactions in this context would likely support learning directly and via increases in student EFs and motivation. Additional research in this area is needed in order to contribute to a cross-cultural research program that is critical for understanding child development and education from a global perspective, and if global efforts to improve educational quality and child development are to succeed.

References

- Alderman, H., & King, E. M. (1998). Gender differences in parental investment in education. *Structural Change and Economic Dynamics*, 9(4), 453–468.
[https://doi.org/10.1016/S0954-349X\(98\)00040-X](https://doi.org/10.1016/S0954-349X(98)00040-X)
- Angrist, N., Djankov, S., Goldberg, P. K., & Patrinos, H. A. (2021). Measuring human capital using global learning data. *Nature*, 592(7854), 403–408. <https://doi.org/10.1038/s41586-021-03323-7>
- Appelbaum, M., Cooper, H., Kline, R. B., Mayo-Wilson, E., Nezu, A. M., & Rao, S. M. (2018). Journal article reporting standards for quantitative research in psychology: The APA Publications and Communications Board task force report. *American Psychologist*, 73(1), 3–25. <https://doi.org/10.1037/amp0000191>
- Azomahou, T., & Yitbarek, E. (2016). *Intergenerational education mobility in Africa. Has progress been inclusive?* (Policy Research Working Paper No. 7843).
- Bagozzi, R. P. (2007). On the meaning of formative measurement and how it differs from reflective measurement: Comment on Howell, Breivik, and Wilcox (2007). *Psychological Methods*, 12(2), 229–237. <https://doi.org/10.1037/1082-989X.12.2.229>
- Bashir, S., Lockheed, M., Ninan, E., & Tan, J.-P. (2018). *Facing forward: Schooling for learning in Africa* (Africa Development Forum Serie). The World Bank.
- Bold, T., Filmer, D., Martin, G., Molina, E., Stacy, B., Rockmore, C., Svensson, J., & Wane, W. (2017). Enrollment without learning: Teacher effort, knowledge, and skill in primary schools in Africa. *Journal of Economic Perspectives*, 31(4), 185–204.
<https://doi.org/10.1257/jep.31.4.185>
- Camerota, M., Willoughby, M. T., & Blair, C. B. (2020). Measurement models for studying

- child executive functioning: Questioning the status quo. *Developmental Psychology*, 56(12), 2236–2245. <https://doi.org/10.1037/dev0001127>
- Carlson, S. M. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology*, 28(2), 595–616. https://doi.org/10.1207/s15326942dn2802_3
- Cartwright, K. B. (2012). Insights from cognitive neuroscience: The importance of executive function for early reading development and education. *Early Education & Development*, 23(1), 24–36. <https://doi.org/10.1080/10409289.2011.615025>
- Chen, S. H., Deng, X. F., Zhang, E., Wang, L. K., & Liu, C. H. (2021). Self-regulatory development in children from Chinese immigrant families: Evidence for commonality and specificity. *Child Development*, cdev.13593. <https://doi.org/10.1111/cdev.13593>
- Chiu, M. M., & Xihua, Z. (2008). Family and motivation effects on mathematics achievement: Analyses of students in 41 countries. *Learning and Instruction*, 18(4), 321–336. <https://doi.org/10.1016/j.learninstruc.2007.06.003>
- Conn, K. M. (2017). Identifying effective education interventions in sub-Saharan Africa: A meta-analysis of impact evaluations. *Review of Educational Research*, 87(5), 863–898. <https://doi.org/10.3102/0034654317712025>
- Corpus, J. H., & Wormington, S. V. (2014). Profiles of intrinsic and extrinsic motivations in elementary school: A longitudinal analysis. *The Journal of Experimental Education*, 82(4), 480–501. <https://doi.org/10.1080/00220973.2013.876225>
- Cortés Pascual, A., Moyano Muñoz, N., & Quílez Robres, A. (2019). The relationship between executive functions and academic performance in primary education: Review and meta-analysis. *Frontiers in Psychology*, 10, 1582. <https://doi.org/10.3389/fpsyg.2019.01582>

