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Predictive Model of Students' Intelligence Quotient (IQ) Based on Cognitive Abilities in Mathematics, Indonesian Language, and English

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ABSTRACT

Purpose – This study aims to analyze the influence of cognitive abilities in Mathematics, Indonesian Language, and English subjects on students' Intelligence Quotient (IQ).

Methodology – This study employed a quantitative approach using multiple linear regression analysis. The research data consisted of academic scores for 82 students across three subjects and their IQ scores. Prior to conducting the regression analysis, descriptive statistics and classical assumption tests were performed, including tests for normality, multicollinearity, and heteroscedasticity.

Findings – The regression analysis results from the initial model indicated that Mathematics and Indonesian Language abilities had a positive and significant effect on students' IQ. In contrast, English ability did not show a significant effect. Therefore, the regression model was simplified by including only the Mathematics and Indonesian Language variables. The final model analysis demonstrated that both variables continued to have a positive and significant effect on students' IQ. The coefficient of determination indicated that the research model explained approximately 23.3% of the variation in students' IQ.

Contribution – The findings of this study indicate that numerical and verbal abilities help explain students' cognitive abilities.

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INTRODUCTION

Intelligence Quotient (IQ) is commonly used as a psychometric indicator of students' general cognitive ability, particularly in relation to reasoning, problem-solving, information processing, and understanding new situations. However, IQ should not be interpreted as the only representation of intelligence. Contemporary perspectives view intelligence as a multidimensional construct encompassing cognitive domains such as fluid intelligence, crystallized intelligence, verbal ability, quantitative reasoning, working memory, and other cognitive processes. Within this perspective, IQ scores can be understood as an operational measure of cognitive ability rather than a complete representation of all forms of intelligence. This distinction is important because theoretical debates continue regarding the relationship among IQ, intelligence, cognitive ability, and broader concepts such as multiple intelligences (Amland et al., 2025; Biesok et al., 2024; Lozano-Blasco et al., 2022a).

In educational research, intelligence and cognitive ability are often examined in relation to students' academic achievement. Many studies have shown that cognitive ability is associated with academic success because learning in school requires reasoning, conceptual understanding, working memory, problem-solving, and information processing. Nevertheless, the relationship between intelligence and academic achievement should be interpreted carefully. In many theoretical and empirical studies, cognitive ability and IQ are often treated as predictors of academic achievement. However, academic achievement can also be examined as an observable indicator that reflects students' accumulated cognitive, verbal, and numerical abilities within specific learning contexts. Therefore, this study does not assume a causal effect of academic achievement on IQ; rather, it examines the extent to which academic abilities in core subjects can statistically explain variation in students' IQ scores (Hajovsky et al., 2023; Lemos et al., 2025; Lin & Powell, 2022).

Academic abilities in Mathematics and language are particularly relevant to cognitive development. Mathematical ability is closely related to numerical reasoning, logical thinking, quantitative processing, and problem-solving. In contrast, language ability is related to verbal comprehension, conceptual understanding, symbolic processing, and the organization of knowledge. Recent studies indicate that mathematics, reading, language skills, and cognitive abilities are interrelated in supporting students' academic development. However, the contribution of each academic domain may differ depending on the subject area, students' proficiency level, and educational context. Mathematics may reflect fluid-intelligence-related processes, whereas first-language ability may reflect crystallized knowledge and verbal comprehension developed through learning experience (Amland et al., 2025; Breit et al., 2025; Pham et al., 2025).

Most previous studies on the relationship between intelligence and academic achievement have been conducted in general school contexts rather than in Indonesian madrasah settings. This leaves an important research gap because madrasahs have distinctive educational characteristics. Madrasahs are formal educational institutions under the Ministry of Religious Affairs that combine general education with Islamic educational characteristics. In this context, students learn core subjects such as Mathematics, Indonesian Language, and English while also being situated in a religiously distinctive learning environment. Therefore, examining the relationship between academic abilities and IQ in a madrasah context is important to determine whether findings from broader educational psychology research are also reflected in Indonesian Islamic school settings.

The novelty of this study lies in its examination of the predictive contribution of three core academic abilities (Mathematics, Indonesian Language, and English) to students' IQ within the specific context of a madrasah in Sleman, Indonesia. This study is also novel because it compares the relative contributions of numerical, first-language, and foreign-language abilities to explaining variation in students' IQ scores. By doing so, the study provides empirical evidence on whether students' academic abilities in core subjects can function as statistical indicators of broader cognitive ability in the madrasah context.

Based on the aforementioned explanations, this study aims to analyze the predictive contribution of students' academic abilities in Mathematics, Indonesian Language, and English to their Intelligence Quotient (IQ), based on Academic Competency Test (TKA) scores and documented IQ test results from one madrasah in Sleman. The findings of this study are expected to provide a more careful understanding of the relationship between academic achievement and cognitive ability without assuming direct causality. In addition, the findings may inform the development of instructional strategies to strengthen numerical reasoning, verbal comprehension, and language learning, all of which are important components of students' cognitive development.

METHODOLOGY

Research Design

This study employed a quantitative approach using multiple linear regression analysis. The dependent variable in this study was students' Intelligence Quotient (IQ), while the independent variables were students' cognitive abilities in Mathematics, Indonesian Language, and English. A quantitative approach was utilized because the study aimed to statistically analyze the relationships and effects of several independent variables on the dependent variable. Regression analysis was selected because it enables researchers to measure the extent to which academic ability variables influence students' Intelligence Quotient (IQ), both individually and jointly.

Participant

This study involved one dependent variable and three independent variables. The IQ variable served as an indicator of students' general cognitive ability, obtained from IQ test results. In contrast, Mathematics, Indonesian Language, and English scores were used as indicators of students' academic abilities derived from the Academic Competency Test (TKA) conducted at a school in Yogyakarta, Indonesia. The participants in this study were students from one madrasah in Sleman who were actively enrolled at the school and had participated in both the IQ test and the Academic Competency Test (TKA). Students were eligible to be included as participants if they had complete scores on all research variables: IQ, Mathematics, Indonesian Language, and English. Therefore, students who did not participate in any of the tests or had incomplete data were excluded from the final sample. The sample consisted of 82 students selected through random sampling from a total population of 120 students who met the initial participation criteria.

Data Collection

Data were collected using a documentation technique. This technique was used because the data analyzed in this study were obtained from existing school records, namely, students' IQ test results and Academic Competency Test (TKA) scores. The IQ scores were used to represent students' general cognitive ability. In contrast, the TKA scores in Mathematics, Indonesian Language, and English were used to represent students' academic abilities in core subjects. The data were collected from students who had participated in both the IQ test and the TKA and had complete scores for all variables required in the study. Thus, the data collection process did not involve administering new tests by the researchers, but rather compiling and organizing documented test results that were relevant to the research objectives. The data collection and analysis procedures in this study are presented in Figure 1.

Instrument

The instruments used in this study consisted of students' IQ test results and Academic Competency Test (TKA) scores documented by the school. The IQ test results were used to measure students' general cognitive ability and served as the dependent variable. In contrast, the TKA scores in Mathematics, Indonesian Language, and English were used to measure students' academic abilities and served as the independent variables. Mathematics scores represented numerical and logical ability, Indonesian Language scores represented verbal comprehension and conceptual understanding, and English scores represented foreign language ability. Only students with complete data on all variables were included in the final analysis.

