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Predicting Early Academic Achievement: The Role of Teacher Ratings, Cognitive and Motor Skills, and Gender

Tamara Grgić, Haris Memisevic

University of Sarajevo- Faculty of Educational Sciences

Abstract

Early elementary education represents a critical period for the development of foundational reading and mathematics skills. This study investigated the relative contributions of teacher ratings, cognitive abilities, fine motor skills, and gender to academic achievement in a sample of 129 primary school students (Grades 2–5; M age = 9.1 years, SD = 1.2; 68 girls). Reading and mathematics performance were assessed using decoding and arithmetic tasks, respectively. Predictor variables included teacher ratings of academic performance, processing speed, visual-spatial working memory, fine motor speed, visuomotor integration, and gender. Hierarchical regression analyses revealed that teacher ratings were the strongest predictors of reading achievement but were less predictive of mathematics outcomes. Processing speed significantly predicted both reading and mathematics performance. Working memory showed no significant effect on mathematics and a negative association with reading after motor skills were included in the model, suggesting a suppression effect. Fine motor skills emerged as unique contributors to reading, but not mathematics, highlighting their specific relevance for literacy acquisition. Gender differences were observed only in mathematics, where boys outperformed girls; no significant gender effect was found for reading. These findings highlight the importance of integrating teacher evaluations with cognitive and motor assessments to gain a better understanding of early academic achievement.

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Introduction

Early elementary education is fundamental for shaping children's cognitive, social, and emotional development, providing the foundation for later academic success and overall well-being. Literacy and mathematics skills are particularly important to master at this age, as they serve as essential building blocks for more advanced learning across the curriculum. Numerous studies have established the important role of early literacy and mathematics skills in supporting later academic success, highlighting the need to understand their early predictors. Early proficiency in mathematics serves as a significant predictor of later academic achievement, with a robust association established between children's early mathematics skills and their subsequent performance in both mathematics and reading (Bodovski & Farkas, 2007; ten Braak et al., 2022). Learning to read is among the most important academic milestones in the early years of elementary education (Memisevic et al., 2019). Reading proficiency is strongly associated with later academic success, career achievement, and health outcomes, making the attainment of age-appropriate literacy skills in the early elementary grades a central educational goal for preventing future risks of school failure (Rabiner et al., 2016; Snow & Matthews, 2016). Given the importance of early literacy and mathematics, identifying the factors that support their early development is one of the central themes of educational research. While contextual factors such as socioeconomic status and home learning environments strongly influence early academic success (Ibralić et al., 2025), individual-level cognitive and behavioral characteristics remain critical for understanding within-group variability.

Among the factors most extensively studied in relation to academic success are individual differences in cognitive abilities, particularly working memory and processing speed (Memisevic et al., 2022). Working memory refers to a cognitive system responsible for the temporary storage and manipulation of information necessary for performing complex tasks such as comprehension, learning, and reasoning (Baddeley, 1992). It is considered a central component of broader memory models, though it may involve multiple interacting subsystems rather than a single unified structure. Working memory, which enables children to hold and manipulate information over short periods, has been identified as a significant predictor of mathematical problem-solving accuracy in children (Swanson & Beebe-Frankenberger, 2004). It plays a central role in multidigit arithmetic, supporting the storage of partial results and the coordination of ongoing calculation processes that cannot rely solely on long-term memory retrieval (Adams & Hitch, 2022). In addition, working memory has been associated with reading proficiency, with working memory capacity uniquely predicting word reading performance and contributing to overall reading achievement (Slattery et al., 2021).

Another cognitive predictor of early academic success that has been widely studied is the processing speed. It refers to the ability to perform simple or automated cognitive tasks quickly and efficiently, involving processes such as visual search, motor speed, eye-hand coordination,

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short-term memory, sustained attention, and learning ability (Roivainen, 2011). Processing speed is one of the major cognitive abilities that not only influences immediate academic skills but also serves as a predictor of long-term educational outcomes in children. Research has shown a strong correlation between processing speed and educational outcomes, with slower processing being correlated with lower academic achievement (Benner et al., 2007; Brydges et al., 2018; Christopher et al., 2012).