- Dabalen, A. L., & Paul, S. (2014). Estimating the effects of conflict on education in Côte d'Ivoire. *The Journal of Development Studies*, 50(12), 1631–1646.
<https://doi.org/10.1080/00220388.2014.959501>
- Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, 44(11), 2037–2078.
<https://doi.org/10.1016/j.neuropsychologia.2006.02.006>
- Dembélé, M., & Lefoka, P. (2007). Pedagogical renewal for quality universal primary education: Overview of trends in sub-Saharan Africa. *International Review of Education*, 53(5–6), 531–553. <https://doi.org/10.1007/s11159-007-9066-8>
- Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64(1), 135–168.
<https://doi.org/10.1146/annurev-psych-113011-143750>
- Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and Learning*, 3(3), 231–264. <https://doi.org/10.1007/s11409-008-9029-x>
- Enders, C., & Bandalos, D. (2001). The relative performance of full information maximum likelihood estimation for missing data in structural equation models. *Structural Equation Modeling: A Multidisciplinary Journal*, 8(3), 430–457.
https://doi.org/10.1207/S15328007SEM0803_5
- Evans, D. K., & Yuan, F. (2018). *The working conditions of teachers in low- and middle-income countries* (RISE Working Paper). World Bank.
- Felton, K. A., & Akos, P. (2011). The ups and downs of third grade. *Educational Leadership*, 68(7), 28–31.

- Finch, J. E., & Obradović, J. (2017). Independent and compensatory contributions of executive functions and challenge preference for students' adaptive classroom behaviors. *Learning and Individual Differences*, 55, 183–192. <https://doi.org/10.1016/j.lindif.2017.03.002>
- Fleisch, B., Schöer, V., Roberts, G., & Thornton, A. (2016). System-wide improvement of early-grade mathematics: New evidence from the Gauteng Primary Language and Mathematics Strategy. *International Journal of Educational Development*, 49, 157–174. <https://doi.org/10.1016/j.ijedudev.2016.02.006>
- Garner, J. K. (2009). Conceptualizing the relations between executive functions and self-regulated learning. *The Journal of Psychology*, 143(4), 405–426. <https://doi.org/10.3200/JRLP.143.4.405-426>
- Glick, P., & Sahn, D. E. (2000). Schooling of girls and boys in a West African country: The effects of parental education, income, and household structure. *Economics of Education Review*, 19(1), 63–87. [https://doi.org/10.1016/S0272-7757\(99\)00029-1](https://doi.org/10.1016/S0272-7757(99)00029-1)
- Gove, A. (2017). What we are learning about early education in sub-Saharan Africa. *Journal of Research on Educational Effectiveness*, 10(3), 530–534. <https://doi.org/10.1080/19345747.2017.1335091>
- Guay, F., Marsh, H. W., Dowson, M., & Larose, S. (2005). Assessing academic motivation among elementary school children: The Elementary School Motivation Scale (ESMS). *Australian Association For Research In Education 2005 Conference Papers*. <http://www.aare.edu.au/05pap/abs05.htm>
- Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences*, 16(3), 174–180. <https://doi.org/10.1016/j.tics.2012.01.006>

- Howse, R. B., Lange, G., Farran, D. C., & Boyles, C. D. (2003). Motivation and self-regulation as predictors of achievement in economically disadvantaged young children. *The Journal of Experimental Education*, 71(2), 151–174. <https://doi.org/10.1080/00220970309602061>
- Jasińska, K., Seri, A., Tanoh, F., & Guei, S. (2018). How the brain learns to read in environments with high-risk of illiteracy: An fNIRS study of EF and reading development in rural Côte d'Ivoire. *Neurobiology of Language*.
- King, V. L., & Mrug, S. (2018). The relationship between violence exposure and academic achievement in African American adolescents is moderated by emotion regulation. *The Journal of Early Adolescence*, 38(4), 497–512. <https://doi.org/10.1177/0272431616675973>
- Knouse, L. E., Feldman, G., & Blevins, E. J. (2014). Executive functioning difficulties as predictors of academic performance: Examining the role of grade goals. *Learning and Individual Differences*, 36, 19–26. <https://doi.org/10.1016/j.lindif.2014.07.001>
- Koissy-Kpein, S. A. (2020). Achieving gender equality in education in Sub-Saharan Africa: Progress and challenges in moving from the MDGs to the SDGs. In M. Konte & N. Tirivayi (Eds.), *Women and Sustainable Human Development* (pp. 143–164). Springer International Publishing. https://doi.org/10.1007/978-3-030-14935-2_9
- Kolawole, E. B. (2008). Effects of competitive and cooperative learning strategies on academic performance of Nigerian students in mathematics. *Educational Research and Review*, 3(1), 33–37.
- Kroesbergen, E., Van Luit, J., Van Lieshout, E., Van Loosbroek, E., & Van de Rijt, B. (2009). Individual differences in early numeracy: The role of executive functions and subitizing. *Journal of Psychoeducational Assessment*, 27(3), 226–236.