Data Analysis

Data analysis was conducted in R using several stages of statistical analysis. First, descriptive statistics were computed to examine the characteristics of the sample. Subsequently, classical assumption tests for multiple regression analysis were conducted, including tests for normality, multicollinearity, and heteroscedasticity. Multiple linear regression analysis was then employed to determine the effects of Mathematics (MATH), Indonesian Language (INDO), and English (ENG) variables on students' IQ. Furthermore, partial t-tests were conducted to examine whether each independent variable had a significant effect on the dependent variable. The testing criterion was that a p-value < 0.05 indicated a significant effect, whereas a p-value ≥ 0.05 indicated a non-significant effect. In addition, a simultaneous F-test was performed to determine whether all independent variables collectively influenced the dependent variable. Finally, the coefficient of determination (R^2) was calculated to measure the extent to which the independent variables explained the variation in the dependent variable.

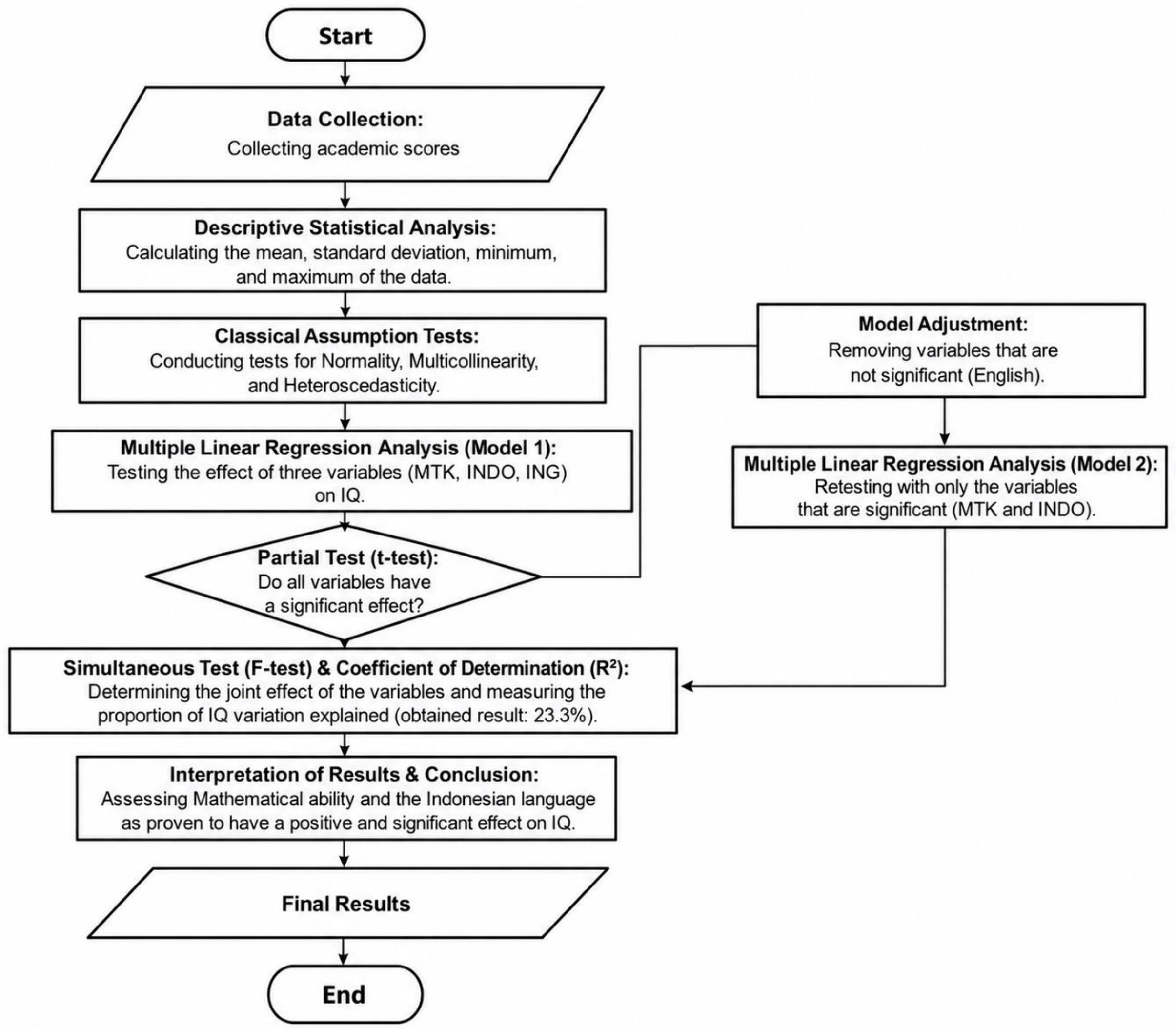

Figure 1. Research Method Flowchart

FINDINGS

Descriptive Statistics

Descriptive statistical analysis was conducted to characterize the research data. The descriptive statistics included the mean, standard deviation, minimum, and maximum for each research variable, as presented in Table 1.

Table 1. Descriptive Statistics of Research Variables

Variable	N	Mean	Std. Dev	Min	Max
MATH	82	41.55	9.14	21	67
INDO	82	67.39	8.80	43	84
ENG	82	32.90	8.12	16	56
IQ	82	95.78	6.20	83	113

The descriptive statistics showed that the mean IQ score was 95.78, with a standard deviation of 6.20, indicating a relatively moderate variation in students' IQ scores. The mean scores for Mathematics, Indonesian Language, and English were 41.55, 67.39, and 32.90, respectively. Variations in each variable indicate differences in academic abilities among the students in the study.

Normality Test

The normality test was conducted to assess whether the regression model residuals were normally distributed. The test was performed using the Shapiro–Wilk test, as presented in Table 2.

Table 2. Results of the Normality Test

Statistics	Value
Shapiro–Wilk statistic	0.989
p-value	0.686

The results presented in Table 2 show a p-value of 0.686 (> 0.05), indicating that the regression model residuals were normally distributed. Therefore, the regression model satisfied the normality assumption. The next assumption test was the multicollinearity test, conducted to identify high correlations among the independent variables. The test was performed by examining the Variance Inflation Factor (VIF) values.

Multicollinearity Test

The multicollinearity test was conducted to identify the presence of high correlations among the independent variables. This test was performed by examining the Variance Inflation Factor (VIF) values, as presented in Table 3.

Table 3. Results of the Multicollinearity Test

Variable	VIF
MATH	23.69
INDO	40.71
ENG	20.97

The results presented in Table 3 indicate that the VIF values for all independent variables exceeded 10, suggesting multicollinearity among them. This indicates that there were relatively strong correlations among the Mathematics, Indonesian Language, and English variables. The final assumption test conducted was the heteroscedasticity test, which was performed using the Breusch–Pagan test to determine whether unequal residual variances existed in the regression model.

Heteroscedasticity Test

The heteroscedasticity test was conducted to determine whether unequal residual variances existed in the regression model. The test was performed using the Breusch–Pagan test, as presented in Table 4.

Table 4. Results of the Heteroscedasticity Test

Statistics	Value
Breusch–Pagan statistic	8.44
p-value	0.037

The results presented in Table 4 show a p-value of 0.037 (< 0.05), indicating heteroscedasticity in the regression model. This suggests that the residual variances were not entirely constant. Nevertheless, the regression model could still be used to analyze the relationships among variables, provided that the results were interpreted carefully.

Multiple Linear Regression Analysis: Model 1

After the assumption tests were completed, multiple linear regression analysis was conducted to examine the influence of cognitive abilities in Mathematics (MATH), Indonesian Language (INDO), and English (ENG) on students' Intelligence Quotient (IQ). The analysis was carried out in two stages. The first stage employed a full model with three independent variables, referred to as Model 1, to examine the contribution of each variable to students' IQ. Based on the regression analysis results (see Table 5), the equation for Model 1 can be formulated as follows:

$$IQ = 72.7847 + 0.1663(MATH) + 0.2021(INDO) + 0.0749(ENG)$$

The regression analysis results for the first model showed that the Mathematics and Indonesian Language variables had positive and significant effects on students' IQ. In contrast, the English variable did not show a significant effect. Therefore, the English variable was removed from the regression model, and the regression analysis was repeated using only the Mathematics and Indonesian Language variables to obtain a simpler, more interpretable model.