Fine motor skills are also associated with academic outcomes. They have been shown to be one of the key components of school readiness (Jones et al., 2021). Fine motor skills are necessary for the acquisition of foundational literacy and numeracy skills during the early elementary years. Research has shown that fine motor skills measured at kindergarten entry are strong and consistent predictors of later academic achievement, particularly in reading, math, and science (Grissmer et al., 2010). The observed association between fine motor skills and academic outcomes may be attributable to shared cognitive underpinnings, particularly executive and reasoning processes that support learning. This is not surprising given that fine motor skills are related to fluid intelligence at early grades of elementary school (Memisevic et al., 2023).

In addition to cognitive and motor abilities, teacher ratings represent an important source of information about students' academic skills in the early years of schooling. Some studies indicate that teacher's ratings are not a good indicator of children's academic attainment. For example, in one study teachers' ratings of children's academic achievement showed limited accuracy, with only 45% and 52% of students performing below curriculum level in reading and mathematics, respectively, correctly identified, and weak agreement with standardized educational assessments ($\kappa = 0.23$ for reading; $\kappa = 0.07$ for mathematics). (Shah et al., 2020). Also, teachers' perceptions of students' literacy skills are influenced by students' race, socioeconomic status, and gender, with significant inaccuracies particularly in lower-SES and lower-achieving classrooms, highlighting structural biases rather than teacher-level factors (Ready & Wright, 2011). On the other hand, there are studies showing that teacher evaluation ratings are positively associated with student achievement, suggesting that under certain conditions, teacher assessments can provide valid insights into students' academic performance (Milanowski, 2004). Lastly, many studies have examined the role of gender in academic achievement. Gender differences in academic performance may emerge during the elementary school years, reflecting distinct developmental trajectories for boys and girls (Carr et al., 2008). However, there are often contradictory results regarding the role of gender in early academic skills. Some studies have found that girls outperform boys in tests of both literacy and mathematics (Nakajima et al., 2020). On the other hand, other research has indicated boys advantage in mathematics but the difference was rather small (Ibralić et al., 2025). Finally, there are studies showing no gender effects on math achievement in children aged 7 to 10 years (Rosselli et al., 2009).

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While a substantial body of research has examined the role of cognitive abilities, fine motor skills, teacher ratings, and gender in relation to academic achievement, these factors are often studied in isolation, without considering their relative or combined contributions. As a result, less is known about how these domains interact in predicting early literacy and mathematics outcomes within a single analytic framework.

The present study aims to examine the relative contribution of cognitive abilities (working memory and processing speed), fine motor skills, teacher ratings, and gender to early academic achievement in literacy and mathematics.

Method

Participants

The initial sample consisted of 133 children; however, four were identified as significant multivariate outliers using Mahalanobis distance, with values exceeding the upper control limit (UCL > 3.5), and were excluded from the analyses. This resulted in a final sample of 129 children (61 boys and 68 girls) from grades 2 to 5 (mean age = 9.1 years, SD = 1.2 years). Children were recruited from 4 schools in central Bosnia and Herzegovina. Based on educational records, all children had no documented developmental disabilities or neurological conditions and were not receiving any special education services.

Procedure

The study protocol was approved by the Faculty of Educational Sciences. Four elementary schools in central Bosnia and Herzegovina were randomly selected for participation. Consent forms were distributed to the parents of children in grades 2 through 5 at these schools. Teachers provided basic demographic information for each child, and teacher evaluations were collected during the second semester (February to April 2025), ensuring that teachers had sufficient familiarity with their students' performance. Individual testing sessions were conducted in available school classrooms and lasted approximately 20 minutes per child. All children provided verbal assent to participate, and only those with written parental consent were included in the study.

Measures

Outcome measures

The outcome measure was word list reading as a measure of reading performance and arithmetic task as a measure of mathematics performance. In the reading task, children were asked to read aloud a list of real words, increasing in difficulty and length. The number of words read in 1 min was used as a dependent variable. Test-retest reliability for this task was reported to be high, above .90 (Georgiou et al., 2012).

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For the mathematics task, we used a Mathproc task from the PEBL battery (Mueller & Piper, 2014). The math processing task required children to mentally solve arithmetic expressions involving 2, 3, or 4 single-digit numbers (e.g., 4 + 3; 3 + 2 + 1; 3 + 7 + 2 – 6). After calculating the result, children had to decide whether the outcome was greater than or less than a fixed reference value, which was always 5. The result was never equal to 5. This task measured basic arithmetic fluency and numerical comparison skills, engaging children in mental computation.