<https://doi.org/10.1177/0734282908330586>

Lerkkanen, M.-K., Kiuru, N., Pakarinen, E., Poikkeus, A.-M., Rasku-Puttonen, H., Siekkinen, M., & Nurmi, J.-E. (2016). Child-centered versus teacher-directed teaching practices: Associations with the development of academic skills in the first grade at school. *Early Childhood Research Quarterly*, 36, 145–156.

<https://doi.org/10.1016/j.ecresq.2015.12.023>

Liew, J., Chen, Q., & Hughes, J. N. (2010). Child effortful control, teacher–student relationships, and achievement in academically at-risk children: Additive and interactive effects. *Early Childhood Research Quarterly*, 25(1), 51–64.

<https://doi.org/10.1016/j.ecresq.2009.07.005>

Liu, A. (2019). Can non-cognitive skills compensate for background disadvantage? The moderation of non-cognitive skills on family socioeconomic status and achievement during early childhood and early adolescence. *Social Science Research*, 83, 102306.

<https://doi.org/10.1016/j.ssresearch.2019.04.019>

MacCallum, R. C., Zhang, S., Preacher, K. J., & Rucker, D. D. (2002). On the practice of dichotomization of quantitative variables. *Psychological Methods*, 7(1), 19–40.

<https://doi.org/10.1037//1082-989X.7.1.19>

Mbiti, I. M. (2016). The need for accountability in education in developing countries. *Journal of Economic Perspectives*, 30(3), 109–132. <https://doi.org/10.1257/jep.30.3.109>

McCoy, D. C., Salhi, C., Yoshikawa, H., Black, M., Britto, P., & Fink, G. (2018). Home-and center-based learning opportunities for preschoolers in low-and middle-income countries. *Children and Youth Services Review*, 88, 44–56.

McCoy, D. C., Zuilkowski, S. S., Yoshikawa, H., & Fink, G. (2017). Early childhood care and

- education and school readiness in Zambia. *Journal of Research on Educational Effectiveness*, 10(3), 482–506. <https://doi.org/10.1080/19345747.2016.1250850>
- McGeown, S. P., Norgate, R., & Warhurst, A. (2012). Exploring intrinsic and extrinsic reading motivation among very good and very poor readers. *Educational Research*, 54(3), 309–322. <https://doi.org/10.1080/00131881.2012.710089>
- McLaughlin, M., McGrath, D., Burian-Fitzgerald, M., Lanahan, L., Scotchmer, M., Enyeart, C., & Salganik, L. (2005). *Student content engagement as a construct for the measurement of effective classroom instruction and teacher knowledge*. American Institutes for Research.
- Metto, E., & Makewa, L. N. (2014). Learner-centered teaching: Can it work in Kenyan public primary schools? *American Journal of Educational Research*, 2(11A), 23–29. <https://doi.org/10.12691/education-2-11A-4>
- Muthén, L. K., & Muthén, B. O. (2021). *Mplus (Version 8.6)*.
- Nelson, T. D., Nelson, J. M., James, T. D., Clark, C. A. C., Kidwell, K. M., & Espy, K. A. (2017). Executive control goes to school: Implications of preschool executive performance for observed elementary classroom learning engagement. *Developmental Psychology*, 53(5), 836–844. <https://doi.org/10.1037/dev0000296>
- NICHD ECCRN, & Duncan, G. J. (2003). Modeling the impacts of child care quality on children's preschool cognitive development. *Child Development*, 74(5), 1454–1475. <https://doi.org/10.1111/1467-8624.00617>
- Nicholson, J. S., Deboeck, P. R., & Howard, W. (2017). Attrition in developmental psychology: A review of modern missing data reporting and practices. *International Journal of Behavioral Development*, 41(1), 143–153. <https://doi.org/10.1177/0165025415618275>
- Noël, M.-P. (2009). Counting on working memory when learning to count and to add: A