Table 5. Comparison of Regression Results

Variable	Model 1 (MATH, INDO, ENG)	Model 2 (MATH, INDO)
constant	72.7847***	73.2938***
MATH	0.1663*	0.1689*
INDO	0.2021*	0.2296**
ENG	0.0749	–

**Highly significant ($p<0.01$) ; *Significant ($p<0.05$)

Model Adjustment

Based on the results of Model 1, the English variable did not show a significant effect on students' IQ. Therefore, the model was adjusted by removing the non-significant variable and retaining only Mathematics and Indonesian Language.

Table 6. Model Statistics

Statistics	Model 1	Model 2
R^2	0.233	0.233
Adjusted R^2	0.204	0.204
f-statistic	7.917	significant

Based on the model statistics presented in Table 6, the coefficient of determination (R^2) for both models was 0.233, indicating that the academic ability variables explained approximately 23.3% of the variation in students' IQ. In contrast, other factors outside the research model influenced the remaining variation. Furthermore, the Adjusted R^2 value of 0.204 indicates that, after accounting for the number of variables in the model, approximately 20.4% of the variation in students' IQ is explained by the independent variables in this study. In addition, the results of the simultaneous test (F-test) showed that the regression model as a whole was statistically significant, meaning that the independent variables collectively influenced students' IQ.

Multiple Linear Regression Analysis: Model 2

The second stage of analysis produced Model 2, a simplified version of the model that included only the variables that showed significant effects: Mathematics (MATH) and Indonesian Language (INDO). The regression equation for this final model is as follows:

$$IQ = 73.2938 + 0.1689(MATH) + 0.2296(INDO)$$

The equation of Model 2 indicates that a one-point increase in the Mathematics (MATH) score would increase the IQ score by 0.1689 points, and a one-point increase in the Indonesian Language (INDO) score would increase the IQ score by 0.2296 points, assuming other variables remain constant. The clear, directed linear relationships between each academic ability and students' IQ can be further observed in the following data distributions and linear regression lines.

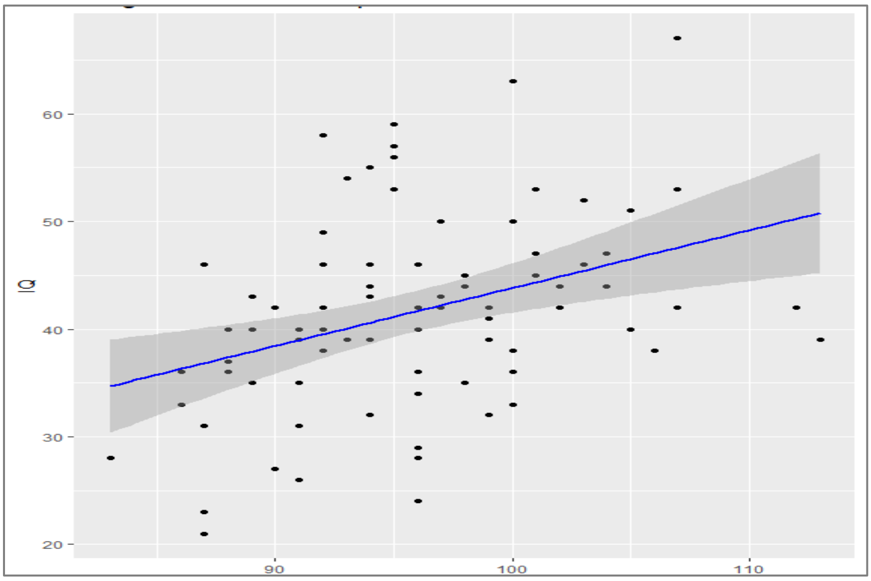

Figure 2. Linear Regression Graph of the Effect of Mathematics Ability on IQ (a)

Figure 2 shows the linear relationship between Mathematics ability and students' IQ. The scatter points represent individual students' scores, while the blue regression line indicates the general direction of the relationship between the two variables. The upward slope of the regression line suggests a positive relationship, meaning that students with higher Mathematics scores tend to have higher IQ scores. However, the spread of the data points around the regression line indicates that the relationship is not perfectly strong, suggesting that Mathematics ability is not the only factor influencing students' IQ. The grey-shaded area represents the confidence interval for the regression line, indicating the uncertainty in the estimated relationship.

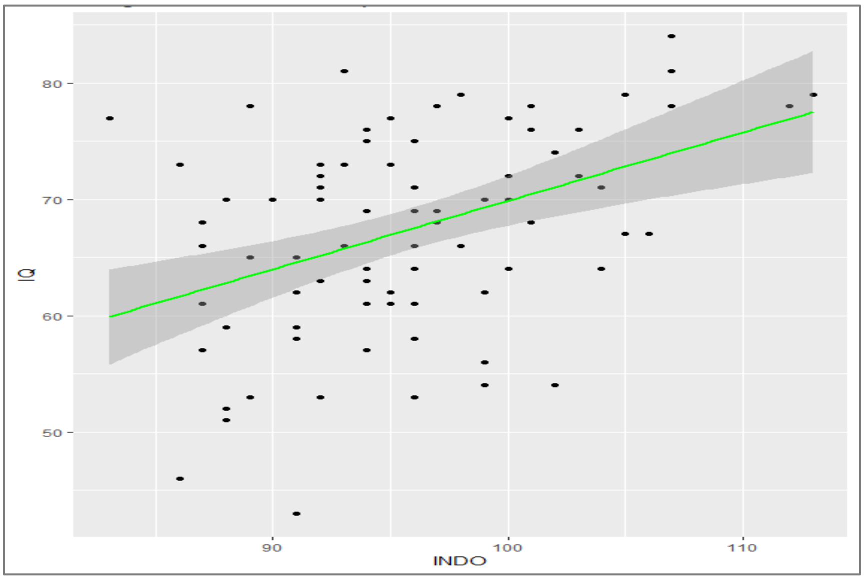

Figure 3. Linear Regression Graph of the Effect of Indonesian Language Ability on IQ (b)

Figure 3 illustrates the linear relationship between Indonesian Language ability and students' IQ. The scatter points represent individual students' Indonesian Language scores and IQ scores, while the green regression line shows the general direction of the relationship between the two variables. The upward slope of the regression line indicates a positive relationship: students with higher Indonesian Language scores tend to have higher IQ scores. This finding supports the regression result showing that Indonesian Language ability has a positive and significant effect on students' IQ. However, the data points are still spread around the regression line, indicating that Indonesian Language ability does not fully explain variations in IQ and that other factors may also contribute to students' intellectual intelligence. The grey shaded area represents the confidence interval around the regression line.