Both the reading and math processing tasks are suitable for use across a wide age range, as they do not require prior standardization and allow for age-appropriate comparisons, making them practical tools for assessing core academic skills in diverse developmental stages.

Predictors

1. A computerized version of the Corsi backwards task was used as a measure of working memory (Mueller & Piper, 2014). Children were instructed to reproduce the researcher's tapping sequence in reverse order across nine identical, spatially separated blocks. Higher scores indicated better performance.
2. Processing speed was assessed using a computerized version of the letter-digit symbol substitution test from the Psychological Experiment Building Language (Mueller & Piper, 2014). In this task, nine letters are paired with nine digits displayed at the top of the screen, and children are required to press the corresponding digit keys for letters presented in random order. The task includes 30 trials and takes approximately 3 minutes to complete. Substitution tasks are widely used to measure information processing speed, which reflects the efficiency of performing basic cognitive operations (Van der Elst et al., 2012). Response time was recorded in milliseconds, with faster times indicating better performance.
3. Tapping task was used as a measure of fine motor skills. We used a computerized version of the test from the PEBL battery (Mueller & Piper, 2014). In the original version of the task, children were instructed to tap a key on the keyboard as quickly as possible using their index finger. However, due to variability in tapping methods—such as differences in finger positioning and wrist movement—we implemented a modified version of the task using a joystick. Children were instructed to tap the joystick with the thumb of their dominant hand. Each child completed three trials, and the highest number of taps recorded across trials was used as the performance measure.
4. The Pursuit Rotor Task was used to assess visual-motor coordination and manual dexterity (Mueller & Piper, 2014). In this task, children were instructed to use a computer mouse to continuously track a moving dot that followed a circular path on the screen. Each child completed three trials, and the primary outcome measure was total time on target, reflecting the duration the cursor remained accurately aligned with the moving stimulus. Again, best performance of each child was used as the performance measure.

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5. Teacher's ratings of mathematics and reading performance. A total of eight teachers rated the students from their respective classes on a scale from 1 to 10 for both mathematics and reading performance. A rating of 1 indicated that the student had not met the minimum requirements set by the national curriculum, while a rating of 10 reflected that the student excelled and had fully met all curriculum expectations for their grade level. The consistency of teacher ratings across grade levels justifies their use as a comparative measure of student performance across grades (Bukva & and Memisevic, 2025).

Statistical Analysis

To examine the unique and combined contributions of teacher ratings, cognitive abilities, and motor skills to academic performance, we conducted two separate hierarchical multiple regression analyses—one predicting mathematics achievement and the other reading achievement. Each regression model was structured in four blocks. In the first block, teacher ratings of student performance were entered to account for educators' subjective evaluations. In the second block, cognitive variables (working memory and processing speed) were added to assess their additional predictive value. In the third block, fine motor skills were included to determine their contribution beyond cognitive and observational measures. Finally, gender was entered as the final block in the hierarchical regression model to examine whether it accounted for any additional variance in academic achievement after controlling for teacher ratings, cognitive abilities, and motor skills. In case of significant effect of gender, we performed an independent t-test. To ensure comparability across different grade levels, all performance-based measures—including reading, mathematics, working memory, processing speed, and fine motor skills—were standardized within grade prior to analysis. This approach accounts for expected developmental differences and allows for meaningful comparisons across the sample. Teacher ratings were not standardized, as prior analyses indicated consistent use of the rating scale across grades, justifying their use in raw form for cross-grade comparisons. An alpha level of .05 was used to determine statistical significance for all analyses. The statistical analyses were conducted using SPSS v.27 for Windows (IBM, 2020).

Results

We first present the results of hierarchical regression analysis predicting mathematical achievement from the set of predictors. These results are shown in Table 1.