- preschool study. *Developmental Psychology*, 45(6), 1630–1643.
<https://doi.org/10.1037/a0016224>
- Obradović, J. (2010). Effortful control and adaptive functioning of homeless children: Variable-focused and person-focused analyses. *Journal of Applied Developmental Psychology*, 31(2), 109–117. <https://doi.org/10.1016/j.appdev.2009.09.004>
- Obradović, J., Finch, J. E., Portilla, X. A., Rasheed, M. A., Tirado-Strayer, N., & Yousafzai, A. K. (2019). Early executive functioning in a global context: Developmental continuity and family protective factors. *Developmental Science*, 22, e12795.
<https://doi.org/10.1111/desc.12795>
- Obradović, J., & Willoughby, M. T. (2019). Studying executive function skills in young children in low- and middle-income countries: Progress and directions. *Child Development Perspectives*, 13, 227–234. <https://doi.org/10.1111/cdep.12349>
- Perry, N. E., VandeKamp, K. O., Mercer, L. K., & Nordby, C. J. (2002). Investigating teacher-student interactions that foster self-regulated learning. *Educational Psychologist*, 37(1), 5–15. https://doi.org/10.1207/S15326985EP3701_2
- Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In *Handbook of Self-Regulation* (pp. 451–502). Elsevier. <https://doi.org/10.1016/B978-012109890-2/50043-3>
- Pisani, L., Borisova, I., & Dowd, A. J. (2018). Developing and validating the International Development and Early Learning Assessment (IDELA). *International Journal of Educational Research*, 91, 1–15. <https://doi.org/10.1016/j.ijer.2018.06.007>
- Pufall, E., Eaton, J. W., Nyamukapa, C., Schur, N., Takaruzza, A., & Gregson, S. (2016). The relationship between parental education and children's schooling in a time of economic

- turmoil: The case of East Zimbabwe, 2001 to 2011. *International Journal of Educational Development*, 51, 125–134. <https://doi.org/10.1016/j.ijedudev.2016.09.003>
- Rao, N., Sun, J., Pearson, V., Pearson, E., Liu, H., Conostas, M. A., & Engle, P. L. (2012). Is something better than nothing? An evaluation of early childhood programs in Cambodia. *Child Development*, 83(3), 864–876. <https://doi.org/10.1111/j.1467-8624.2012.01746.x>
- Rhemtulla, M., van Bork, R., & Borsboom, D. (2020). Worse than measurement error: Consequences of inappropriate latent variable measurement models. *Psychological Methods*, 25(1), 30–45. <https://doi.org/10.1037/met0000220>
- RTI International. (2009a). *Early Grade Mathematics Assessment (EGMA): A conceptual framework based on mathematics skills development in children*.
- RTI International. (2009b). *Early Grade Reading Assessment (EGRA) toolkit*.
- Sania, A., Sudfeld, C. R., Danaei, G., Fink, G., McCoy, D. C., Zhu, Z., Fawzi, M. C. S., Akman, M., Arifeen, S. E., Barros, A. J. D., Bellinger, D., Black, M. M., Bogale, A., Braun, J. M., van den Broek, N., Carrara, V., Duazo, P., Duggan, C., Fernald, L. C. H., ... Fawzi, W. (2019). Early life risk factors of motor, cognitive and language development: A pooled analysis of studies from low/middle-income countries. *BMJ Open*, 9(10), e026449. <https://doi.org/10.1136/bmjopen-2018-026449>
- Schunk, D. H., & Zimmerman, B. J. (Eds.). (2012). *Motivation and Self-Regulated Learning: Theory, Research, and Applications*. Routledge.
- Schwartz, K., Cappella, E., & Aber, J. L. (2019). Teachers' lives in context: A framework for understanding barriers to high-quality teaching within resource deprived settings. *Journal of Research on Educational Effectiveness*, 12(1), 160–190. <https://doi.org/10.1080/19345747.2018.1502385>