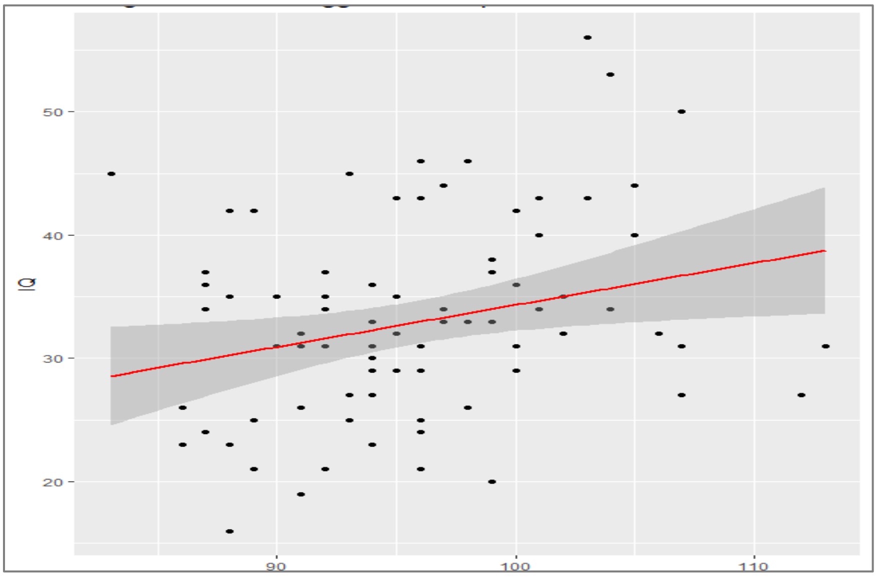

Figure 4. Linear Regression Graph of the Effect of English Ability on IQ (c)

Figure 4 illustrates the linear relationship between English ability and students' IQ. The scatter points represent individual students' English scores and IQ scores, while the red regression line shows the general direction of the relationship between the two variables. Although the regression line has a slightly upward slope, the data points are widely dispersed around the line, indicating that the relationship between English ability and IQ is relatively weak. This pattern supports the regression result showing that English ability did not have a significant effect on students' IQ. Therefore, English was excluded from the final regression model to obtain a simpler and more interpretable model. The grey-shaded area represents the confidence interval around the regression line, indicating the uncertainty in the estimated relationship.

DISCUSSION

The findings of this study indicate that academic abilities in Mathematics and Indonesian Language had a positive and significant effect on students' Intelligence Quotient (IQ). In contrast, English ability did not show a significant effect. These findings reinforce the assumption in cognitive psychology that numerical and verbal abilities are two fundamental pillars of general intelligence (g). Within the framework of modern intelligence theory, these results can be explained more comprehensively through the concepts of Fluid Intelligence (Gf) and Crystallized Intelligence (Gc), which are the primary components of the Cattell–Horn–Carroll (CHC) theory.

Mathematics as a Representation of Fluid Intelligence (Gf)

In this study, mathematical ability had a significant effect on IQ, indicating that numerical abilities are closely related to fluid intelligence (Gf). Recent studies have shown that mathematics achievement and IQ are closely associated because mathematical tasks require reasoning, quantitative processing, abstraction, and problem-solving abilities(Brandt & Lechner, 2022; Saß et al., 2021; Song & Su, 2022a). In the framework of contemporary intelligence assessment, Gf is generally understood as a process-oriented component of intelligence that involves reasoning, identifying patterns, solving novel problems, and processing unfamiliar information, rather than relying mainly on previously acquired knowledge (Ackerman, 2022). Therefore, the significant effect of Mathematics ability on IQ in this study suggests that students' mathematical performance reflects not only mastery of numerical content but also their capacity for abstract reasoning and adaptive problem-solving, which are central characteristics of fluid intelligence.

Activities in mathematics learning, such as symbol manipulation, problem-solving, and deductive reasoning, directly reflect these cognitive processes. In this process, students rely on working memory to store, update, and manipulate information as they solve mathematical tasks. Recent studies have shown that working memory is significantly associated with mathematical problem-solving and mathematics performance, particularly because students must integrate numerical information, select appropriate strategies, and monitor intermediate results during problem completion (Berkowitz et al., 2022; Ji & Guo, 2023). Furthermore, executive functions such as working memory, cognitive flexibility, and inhibitory control have been found to contribute meaningfully to mathematical performance across the developmental spectrum, indicating that mathematical learning involves higher-order cognitive control processes. This strengthens the interpretation that mathematics functions as an academic domain that reflects fluid-intelligence-related processes in learning contexts (Tette et al., 2026).

From a neurocognitive perspective, when students solve mathematical problems, they rely on working memory to temporarily store, update, and manipulate numerical and symbolic information. Recent meta-analytic evidence has shown that working memory is significantly associated with mathematical problem-solving because it supports the integration of relevant information, the selection of appropriate strategies, and the monitoring of intermediate results during problem completion (Ji & Guo, 2023). In addition, executive functions, particularly working memory, cognitive flexibility, and inhibitory control, have been found to contribute to mathematics performance across development, indicating that mathematical reasoning depends on higher-order cognitive control processes (Tette et al., 2026). Working memory is also closely related to intelligence because it supports attentional control, information integration, and complex reasoning processes, which are central to fluid-intelligence-related performance (Cochrane & Green, 2021; Frischkorn et al., 2022a). Therefore, the positive relationship between Mathematics scores and IQ found in this study indicates that mathematics performance reflects not only subject mastery but also students' cognitive capacity to process information efficiently and adaptively.

Furthermore, these findings are consistent with recent studies showing that mathematics achievement and numerical ability are closely related to general cognitive ability and fluid intelligence. This relationship can be explained by the fact that mathematical activities require integrating several executive functions, including working memory, attentional control, processing speed, and inhibitory control, which support reasoning and problem-solving (Saß et al., 2021; Song & Su, 2022a; Wang et al., 2021). Recent meta-analytic evidence also indicates that executive functions contribute to mathematics performance across development, with working memory playing a particularly important role in supporting mathematical reasoning (Tette et al., 2026). Therefore, the contribution of the Mathematics regression coefficient in the model ($\beta \approx 0.1689$) can be interpreted as an empirical indication that students' Mathematics ability reflects fluid-intelligence-related processes, particularly abstract reasoning, quantitative processing, and adaptive problem-solving.

Indonesian Language as a Representation of Crystallized Intelligence (Gc)

The finding that the Indonesian Language had a greater influence than Mathematics is particularly interesting and carries important theoretical implications. Within contemporary CHC-oriented perspectives, language-related abilities can be linked to acquired knowledge capacities, particularly comprehension knowledge and reading–writing abilities, because they involve vocabulary, semantic memory, verbal comprehension, and culturally accumulated knowledge. In this sense, first-language ability may reflect crystallized intelligence (Gc), as it is shaped by students' accumulated learning experiences, exposure to academic language, and their ability to organize and retrieve conceptual knowledge (Biesok et al., 2024; Li et al., 2024). Recent research also suggests that verbal ability contributes differently to academic achievement across educational stages, indicating that language-based cognitive abilities are important indicators of students' accumulated cognitive development (Almeida et al., 2026). Therefore, the stronger effect of the Indonesian Language in this study may indicate that students' first-language proficiency reflects not only linguistic competence but also the accumulated knowledge and conceptual understanding that support performance on IQ-related tasks.

As the students' first language and the main language of instruction, Indonesian functions as a primary medium for thinking, learning, and organizing knowledge. The ability to comprehend texts, interpret meaning, and construct arguments systematically reflects the depth of students' cognitive structures, as language supports mental representation, semantic organization, and the formation of conceptual knowledge. Recent studies suggest that language comprehension is closely related to cognitive abilities within CHC-oriented models, particularly because it involves verbal comprehension, semantic knowledge, and acquired knowledge structures (Biesok et al., 2024; Li et al., 2024). Furthermore, language ability is associated with higher-order thinking processes such as inference, comprehension monitoring, analysis, and information synthesis, which support students' broader cognitive functioning and academic development (Artuso & Belacchi, 2026; Zhao et al., 2021). Therefore, the stronger contribution of the Indonesian Language in this study may indicate that students' first-language ability reflects not only linguistic competence but also the organization of conceptual knowledge and cognitive processes relevant to general intelligence.