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Table 1. *Hierarchical regression model predicting mathematical achievement*

Predictors	B	SEB	β	p	R^2	$R^2_{(adjusted)}$	ΔR^2	F	F change (p)
Block 1					.02	.02	.02	3.1	3.1 (.08)
TRM	.03	.02	.15	.08					
Block 2					.18	.16	.15	8.9	11.6 (<.01)
TRM	-.01	.02	-.01	.95					
PS	-.12	.03	-.33	**<.01**					
WM	.06	.03	.17	.07					
Block 3					.19	.16	.02	5.9	1.3 (.27)
TRM	-.01	.02	-01	.97					
PS	-.11	.03	-.32	**<.01**					
WM	.05	.03	.14	.15					
Tapping	-.02	.03	-.04	.61					
PR	.05	.03	.14	.11					
Block 4					.24	.20	.05	6.4	7.2 (<.01)
TRM	.01	.02	.02	.82					
PS	-.13	.03	-.35	**<.01**					
WM	.05	.03	.15	.72					
Tapping	-.04	.03	-.11	.21					
PR	.03	.03	.08	.38					
Gender	-.16	.06	-.23	**<.01**					

Note. TRM- Teacher rating's mathematics performance; PS- Processing speed; WM- Working memory; PR- Pursue rotor task. Bolded values are statistically significant.

As can be seen from Table 1, in Block 1, teacher-rated mathematics performance (TRM) was entered first, accounting for 2% of the variance in math achievement, though the model was not statistically significant, $R^2 = .02$, $F(1, 127) = 3.10$, $p = .08$. In Block 2, cognitive variables—processing speed (PS) and working memory (WM)—were added, resulting in a significant improvement in model fit, $\Delta R^2 = .15$, F change = 11.6, $p < .01$, raising the total explained variance to 18% (adjusted $R^2 = .16$). Processing speed was a significant predictor ($\beta = –.33$, $p < .01$), with faster processing associated with higher math scores. Working memory approached significance ($\beta = .17$, $p = .07$), while teacher ratings became non-significant. In Block 3, motor skill variables (tapping and pursuit rotor) were included. This step did not significantly improve the model, $\Delta R^2 = .02$, F change = 1.3, $p = .27$. Neither tapping ($\beta = –.04$, $p = .61$) nor pursuit rotor ($\beta = .14$, $p = .11$) were significant predictors. In Block 4, gender was added as a final predictor. This resulted in a significant increase in explained variance, $\Delta R^2 = .05$, F change = 7.2, $p < .01$, bringing the final model R^2 to .24 (adjusted $R^2 = .20$). Gender was a significant predictor ($\beta = –.23$, $p < .01$), indicating that boys had higher math achievement scores compared to girls, after controlling for all other variables. Processing speed remained a strong and significant predictor in the final model ($\beta = –.35$, $p < .01$). Overall, the final model explained 24% of the variance in mathematics achievement, with processing speed and gender emerging as the most consistent and significant predictors. Variance inflation factor (VIF) values across all models remained well below 2, indicating no issues with multicollinearity. Additionally, as we found the effect of gender on mathematical

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performance, we examined the mean standardized difference between boys and girls through the independent t-test.. These results are shown in Table 2.

Table 2. Mean standardized difference between boys and girls on mathematics performance

Gender	Mean (SD)	t-test	p-value	Cohen's d
Boys	0.08 (0.40)	2.2	.027	0.4
Girls	-0.06 (0.30)			

As can be seen from the Table 2, the difference was statistically significant, and the effect size was small to medium.

In Table 3. are results of hierarchical regression analysis predicting reading performance

Table 3. *Hierarchical regression model predicting reading performance*

Predictors	B	SEB	β	p	R^2	R^2 (adjusted)	ΔR^2	F	F change (p)
Block 1					.31	.31	.31	57.76	57.76 (<.01)
TRM	.28	.04	.56	<.01					
Block 2					.392	.38	.08	26.89	8.19 (<.01)
TRM	.24	.04	.47	<.01					
PS	–.32	.08	–.31	<.01					
WM	–.06	.08	–.06	.41					
Block 3					.48	.46	.09	22.50	10.1 (<.01)
TRM	.25	.04	.49	<.01					
PS	–.26	.07	–.25	<.01					
WM	–.18	.08	–.18	.02					
Tapping	.22	.07	.23	<.01					
PR	.18	.07	.18	.01					
Block 4					.485	.459	.007	19.14	1.70 (.19)
TRM	.27	.04	.52	<.01					
PS	–.26	.07	–.26	<.01					
WM	–.18	.08	–.18	.02					
Tapping	.20	.07	.20	<.01					
PR	.15	.07	.15	.04					
Gender	–.19	.15	–.10	.19					

Note. TRM- Teacher rating's reading performance; PS- Processing speed; WM- Working memory; PR- Pursue rotor task. Bolded values are statistically significant.