- StataCorp. (2017). *Stata Statistical Software* (Release 15) [Computer software]. StataCorp LLC.
- Sulik, M. J., Finch, J. E., & Obradović, J. (2020). Moving beyond executive functions: Challenge preference as a predictor of academic achievement in elementary school. *Journal of Experimental Child Psychology*, 198, 104883. <https://doi.org/10.1016/j.jecp.2020.104883>
- Taylor, G., Jungert, T., Mageau, G. A., Schattke, K., Dedic, H., Rosenfield, S., & Koestner, R. (2014). A self-determination theory approach to predicting school achievement over time: The unique role of intrinsic motivation. *Contemporary Educational Psychology*, 39(4), 342–358. <https://doi.org/10.1016/j.cedpsych.2014.08.002>
- UNESCO. (2012). *School and teaching resources in sub-Saharan Africa. Analysis of the 2011 UIS Regional Data Collection on Education*. United Nations Educational, Scientific, and Cultural Organization.
- UNESCO. (2019). *Cote d'Ivoire*. <http://uis.unesco.org/en/country/ci>
- von Suchodoletz, A., Uka, F., & Larsen, R. A. A. A. (2015). Self-regulation across different contexts: Findings in young Albanian children. *Early Education and Development*, 26(5–6), 829–846. <https://doi.org/10.1080/10409289.2015.1012189>
- Wachanga, S., & Mwangi, J. G. (2004). Effect of the cooperative class experiment teaching method on secondary school students' Chemistry achievement in Kenya's Nakuru district. *International Education Journal*, 5(1).
- Wang, Y., Yang, Z., Zhang, Y., Wang, F., Liu, T., & Xin, T. (2019). The effect of social-emotional competency on child development in western China. *Frontiers in Psychology*, 10, 1282. <https://doi.org/10.3389/fpsyg.2019.01282>
- Willoughby, M. T., Piper, B., Oyanga, A., & Merseth King, K. (2019). Measuring executive function skills in young children in Kenya: Associations with school readiness.

- Developmental Science*, 22(5), e12818. <https://doi.org/10.1111/desc.12818>
- Wolf, S. (2019). Year 3 follow-up of the ‘Quality Preschool for Ghana’ interventions on child development. *Developmental Psychology*, 55(12), 2587–2602.
<https://doi.org/10.1037/dev0000843>
- Wolf, S., Aber, J. L., Behrman, J. R., & Tsinigo, E. (2019). Experimental impacts of the “Quality Preschool for Ghana” interventions on teacher professional well-being, classroom quality, and children’s school readiness. *Journal of Research on Educational Effectiveness*, 12(1), 10–37. <https://doi.org/10.1080/19345747.2018.1517199>
- Wolf, S., & McCoy, D. C. (2017). Household socioeconomic status and parental investments: Direct and indirect relations with school readiness in Ghana. *Child Development*.
<https://doi.org/10.1111/cdev.12899>
- Wolf, S., & McCoy, D. C. (2019). The role of executive function and social-emotional skills in the development of literacy and numeracy during preschool: A cross-lagged longitudinal study. *Developmental Science*, 22(4), e12800. <https://doi.org/10.1111/desc.12800>
- Wolters, C. A. (2003). Regulation of motivation: Evaluating an underemphasized aspect of self-regulated learning. *Educational Psychologist*, 38(4), 189–205.
https://doi.org/10.1207/S15326985EP3804_1
- World Bank. (2018). There is no learning without prepared, motivated learners. In *World Development Report 2018: Learning to Realize Education’s Promise* (pp. 107–130). The World Bank. https://doi.org/10.1596/978-1-4648-1096-1_ch5
- Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist*, 25(1), 3–17. https://doi.org/10.1207/s15326985ep2501_2
- Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background,

methodological developments, and future prospects. *American Educational Research Journal*, 45(1), 166–183. <https://doi.org/10.3102/0002831207312909>

Zuilkowski, S. S., McCoy, D. C., Jonason, C., & Dowd, A. J. (2019). Relationships among home literacy behaviors, materials, socioeconomic status, and early literacy outcomes across 14 low- and middle-income countries. *Journal of Cross-Cultural Psychology*, 50(4), 539–555. <https://doi.org/10.1177/0022022119837363>