The higher regression coefficient for Indonesian Language ($\beta \approx 0.2296$) indicates that verbal ability contributed more substantially to explaining variation in students' IQ than numerical ability. This finding is consistent with recent studies showing that reading comprehension and language-related abilities are strongly connected to cognitive processes such as working memory updating, semantic organization, conceptual integration, and information processing (Li et al., 2024; Linares & Pelegrina, 2023). In addition, reading and cognitive skills have been shown to contribute to students' academic performance across domains, including mathematics, indicating that verbal ability may support broader cognitive and academic development rather than functioning as an isolated linguistic skill (Kritsotakis & Morfidi, 2024; Lin & Powell, 2022). This suggests that Indonesian Language ability may serve as a foundation for the development of other cognitive abilities through symbolic understanding, meaning construction, and the organization of conceptual knowledge.

In addition, from a practical perspective, proficiency in Indonesian enables students to understand the linguistic demands of IQ tests better. Several IQ subtests, particularly those involving verbal comprehension, analogical reasoning, vocabulary, and conceptual interpretation, require students to understand instructions, interpret meanings, and select answers based on accurate verbal reasoning. Recent studies on cognitive assessment and language-related abilities indicate that verbal comprehension and reading-related skills are closely linked to cognitive ability, while linguistic clarity in test items is important for maintaining the validity of test performance interpretation (Biesok et al., 2024; Caemmerer et al., 2024; Tarigan & Fadillah, 2021). Therefore, students with strong Indonesian Language abilities tend to have advantages in interpreting test items and constructing more accurate conceptual understanding, which may ultimately contribute to higher IQ scores.

The Non-Significance of English: Cognitive and Contextual Perspectives

Unlike the other two variables, English did not show a significant effect on IQ. This finding can be explained from cognitive, pedagogical, and contextual perspectives. In general, recent literature suggests that the relationship between second-language (L2) proficiency and broader cognitive performance is complex and may depend on learners' proficiency level, working memory capacity, cognitive control, and learning experience. Studies on L2 learning have shown that cognitive control and working memory may support L2 proficiency and vocabulary learning, but these relationships are influenced by learners' level of language mastery and task demands (Luque & Morgan-Short, 2021; Teng, 2024). In addition, meta-analytic evidence indicates that the cognitive advantages associated with bilingual or second-language experience are small, variable, and not always attributable solely to language status (Lowe et al., 2021). Therefore, the non-significant effect of English in this study may reflect the possibility that students' English ability has not yet developed into an automatic cognitive tool comparable to their first-language ability.

From a cognitive perspective, English as a second language (L2) may not yet have been fully internalized as an automatic tool of thought for many students. When L2 proficiency is still developing, learners often need to allocate more cognitive resources to vocabulary retrieval, syntactic processing, and meaning construction, which may increase cognitive load and reduce information-processing efficiency. Recent studies have shown that working memory and cognitive control play important roles in L2 comprehension and proficiency, particularly among learners with lower levels of linguistic knowledge (Luque & Morgan-Short, 2021; Satori, 2021). In addition, L2 performance is often influenced by proficiency level, vocabulary knowledge, and task demands, indicating that English scores may reflect technical linguistic competence more strongly than broader reasoning or problem-solving capacity (Bril et al., 2022; Teng, 2024). Therefore, the non-significant effect of English in this study may indicate that students' English ability has not yet functioned as a stable cognitive indicator comparable to Mathematics and Indonesian Language.

From a pedagogical perspective, English instruction at the secondary school level may still place considerable emphasis on vocabulary mastery and grammatical accuracy rather than on the development of critical thinking and higher-order language use. Recent studies in EFL pedagogy have shown that critical thinking in English learning is more effectively developed through instructional practices that involve argumentation, problem-solving, analytical writing, questioning, feedback, and meaningful communication, rather than through language drills alone (AlBadi et al., 2025; Yin et al., 2023; Yuan et al., 2022). As a result, English scores may not fully reflect students' broader cognitive abilities. However, they may instead be influenced by linguistic proficiency, instructional approach, learning environment, and the amount of exposure to English inside and outside the classroom (Liu & Soyoof, 2026; Muñoz & Cadierno, 2021). Therefore, the non-significant effect of English in this study may be explained by the possibility that students' English achievement reflects language-learning conditions and proficiency differences more strongly than general reasoning or intellectual ability.

Empirically, these findings are also consistent with recent literature indicating that the relationship between second-language proficiency and cognitive performance is complex and depends on learners' proficiency level, exposure, cognitive control, and task demands. Studies have shown that cognitive control may contribute to second-language proficiency. In contrast, cognitive factors such as working memory, attention, and statistical learning may predict specific aspects of L2 learning, including grammar acquisition (Chen et al., 2022; Luque & Morgan-Short, 2021). In addition, meta-analytic evidence suggests that the cognitive advantages associated with bilingual or second-language experience are small, variable, and not always directly attributable to language status alone (Lowe et al., 2021). Differences in English exposure and learning environments may also influence students' English achievement, particularly among adolescents with varying levels of access to English input inside and outside school (Muñoz & Cadierno, 2021). Therefore, removing the English variable from the final regression model was a methodologically appropriate step to improve the model's simplicity and interpretability, given that English scores in this context may reflect differences in proficiency and exposure more strongly than general intelligence.

Interpretation of the Coefficient of Determination (R^2) and Latent Factors

The coefficient of determination (R^2) value of 0.233 indicates that approximately 23.3% of the variation in students' IQ can be explained by Mathematics and Indonesian Language abilities. In the context of educational and psychological research, this value suggests meaningful but limited explanatory power, indicating that the model explains part of the variation in students' IQ but does not fully capture the complexity of intelligence development. The interpretation of this value should be approached with caution because the practical meaning of an effect size depends on the research context, the complexity of the outcome variable, and the inferential purpose of the model (Lakens, 2022). These findings are consistent with recent studies showing that academic achievement and cognitive ability are related, but the strength of this relationship may vary across academic domains, cognitive ability levels, and learning contexts (Hajovsky et al., 2023; Saß et al., 2021; Song & Su, 2022b). Therefore, the R^2 value in this study indicates that Mathematics and Indonesian Language abilities are relevant predictors of IQ, and confirms that other cognitive, environmental, motivational, and contextual factors may account for the remaining unexplained variation.

The remaining 76.7% of the variation indicates the presence of other factors not included in the model. These factors may include biological and genetic influences, socioeconomic background, family and learning environments, health-related conditions, executive functions such as working memory, attention, and processing speed, and non-cognitive factors such as motivation, self-regulation, and academic engagement. Recent studies have shown that intelligence is influenced by the interaction of schooling, socioeconomic conditions, genetic factors, and cognitive processes, indicating that students' IQ cannot be fully explained by academic subject scores alone (Frischkorn et al., 2022b; Judd et al., 2022; Sauce et al., 2021). From a cognitive perspective, working memory, processing speed, and executive processes are important mechanisms underlying individual differences in intelligence, while attention control has also been emphasized as a key component of broader cognitive ability (Frischkorn et al., 2022b; Lee & Engle, 2026). In addition, motivational and self-regulatory factors have been shown to contribute to students' academic outcomes by influencing learning persistence, strategy use, and engagement in academic tasks (Howard et al., 2021; Shao et al., 2023). Therefore, the unexplained variation in this study suggests that future research should include a broader range of cognitive, environmental, motivational, and contextual variables to obtain a more comprehensive explanation of students' IQ.