In Block 1, a teacher-rated reading performance (TRM) was entered as a single predictor. This model accounted for a significant portion of the variance in reading scores, $R^2 = .31$, $F(1, 127) = 57.76$, $p < .01$. Teacher ratings were a strong and statistically significant predictor ($\beta = .56$, $p < .01$). In Block 2, cognitive variables- processing speed (PS) and working memory (WM)—were added to the model. This block significantly improved model fit, $\Delta R^2 = .08$, F change = 8.19, $p <$

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.01, increasing the total explained variance to $R^2 = .39$ (adjusted $R^2 = .38$). Processing speed remained a strong and significant predictor ($\beta = –.31$, $p < .01$), while working memory was not significant ($\beta = –.06$, $p = .41$). Teacher ratings remained a significant predictor ($\beta = .47$, $p < .01$). In Block 3, motor skills (tapping and pursuit rotor) were introduced, significantly increasing the explained variance, $\Delta R^2 = .09$, F change = 10.1, $p < .01$. Both motor skills emerged as significant predictors: tapping ($\beta = .23$, $p < .01$) and pursuit rotor ($\beta = .18$, $p = .01$). In this model, processing speed ($\beta = –.25$, $p < .01$), working memory ($\beta = –.18$, $p = .02$), and teacher ratings ($\beta = .49$, $p < .01$) all remained significant. In Block 4, gender was added as the final predictor. Although this step slightly increased the total explained variance to $R^2 = .48$ (adjusted $R^2 = .46$), the change was not statistically significant, $\Delta R^2 = .007$, F change = 1.70, $p = .19$. Gender itself was not a significant predictor ($\beta = –.10$, $p = .19$). All other predictors retained their direction and significance. Again, all VIF values across all models were well below 2, indicating no issues with multicollinearity.

Discussion

The present study examined how teacher ratings, cognitive abilities, fine motor skills, and gender are related to reading and mathematics performance in early elementary school children. Of all the predictors examined, processing speed was the only variable that emerged as a significant predictor in both reading and mathematics models, highlighting its central role in early academic achievement. In contrast, the predictive value of other variables—such as teacher ratings, working memory, fine motor skills, and gender—varied across domains, suggesting that reading and mathematics are influenced by partially distinct cognitive and behavioral processes.

Predictors of Mathematical Performance

The model predicting mathematical achievement only had two significant predictors – processing speed and gender. All other predictors were non-significant in the model. Teacher ratings of math performance were not a significant predictor of math achievement. One possible explanation is that teacher ratings likely reflect a broader and more complex set of mathematical competencies than the narrow scope of the experimental task used in this study. While the computerized math task required children to perform basic mental arithmetic and make rapid comparisons, teachers may have based their evaluations on a wider range of skills, including problem-solving strategies, understanding of mathematical concepts, classroom participation, homework performance, and persistence with tasks. As such, the mismatch between the broader construct assessed by teachers and the narrow focus of the task may explain the limited predictive value of teacher ratings in the final model. Other studies have found contradictory results regarding the validity of teachers' ratings in assessing mathematical proficiency. While some studies have reported a significant association between teacher ratings and students' mathematics performance (Helwig et al., 2001), others—consistent with the present findings—have demonstrated only weak correlations between teacher assessments and measured math skills (Eckert et al., 2006). These mixed findings highlight

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the importance of considering both the scope of teacher ratings and the specificity of assessment tools when interpreting the predictive value of observational measures in academic research.