Table 1***Descriptive Statistics***

Variable	<i>N</i>	<i>M</i> / %	<i>SD</i>	Range
Intrinsic motivation (fall)	2,246	4.557	0.693	1 – 5
Extrinsic motivation (fall)	2,246	4.378	0.759	1 – 5
Hearts & Flowers (fall)	2,246	0.727	0.197	0 – 1
Backward digit span (fall)	2,246	2.441	0.938	1 – 6
Literacy (fall)	2,500	0.285	0.215	0 – 0.953
Literacy (spring)	2,233	0.231	0.190	0 – 0.920
Numeracy (fall)	2,500	0.576	0.214	0 – 0.983
Numeracy (spring)	2,246	0.502	0.222	0 – 0.933
<u>Covariates</u>				
Child age	2,463	8.624	2.005	3 – 18
Region	2,475	50.51 %		0 – 1
Male child	2,500	49.48 %		0 – 1
Parent treatment	2,500	50.00 %		0 – 1
Teacher treatment	2,500	51.00%		0 – 1
Parental education	2,486	4.102	4.629	0 – 16
Household income (1000 CFA/month)	2,241	77.851	90.212	5 – 350

Table 2***Bivariate Correlations Among All Study Variables***

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Intrinsic motivation	—													
2 Extrinsic motivation	.43***	—												
3 Hearts & Flowers	.15***	.00	—											
4 Backward Digit Span	.14***	.01	.31***	—										
5 Literacy (fall)	.21***	.07**	.32***	.49***	—									
6 Literacy (spring)	.25***	.11***	.38***	.53***	.76***	—								
7 Numeracy (fall)	.19***	.07**	.32***	.55***	.73***	.62***	—							
8 Numeracy (spring)	.24***	.12***	.41***	.63***	.68***	.73***	.79***	—						
9 Child age	.04	-.02	.15***	.37***	.28***	.31***	.40***	.47***	—					
10 Region	.09***	.07***	.07***	.15***	.17***	.18***	.12***	.15***	-.14***	—				
11 Male child	.00	.00	.03	.02	.01	.00	.08***	.07***	.07***	-.04	—			
12 Tx parent	.00	-.02	.03	.00	.05*	.03	.03	.01	.01	.01	-.04	—		
13 Tx teacher	.03	.04	-.06*	.02	-.02	.03	-.01	.01	.01	.01	.00	.02	—	
14 Parental education	.08***	.03	.05*	.09***	.20***	.18***	.11***	.10***	-.19***	.14***	.01	.03	.00	—
15 Household income	.06**	.02	.05*	.10***	.15***	.13***	.11***	.11***	-.07***	.12***	.02	.07***	.04	.37***

Note. Tx parent = parent intervention treatment, Tx teacher = teacher intervention treatment.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3*Standardized Coefficients for Main Pathways*

Pathway	β	SE	t	p
Direct Pathways				
Literacy (spring)				
Literacy (fall) $\rightarrow$ literacy (spring)	0.607	(0.020)	31.034	< .001
Intrinsic motivation $\rightarrow$ literacy (spring)	0.052	(0.013)	3.914	< .001
Extrinsic motivation $\rightarrow$ literacy (spring)	0.045	(0.013)	3.362	.001
EFs $\rightarrow$ literacy (spring)	0.210	(0.016)	13.069	< .001
Numeracy (spring)				
Numeracy (fall) $\rightarrow$ numeracy (spring)	0.468	(0.017)	27.123	< .001
Intrinsic motivation $\rightarrow$ numeracy (spring)	0.043	(0.012)	3.519	< .001
Extrinsic motivation $\rightarrow$ numeracy (spring)	0.055	(0.012)	4.738	< .001
EFs $\rightarrow$ numeracy (spring)	0.722	(0.113)	6.400	< .001