Therefore, the findings of this study confirm that academic achievement is an important indicator of cognitive ability; however, it cannot be used as the sole measure of students' intelligence. Intelligence is a multidimensional construct that encompasses the interplay among cognitive processes, academic experiences, and contextual factors, and cannot be fully captured by academic performance alone. Recent studies have shown that intelligence is related to academic performance, but this relationship may vary across domains, ability levels, and learning contexts (Hajovsky et al., 2023; Lozano-Blasco et al., 2022b). In addition, cognitive processes such as working memory, processing speed, and executive control are important mechanisms underlying differences in intelligence, suggesting that intelligence should be interpreted as broader than subject-specific achievement scores (Frischkorn et al., 2022a). Consequently, the interpretation of the research findings should consider the limitations of the regression model and the complexity of the intelligence construct in educational contexts.

Theoretical and Practical Implications in Education

The findings of this study have important implications for the development of instructional strategies in schools. First, the role of the Indonesian Language as the primary predictor of IQ indicates that literacy programs should become a priority within the educational curriculum. Recent studies have shown that literacy is not only related to reading and writing skills but also encompasses broader cognitive processes, including verbal comprehension, working memory, semantic organization, and meaning construction (Caemmerer et al., 2024; Linares & Pelegrina, 2023). Furthermore, strong literacy skills enable students to develop more complex mental representations and support the organization of conceptual knowledge, which is closely related to crystallized intelligence and broader cognitive functioning (Kritsotakis & Morfidi, 2024; Li et al., 2024). Therefore, strengthening literacy instruction in the Indonesian Language may help students improve not only their linguistic competence but also their analytical, reflective, and conceptual thinking abilities.

Second, mathematics instruction should be directed toward the development of reasoning rather than merely computational skills. Recent studies have emphasized that problem-based learning, reasoning-oriented instruction, and higher-order thinking skills (HOTS)-based approaches can support students' mathematical reasoning, problem-solving ability, and critical-analytic thinking more effectively than instruction that focuses only on procedural computation (Fitriyah et al., 2022; Loyens et al., 2023; Tanujaya et al., 2021). Such approaches require students to analyze problems, evaluate solution strategies, justify mathematical arguments, and synthesize information, all of which are closely related to higher-order cognitive processes. In addition, mathematics learning that emphasizes reasoning and problem-solving may support fluid intelligence-related processes by encouraging students to think flexibly, identify patterns, and adapt their strategies when facing novel mathematical situations (Brandt & Lechner, 2022; Saß et al., 2021). Therefore, mathematics instruction should not only strengthen computational fluency but also provide opportunities for students to engage in reasoning, exploration, and reflective problem-solving.

Third, English instruction needs to be reoriented to emphasize the use of language as a medium for communication, reasoning, and meaning-making rather than merely as an object of memorization. Recent studies in EFL pedagogy indicate that critical thinking in English learning can be developed through instructional practices that involve argumentation, contextualized writing tasks, questioning, scaffolding, feedback, and meaningful interaction (Yin et al., 2023; Yuan et al., 2022). Contextual and communicative learning experiences may also help students process English more effectively by connecting vocabulary, grammar, and meaning within authentic language-use situations. Moreover, students' English development is influenced by proficiency level, working memory, task demands, and exposure to English inside and outside the classroom (Muñoz & Cadierno, 2021; Roussel et al., 2022; Teng, 2024). Thus, when students achieve sufficient proficiency and receive meaningful exposure, English may gradually function as a cognitive tool that supports thinking processes rather than merely as a technical linguistic skill. Therefore, transforming English instructional approaches to become more contextual, communicative, and cognitively engaging represents a strategic step toward enhancing its contribution to students' cognitive development.

Research Limitations and Directions for Future Research

Although this study produced significant findings, several limitations should be acknowledged. First, the relatively limited sample size (n = 82) may affect the generalizability of the research findings. In quantitative research, sample size should be considered in relation to the inferential goals of the study, the expected effect size, statistical power, and the desired precision of parameter estimates. Therefore, the findings of this study should be interpreted with caution, as a limited sample size may reduce the stability of regression estimates and limit the generalizability of the results to a broader student population (Lakens, 2022). In addition, using students from only one madrasah may limit the variability of sample characteristics, making the model less representative of students with diverse educational, socioeconomic, and learning backgrounds.

Second, the indications of multicollinearity and heteroscedasticity suggest that the regression model still has statistical limitations. Multicollinearity may inflate the variance of regression coefficients and reduce the precision of parameter estimates, particularly when the predictors are conceptually and empirically related. Therefore, the strong relationship among Mathematics, Indonesian Language, and English scores should be considered when interpreting the contribution of each variable in the regression model. In addition, heteroscedasticity may affect the reliability of standard errors and significance testing, making robust estimation or alternative modeling strategies useful for future research (Jochmans, 2022; Salmerón-Gómez et al., 2025). Although these assumption issues do not necessarily invalidate the model, they indicate that the regression results should be interpreted with statistical caution.

Third, the variables used in this study were limited to academic aspects and therefore were unable to fully capture the complexity of the factors influencing IQ. Intelligence is a multidimensional construct influenced by cognitive, biological, environmental, and psychological factors. Recent studies have shown that schooling, socioeconomic conditions, and genetic factors may contribute to intelligence, while cognitive processes such as working memory, processing speed, and executive control are also important mechanisms underlying individual differences in intelligence (Frischkorn et al., 2022a; Judd et al., 2022; Sauce et al., 2021). In addition, non-cognitive factors such as motivation, self-regulation, and academic engagement may influence students' learning outcomes and cognitive development. Therefore, future research should include broader variables, such as family background, socioeconomic status, learning motivation, self-regulation, executive functions, and school environment, to obtain a more comprehensive understanding of the determinants of students' intelligence.

CONCLUSION

This study found that students' cognitive abilities in Mathematics and Indonesian Language had positive and significant contributions to students' IQ, whereas English cognitive ability did not show a significant contribution. Therefore, the final regression model retained only Mathematics and Indonesian Language as predictor variables. The coefficient of determination indicated that the model explained approximately 23.3% of the variation in students' IQ, suggesting that numerical and verbal abilities help explain students' cognitive ability. However, most of the variation remains attributable to other factors outside the model. These findings answer the research objective by showing that academic abilities in core subjects, particularly Mathematics and Indonesian Language, are related to students' IQ and may serve as important indicators of students' broader cognitive functioning.

REFERENCES

Ackerman, P. L. (2022). Intelligence Process vs. Content and Academic Performance: A Trip through a House of Mirrors. *Journal of Intelligence 2022, Vol. 10, Page 128*, *10*(4), 128. https://doi.org/10.3390/JINTELLIGENCE10040128

AlBadi, N. M., Nayan, N. A., & Rahman, N. A. (2025). Higher Order and Critical Thinking Skills in Asking Verbal Questions among English as a Foreign Language Teachers: A Systematic Review. *Forum for Linguistic Studies*, *7*(9), 972–984–972–984. https://doi.org/10.30564/FLS.V7I9.10709

Almeida, L. S., Lemos, G. C., Silva, A. C., & Peixoto, F. (2026). Academic Achievement in Language and Mathematics: The Role of Cognitive Abilities and Academic Self-Concept Across the Third Cycle and Secondary Education. *Journal of Intelligence 2026, Vol. 14, Page 57*, *14*(4), 57. https://doi.org/10.3390/JINTELLIGENCE14040057

Amland, T., Grande, G., Scherer, R., Lervåg, A., & Melby-Lervåg, M. (2025). Cognitive factors underlying mathematical skills: A systematic review and meta-analysis. *Psychological Bulletin*, *151*(1), 88–129. https://doi.org/10.1037/BUL0000457