As processing speed was a significant predictor in all models, this underscores its status as a domain-general cognitive ability that facilitates performance across academic domains by enabling faster access to, and manipulation of, information necessary for both reading and mathematical tasks. In the context of mathematics, processing speed has been linked to mathematical proficiency in many studies (Formoso et al., 2018; Lambert & Spinath, 2018; Paz-Baruch et al., 2014). Processing speed refers to the efficiency with which individuals can perceive, process, and respond to simple cognitive tasks, and it underlies the fluency of more complex mental operations. Severity of mathematical difficulties is related to processing speed deficits (Peng et al., 2018). However, a somewhat surprising finding, and contrary to most research, was that our second cognitive predictor, working memory was not related to mathematical achievement. One possible explanation is related to the very nature of mathematics task in this study. The math task involved solving simple arithmetic expressions and making binary comparisons (greater or less than), which primarily taxed basic cognitive efficiency rather than complex reasoning or problem-solving. Such tasks place a greater demand on rapid information processing and mental calculation, making processing speed more relevant than the manipulative and integrative demands typically associated with working memory. This interpretation aligns with the bottleneck theory (Peng et al., 2018), which posits that low-level cognitive processes like processing speed act as foundational gateways that support or constrain higher-order cognitive functioning. When tasks do not sufficiently engage working memory processes, its contribution to performance may be diminished, despite its broader role in academic success. Additional explanation might be that working memory—particularly the visuospatial working memory task used in this study—may have been less relevant to the math task demands. It is plausible that a verbal working memory task would have better captured the cognitive processes involved in mental arithmetic, such as temporarily storing and updating intermediate results, thus showing stronger predictive power for math achievement.

Next, although fine motor skills are a good indicator of child's overall development (Bukva & Memisevic, 2024), in this study we found no significant effect of motor skills on math performance. Most studies examining the relationship between fine motor skills and mathematics have found a positive relationship (Flores et al., 2023; Luo et al., 2007; Pitchford et al., 2016). However, majority of these studies involved preschool children, and the relationship between fine motor skills and mathematics seem to change from preschool to later elementary grades. For example, a study by Gashaj and Trninic (2023), revealed significant correlations between motor skills and math in kindergarten children and 2nd grade children, but no relationship in 4th grade children. This suggests that the influence of fine motor skills on math performance may diminish as children advance in school and cognitive factors take on a more central role in academic achievement.

Finally, gender emerged as a significant predictor of mathematics performance, with boys outperforming girls. Although the difference reached statistical significance, the effect size was in

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the small-to-moderate range. It is important to note that research on gender role in mathematics performance yielded contradicting results (Else-Quest et al., 2010; Hyde et al., 1990) It is most likely that differences, even if they do exist, are quite trivial, especially at the early elementary school level (Hyde et al., 2008; Ibralić et al., 2025). These findings suggest that while gender differences in early mathematics achievement may be statistically detectable, their practical significance remains limited, warranting cautious interpretation and further investigation.

Predictors of Reading Performance

In our reading model, all predictors, except gender, were significantly related to reading performance. Teachers' ratings of children's reading performance were the strongest predictor in the model, explaining about 30% of the variance. Earlier studies have also shown that teacher ratings may serve as a valid proxy for children's reading proficiency. (Missall et al., 2019). Evidence suggests that teacher ratings are closely aligned with students' actual performance, particularly for higher-achieving students. In contrast, teachers may find it more difficult to accurately assess the abilities of lower-performing students (Begeny et al., 2008; Feinberg & and Shapiro, 2009). The advantage of our study compared to most previous work is that teacher ratings of children's performance were not limited to broad categorical judgments (e.g., poor, moderate, good). Instead, teachers evaluated students using a more nuanced 10-point scale, allowing for greater sensitivity in capturing individual differences in academic achievement. We believe that this approach enhances both the reliability and validity of the teacher ratings, as it allows for more precise differentiation among students' performance levels.

As for the cognitive variables and its role in reading, we encountered some unexpected and contradictory results. First, the role of processing speed had a significant impact on reading performance in all models, underscoring its importance as a universal cognitive predictor of academic achievement. The wide range of literature supports this claim about the role of processing speed in reading (Catts et al., 2002; Gerst et al., 2021). In contrast, the role of working memory, particularly visual working memory, appears to be more uncertain. For example, in a study by Lobier et al. (2013), visual working memory, unlike processing speed, did not have an effect on reading speed. In our study, working memory did not have an effect on reading, when the predictors were teacher ratings, processing speed, and working memory. Interestingly, when fine motor skills variables were added to the regression model, the predictive role of working memory became negative. This counterintuitive finding is indicative of a statistical suppression effect. Although working memory and fine motor skills were not highly correlated, they may have captured overlapping cognitive processes relevant to reading. Additional explanation for lack of effect in the model with teacher ratings and cognitive factors might be in the very nature of working memory task we used. Working memory task used in this study primarily assessed visual-spatial working memory, which may be less directly related to reading performance compared to verbal working memory. Given that reading relies heavily on phonological processing and verbal rehearsal, tasks targeting verbal working memory may offer stronger predictive validity in this domain.