Table 4*Standardized Coefficients for Covariate Pathways*

Pathway	β	SE	t	p
Literacy (fall)				
Child age → literacy (fall)	0.342	0.017	20.207	< .001
Region → literacy (fall)	0.180	0.018	10.119	< .001
Male child → literacy (fall)	-0.006	0.018	-0.331	.741
Parent treatment → literacy (fall)	0.038	0.018	2.163	.031
Teacher treatment → literacy (fall)	-0.019	0.018	-1.090	.276
Parental education → literacy (fall)	0.212	0.021	10.022	< .001
Household income → literacy (fall)	0.071	0.022	3.216	.001
Numeracy (fall)				
Child age → numeracy (fall)	0.441	0.015	28.704	< .001
Region → numeracy (fall)	0.159	0.018	9.026	< .001
Male child → numeracy (fall)	0.060	0.017	3.456	.001
Parent treatment → numeracy (fall)	0.022	0.017	1.274	.202
Teacher treatment → numeracy (fall)	-0.013	0.017	-0.765	.444
Parental education → numeracy (fall)	0.139	0.020	6.922	< .001
Household income → numeracy (fall)	0.069	0.020	3.526	< .001
Literacy (spring)				
Numeracy (fall) → literacy (spring)	0.017	0.019	0.896	.370
Child age → literacy (spring)	0.070	0.015	4.714	< .001
Region → literacy (spring)	0.046	0.013	3.499	< .001
Parent treatment → literacy (spring)	-0.009	0.012	-0.751	.453
Teacher treatment → literacy (spring)	0.039	0.012	3.159	.002
Numeracy (spring)				
Literacy (fall) → numeracy (spring)	0.150	0.015	9.757	< .001
Child age → numeracy (spring)	0.160	0.012	13.018	< .001
Region → numeracy (spring)	0.043	0.011	3.849	< .001
Parent treatment → numeracy (spring)	-0.014	0.011	-1.354	.176
Teacher treatment → numeracy (spring)	0.022	0.011	2.034	.042
Intrinsic motivation				
Child age → intrinsic motivation	0.064	0.021	3.102	.002
Region → intrinsic motivation	0.097	0.020	4.778	< .001
Male child → intrinsic motivation	-0.018	0.020	-0.893	.372
Parent treatment → intrinsic motivation	0.007	0.020	0.343	.732
Teacher treatment → intrinsic motivation	0.036	0.020	1.830	.067

Pathway	β	SE	t	p
Parental education → intrinsic motivation	0.083	0.021	4.032	< .001
Household income → intrinsic motivation	0.015	0.022	0.699	.484
Extrinsic motivation				
Child age → extrinsic motivation	-0.005	0.021	-0.242	.809
Region → extrinsic motivation	0.078	0.020	3.887	< .001
Male child → extrinsic motivation	-0.004	0.020	-0.200	.841
Parent treatment → extrinsic motivation	-0.028	0.020	-1.365	.172
Teacher treatment → extrinsic motivation	0.037	0.020	1.860	.063
Parental education → extrinsic motivation	0.018	0.022	0.832	.405
Household income → extrinsic motivation	0.006	0.023	0.238	.812
Executive functioning				
Child age → EF	0.346	0.017	19.974	< .001
Region → EF	0.160	0.018	8.664	< .001
Male child → EF	0.018	0.019	0.971	.332
Parent treatment → EF	-0.003	0.019	-0.136	.892
Teacher treatment → EF	-0.029	0.018	-1.552	.121
Parental education → EF	0.108	0.021	5.174	< .001
Household income → EF	0.049	0.022	2.235	.025
Covariation				
Intrinsic motivation with literacy (fall)	0.169	0.018	9.162	< .001
Extrinsic motivation with literacy (fall)	0.064	0.021	3.098	.002
EF with literacy (fall)	0.410	0.018	23.101	< .001
Intrinsic motivation with numeracy (fall)	0.156	0.022	7.180	< .001
Extrinsic motivation with numeracy (fall)	0.075	0.021	3.536	< .001
EF with numeracy (fall)	0.438	0.017	25.544	< .001
Intrinsic motivation with EF	0.142	0.019	7.430	< .001
Extrinsic motivation with EF	0.008	0.020	0.416	.678
Intrinsic motivation with extrinsic motivation	0.434	0.021	20.529	< .001
Literacy (fall) with numeracy (fall)	0.670	0.009	71.578	< .001
Literacy (spring) with numeracy (spring)	0.354	0.018	19.664	< .001

Figure 1*Main Path Analytic Model with Standardized Estimates*

Note. Standardized estimates are presented. Covariate pathways and longitudinal pathways between literacy in the fall and numeracy in the spring, and vice versa, are not shown. $^{***} p < .001$.