Artuso, C., & Belacchi, C. (2026). Narrative text comprehension: how good and poor reading comprehenders use general working memory and specific semantic resources. *Cognitive Processing 2026*, 1–10. https://doi.org/10.1007/S10339-026-01365-1

Berkowitz, M., Edelsbrunner, P., & Stern, E. (2022). The relation between working memory and mathematics performance among students in math-intensive STEM programs. *Intelligence*, *92*, 101649. https://doi.org/10.1016/j.intell.2022.101649

Biesok, A., Ziegler, M., Montag, C., & Nenchev, I. (2024). Adding a Piece to the Puzzle? The Allocation of Figurative Language Comprehension into the CHC Model of Cognitive Abilities. *Journal of Intelligence*, *12*(3), 29. https://doi.org/10.3390/JINTELLIGENCE12030029/S1

Brandt, N. D., & Lechner, C. M. (2022). Fluid Intelligence and Competence Development in Secondary Schooling: No Evidence for a Moderating Role of Conscientiousness. *Journal of Intelligence*, *10*(2), 27. https://doi.org/10.3390/JINTELLIGENCE10020027/S1

Breit, M., Schneider, M., & Preckel, F. (2025). Mathematics achievement and learner characteristics: A systematic review of meta-analyses. *Learning and Individual Differences*, *118*, 102621. https://doi.org/10.1016/J.LINDIF.2024.102621

Bril, M., Gerrits, A., & Visser, M. (2022). The Effects Of Linguistic And Cognitive Factors On The L2 Processing Of Oral Input: A Self-Paced Listening Experiment. *International Journal of Listening*, *36*(3), 268–282. https://doi.org/10.1080/10904018.2021.1992281

Caemmerer, J. M., Scudder, A. M., Keith, T. Z., & Reynolds, M. R. (2024). Beyond Individual Tests: Youths' Cognitive Abilities, Basic Reading, and Writing. *Journal of Intelligence 2024, Vol. 12, Page 120*, *12*(11), 120. https://doi.org/10.3390/JINTELLIGENCE12110120

Chen, Y., Li, L., Wang, M., & Wang, R. (2022). Which Cognitive Factors Predict L2 Grammar Learning: Cognitive Control, Statistical Learning, Working Memory, or Attention? *Frontiers in Psychology*, *13*, 943988. https://doi.org/10.3389/FPSYG.2022.943988

Cochrane, A., & Green, C. S. (2021). Trajectories of performance change indicate multiple dissociable links between working memory and fluid intelligence. *Npj Science of Learning 2021 6:1*, *6*(1), 33-. https://doi.org/10.1038/s41539-021-00111-w

Fitriyah, I. M., Pancoro, H., Putro, S., & Apino, E. (2022). Meta-analysis study: Effectiveness of problem-based learning on Indonesian students' mathematical reasoning ability. *Jurnal Riset Pendidikan Matematika*, *9*(1), 36–45. https://doi.org/10.21831/JRPM.V9I1.46447

Frischkorn, G. T., Wilhelm, O., & Oberauer, K. (2022a). Process-oriented intelligence research: A review from the cognitive perspective. *Intelligence*, *94*, 101681. https://doi.org/10.1016/J.INTELL.2022.101681

Frischkorn, G. T., Wilhelm, O., & Oberauer, K. (2022b). Process-oriented intelligence research: A review from the cognitive perspective. *Intelligence*, *94*, 101681. https://doi.org/10.1016/J.INTELL.2022.101681

Hajovsky, D. B., Niileksela, C. R., Olsen, S. C., & Sekula, M. K. (2023). Do Cognitive–Achievement Relations Vary by General Ability Level? *Journal of Intelligence 2023, Vol. 11, Page 177*, *11*(9), 177. https://doi.org/10.3390/JINTELLIGENCE11090177

He, G., Chen, S., Lin, H., & Su, A. (2024). The association between initial metacognition and subsequent academic achievement: a meta-analysis of longitudinal studies. *Educational Psychology Review 2024 36:3*, *36*(3), 81-. https://doi.org/10.1007/S10648-024-09922-W

Howard, J. L., Bureau, J., Guay, F., Chong, J. X. Y., & Ryan, R. M. (2021). Student Motivation and Associated Outcomes: A Meta-Analysis From Self-Determination Theory. *Perspectives on Psychological Science*, *16*(6), 1300–1323. https://doi.org/10.1177/1745691620966789

Ji, Z., & Guo, K. (2023). The association between working memory and mathematical problem solving: A three-level meta-analysis. *Frontiers in Psychology*, *14*, 1091126. https://doi.org/10.3389/FPSYG.2023.1091126/FULL

Jochmans, K. (2022). Heteroscedasticity-Robust Inference in Linear Regression Models With Many Covariates. *Journal of the American Statistical Association*, *117*(538), 887–896. https://doi.org/10.1080/01621459.2020.1831924

Judd, N., Sauce, B., & Klingberg, T. (2022). Schooling substantially improves intelligence, but neither lessens nor broadens the effects of socioeconomic status and genetics. *Npj Science of Learning 2022 7:1*, *7*(1), 33-. https://doi.org/10.1038/s41539-022-00148-5

Kritsotakis, G., & Morfidi, E. (2024). Reading Comprehension and Linguistic Abilities of Children with and without Specific Learning Difficulties: Theoretical and Educational Implications. *Education Sciences 2024, Vol. 14, Page 884*, *14*(8), 884. https://doi.org/10.3390/EDUCSCI14080884

Lakens, D. (2022). Sample Size Justification. *Collabra: Psychology*, *8*(1). https://doi.org/10.1525/COLLABRA.33267/120491

Lee, Y., & Engle, R. (2026). Beyond Working Memory Capacity: Attention Control as the Underlying Mechanism of Cognitive Abilities. *Journal of Intelligence 2026, Vol. 14, Page 22*, *14*(2), 22. https://doi.org/10.3390/JINTELLIGENCE14020022

Lemos, G. C., Abad, F. J., Almeida, L. S., & Colom, R. (2014). Past and future academic experiences are related to present scholastic achievement when intelligence is controlled for. *Learning and Individual Differences*, *32*, 148–155. https://doi.org/10.1016/J.LINDIF.2014.01.004

Lemos, G. C., Guisande, M. A., & Almeida, L. S. (2025). Cognitive Abilities and School Achievement: Addressing Challenges Across Adolescence. *Journal of Intelligence 2025, Vol. 13, Page 21*, *13*(2), 21. https://doi.org/10.3390/JINTELLIGENCE13020021

Li, Y., Beaty, R. E., Luchini, S., Hu, W., & Kenett, Y. N. (2024). The role of semantic memory networks in crystallized intelligence and creative thinking ability. *Learning and Individual Differences*, *111*, 102426. https://doi.org/10.1016/J.LINDIF.2024.102426

Lin, X., Peng, P., & Zeng, J. (2021a). Understanding the relation between mathematics vocabulary and mathematics performance: A meta-analysis. *Elementary School Journal*, *121*(3), 504–540. https://doi.org/10.1086/712504

Lin, X., Peng, P., & Zeng, J. (2021b). Understanding the relation between mathematics vocabulary and mathematics performance: A meta-analysis. *Elementary School Journal*, *121*(3), 504–540. https://doi.org/10.1086/712504

Lin, X., & Powell, S. R. (2022). The Roles of Initial Mathematics, Reading, and Cognitive Skills in Subsequent Mathematics Performance: A Meta-Analytic Structural Equation Modeling Approach. *Review of Educational Research*, *92*(2), 288–325. https://doi.org/10.3102/00346543211054576

Linares, R., & Pelegrina, S. (2023). The relationship between working memory updating components and reading comprehension. *Cognitive Processing 2023 24:2*, *24*(2), 253–265. https://doi.org/10.1007/S10339-023-01127-3