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Next, both fine motor tasks were predictive of reading performance. Existing literature on this relationship is mainly conducted in preschool children and 1st grade school children. Most studies have found a relationship between fine motor skills and reading (Dinehart & and Manfra, 2013). The association between fine motor skills and reading supports the notion that these abilities may rely on shared internalized motor processes (Suggate et al., 2019). It is also important to recognize that fine motor skill tasks are complex and multidimensional—engaging elements such as coordination, speed, and visual-motor integration—which likely contributes to differences in their predictive value for reading performance (Buha et al., 2023). Finally, gender did not have a significant effect on reading performance. Again, the jury is still on regarding whether there are significant gender differences in reading performance between boys and girls at early grades of elementary school. Studies have shown that girls tend to have better reading comprehension than boys (Logan & Johnston, 2009). On the other hand, there are studies with mixed results. For example, one study reported mixed gender differences in reading, with small advantages for girls in kindergarten and Grade 4, but no consistent effects across other grades (Below et al., 2010). Consistent gender differences in reading, typically favoring girls, tend to emerge at later developmental stages. For example, by age 15, more pronounced disparities in reading attainment are observed, with girls outperforming boys—a pattern clearly demonstrated in PISA assessments (Brozo et al., 2014). Taken together, these findings suggest that while gender differences in reading may become more evident in adolescence, they are less consistent in the early grades—an observation confirmed by our study, which found no significant gender effect on reading performance among younger students.

Limitations

There are several limitations in this study that need to be acknowledged. First, both reading and mathematics performance were assessed using a single task, which limits generalizability of the findings. The reading measure focused on timed word list decoding, while the math task emphasized mental arithmetic and numerical comparison. Future research would benefit from employing several tests to better reflect the multidimensional nature of reading and mathematical competencies. Second, the working memory measure used was exclusively visual-spatial, which may have underestimated its role in academic outcomes—particularly in reading, where verbal working memory is often more predictive. The limited ecological validity of the visuospatial working memory task may have contributed to the unexpected findings, including the suppression effect observed when motor skills were added to the model. Third, although teacher ratings were found to be strong predictors for reading— they are inherently subjective and may be influenced by implicit biases, prior expectations, or student behavior unrelated to academic competence. While we attempted to minimize this by using a 10-point scale to capture more nuanced evaluations, the lack of inter-rater reliability analysis across teachers limits our ability to assess rating consistency. Lastly, it is important to acknowledge that numerous other factors not addressed in this study—such as motivational and attitudinal variables, socioeconomic status, and parental

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involvement—may also influence academic achievement. Future studies would benefit from employing a broader range of academic and cognitive measures, incorporating both verbal and visuospatial working memory tasks, and using longitudinal designs that can better capture developmental patterns and causal relationships in early academic achievement.

Conclusions

This study investigated the relative contributions of teacher ratings, cognitive abilities (processing speed and working memory), fine motor skills, and gender to early academic achievement in reading and mathematics. The findings offer several important insights into the complex interplay between these factors in early schooling. First, teacher ratings proved to be strong predictors of reading but not of mathematics performance, The use of a detailed 10-point scale likely enhanced the precision of these ratings, enabling a more precise understanding of students' abilities. Second, processing speed showed a robust and consistent association with academic achievement in both reading and mathematics, reinforcing its role as a universal cognitive predictor of academic achievement. In contrast, working memory—assessed through a visual-spatial task—did not significantly predict academic outcomes and even showed a counterintuitive negative effect when fine motor skills were introduced into the reading model. This suppression effect may reflect overlapping variance and highlights the importance of using task-specific working memory measures, particularly verbal working memory in literacy-focused research. Third, fine motor skills contributed independently and significantly to reading, but not to mathematics performance,

Finally, gender had a significant effect on mathematics but not on reading performance. Boys outperformed girls in mathematics and there were no significant differences in reading performance. This finding adds to a growing body of literature suggesting that consistent gender differences in reading—typically favoring girls—may not emerge until later developmental stages.

Taken together, these findings underscore the value of combining teacher evaluations with domain-specific cognitive and fine motor measures, while also considering developmental and contextual factors such as age and gender, in understanding early academic achievement.

Conflict of interest

None.

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