Liu, G. L., & Soyoof, A. (2026). Does informal digital language learning really contribute to second language achievement? Evidence from a multilevel meta-analysis. *System*, *139*, 104036. https://doi.org/10.1016/J.SYSTEM.2026.104036

Lowe, C. J., Cho, I., Goldsmith, S. F., & Morton, J. B. (2021). The Bilingual Advantage in Children's Executive Functioning Is Not Related to Language Status: A Meta-Analytic Review. *Psychological Science*, *32*(7), 1115–1146. https://doi.org/10.1177/0956797621993108

Loyens, S. M. M., van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating Higher-Order, Critical, and Critical-Analytic Thinking in Problem- and Project-Based Learning Environments: A Systematic Review. *Educational Psychology Review 2023 35:2*, *35*(2), 39-. https://doi.org/10.1007/S10648-023-09757-X

Lozano-Blasco, R., Quílez-Robres, A., Usán, P., Salavera, C., & Casanovas-López, R. (2022a). Types of Intelligence and Academic Performance: A Systematic Review and Meta-Analysis. *Journal of Intelligence 2022, Vol. 10, Page 123*, *10*(4), 123. https://doi.org/10.3390/JINTELLIGENCE10040123

Lozano-Blasco, R., Quílez-Robres, A., Usán, P., Salavera, C., & Casanovas-López, R. (2022b). Types of Intelligence and Academic Performance: A Systematic Review and Meta-Analysis. *Journal of Intelligence*, *10*(4). https://doi.org/10.3390/JINTELLIGENCE10040123

Luque, A., & Morgan-Short, K. (2021). The relationship between cognitive control and second language proficiency. *Journal of Neurolinguistics*, *57*, 100956. https://doi.org/10.1016/J.JNEUROLING.2020.100956

Muñoz, C., & Cadierno, T. (2021). How do differences in exposure affect English language learning? A comparison of teenagers in two learning environments. *Studies in Second Language Learning and Teaching*, *11*(2), 185–212. https://doi.org/10.14746/SSLLT.2021.11.2.2

Pham, T., Joanisse, M. F., Ansari, D., Oram, J., Stager, C., & Archibald, L. M. D. (2025). Early cognitive predictors of language, literacy, and mathematics outcomes in the primary grades. *Early Childhood Research Quarterly*, *70*, 187–198. https://doi.org/10.1016/J.ECRESQ.2024.10.004

Roussel, S., Tricot, A., & Sweller, J. (2022). Disadvantages may outweigh the advantages of listening to academic content in a second language: A cognitive load theory approach. *The British Journal of Educational Psychology*, *92*(2). https://doi.org/10.1111/BJEP.12468

Salmerón-Gómez, R., García-García, C. B., & García-Pérez, J. (2025). The Raise Regression: Justification, Properties, and Application. *International Statistical Review*, *93*(1), 73–101. https://doi.org/10.1111/INSR.12575

Saß, S., Schütte, K., Kampa, N., & Köller, O. (2021). Continuous-time models support the reciprocal relationship between academic achievement and fluid intelligence over the course of a school year. *Intelligence*, *87*, 101560. https://doi.org/10.1016/J.INTELL.2021.101560

Satori, M. (2021). Effects of working memory on L2 linguistic knowledge and L2 listening comprehension. *Applied Psycholinguistics*, *42*(5), 1313–1340. https://doi.org/10.1017/S0142716421000345

Sauce, B., Wiedenhoeft, J., Judd, N., & Klingberg, T. (2021). Change by challenge: A common genetic basis behind childhood cognitive development and cognitive training. *Npj Science of Learning 2021 6:1*, *6*(1), 16-. https://doi.org/10.1038/s41539-021-00096-6

Scherrer, V., Breit, M., & Preckel, F. (2024). Crystallized Intelligence, Fluid Intelligence, and Need for Cognition: Their Longitudinal Relations in Adolescence. *Journal of Intelligence*, *12*(11). https://doi.org/10.3390/JINTELLIGENCE12110104

Shao, J., Chen, Y., Wei, X., Li, X., & Li, Y. (2023). Effects of regulated learning scaffolding on regulation strategies and academic performance: A meta-analysis. *Frontiers in Psychology*, *14*, 1110086. https://doi.org/10.3389/FPSYG.2023.1110086

Song, S., & Su, M. (2022a). The Intelligence Quotient-math achievement link: evidence from behavioral and biological research. *Current Opinion in Behavioral Sciences*, *46*, 101160. https://doi.org/10.1016/J.COBEHA.2022.101160

Song, S., & Su, M. (2022b). The Intelligence Quotient-math achievement link: evidence from behavioral and biological research. *Current Opinion in Behavioral Sciences*, *46*, 101160. https://doi.org/10.1016/J.COBEHA.2022.101160

Tanujaya, B., Prahmana, R. C. I., & Mumu, J. (2021). Mathematics Instruction to Promote Mathematics Higher-Order Thinking Skills of Students in Indonesia: Moving Forward. *TEM Journal*, *10*(4), 1945–1954. https://doi.org/10.18421/Tem104-60

Tarigan, M., & Fadillah, F. (2021). Properti Psikometri Struktur Inteligensi Ist Subtes Verbal (Satzergaenzung, Wortauswahl, Dan Analogien) Berbahasa Indonesia. *Jurnal Muara Ilmu Sosial, Humaniora, Dan Seni*, *5*(1), 63–72. https://doi.org/10.24912/JMISHUMSEN.V5I1.9623.2021

Teng, M. F. (2024). The Roles of Second-Language Proficiency Level and Working Memory on Vocabulary Learning from Word-Focused Exercises. *RELC Journal*, *55*(2), 296–312. https://doi.org/10.1177/00336882221102228

Tette, P. P. M., Justi, C. N. G., & dos Reis Justi, F. R. (2026). The relationship between executive functions and mathematics: a systematic review with meta-analysis of longitudinal studies. *Psicologia: Reflexão e Crítica 2026 39:1*, *39*(1), 3-. https://doi.org/10.1186/S41155-025-00362-1

Wang, H., Orosco, M. J., Peng, A., Long, H., Reed, D. K., & Lee Swanson, H. (2024). The relation of bilingual cognitive skills to the second language writing performance of primary grade students. *Journal of Experimental Child Psychology*, *238*. https://doi.org/10.1016/j.jecp.2023.105776

Wang, T., Li, C., Ren, X., & Schweizer, K. (2021). How Executive Processes Explain the Overlap between Working Memory Capacity and Fluid Intelligence: A Test of Process Overlap Theory. *Journal of Intelligence*, *9*(2), 21. https://doi.org/10.3390/JINTELLIGENCE9020021

Yin, X., Saad, M. R. B. M., & Halim, H. B. A. (2023). A systematic review of critical thinking instructional pedagogies in EFL writing: What do we know from a decade of research? *Thinking Skills and Creativity*, *49*, 101363. https://doi.org/10.1016/J.TSC.2023.101363

Yuan, R., Liao, W., Wang, Z., Kong, J., & Zhang, Y. (2022). How do English-as-a-foreign-language (EFL) teachers perceive and engage with critical thinking: A systematic review from 2010 to 2020. *Thinking Skills and Creativity*, *43*, 101002. https://doi.org/10.1016/J.TSC.2022.101002

Zhao, A., Guo, Y., Sun, S., Lai, M. H. C., Breit, A., & Li, M. (2021). The Contributions of Language Skills and Comprehension Monitoring to Chinese Reading Comprehension: A Longitudinal Investigation. *Frontiers in Psychology*, *12*, 625555. https://doi.org/10.3389/FPSYG.2021.625555