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Understanding Indonesian Students' Mathematics Performance: A Secondary Analysis of PISA Data

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Abstract. *Mathematics education faces global challenges in student performance, with increasing awareness that cognitive, emotional, and contextual factors significantly influence learning outcomes. Recognizing these factors is essential for improving educational strategies. This study aims to identify factors affecting the achievement of Indonesian students in mathematics based on the last three periods of PISA data: 2012, 2015, and 2018. Structural Equation Modelling (SEM) was employed in this study. The population of this study was 15-year-old Indonesian students. On the other hand, the sample consists of 5,622 students, 6,513 students, and 12,098 students for each of the three periods. The data were obtained from the OECD website. The results show a high and positive relationship between mathematics achievement, mathematics self-concept, and socioeconomic status. The medium and positive effect can be seen in the motivation variable. It has also been determined that the variable mathematics anxiety has a negative and small effect on mathematics achievement. Despite these results, this study contributes to the development of science by providing empirical evidence on the psychological and contextual factors of academic performance in developing countries, helping to inform more targeted and effective educational interventions.*

Keywords: *factors affecting PISA, mathematics literacy, PISA, structural equation model*

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Introduction

The programme for international student assessment (PISA) is a triennial international evaluation of learning outcomes conducted by the organisation for economic co-operation and development (OECD). First launched in 2000, PISA assesses the competencies of 15-year-old students in reading, mathematics, and science (OECD, 2018). Several OECD member countries, including Indonesia, participated in this assessment. However, Indonesian students consistently perform below the OECD average across all domains tested.

The purpose of PISA is not only to evaluate students' mastery of subject-specific knowledge but also to assess their ability to apply that knowledge in real-life contexts (OECD, 2018). PISA aims to measure the extent to which 15-year-old students are prepared to face the challenges of a rapidly evolving scientific and technological world (OECD, 2023). The PISA dataset offers a wealth of information beyond test scores. It provides insights into various factors that influence student achievement, such as gender, socioeconomic status, immigrant background, family environment, school context, and student attitudes (OECD, 2019a, 2019b). Despite this abundance of data, its utilization in Indonesia remains limited. Some analyses tend to focus narrowly on identity and socioeconomic variables, as seen in Pakpahan's (2016) study, overlooking other crucial factors such as mathematical anxiety, motivation, and sense of belonging.

While several international studies have identified these variables as significant predictors of mathematical performance, such as Sengul (2015) in Turkey, D'Agostino et al. (2022) in Italy, and Lee and Stankov (2013) in Australia, Indonesian research has yet to comprehensively explore them using PISA data across multiple years. This underutilization hampers the development of informed strategies to improve educational outcomes. The specific causes of Indonesian students' consistently low performance in PISA mathematics assessments have yet to be thoroughly identified. Although PISA provides detailed, reliable, and representative data, few studies have attempted a holistic analysis to uncover the full range of factors affecting achievement. As a result, each new release of PISA data is seldom revisited or reanalyzed to inform ongoing educational improvement.

Globally, researchers have explored numerous factors influencing mathematical achievement. Zhao (2011) categorized these into individual variables (e.g., mathematical anxiety), background variables (e.g., family socioeconomic status), and learning environment variables (e.g., teacher quality and instructional time). Other relevant factors include student attitudes toward mathematics, classroom climate, teaching methods (Maat et al., 2011), self-concept (Peteros et al., 2020), sense of belonging (Visser & Arends, 2019), and interest (Zhang & Wang, 2020).

Recent studies continue to broaden this perspective. Xing (2024) emphasized the interplay between personal factors (such as learning attitude, motivation, and confidence), family background (including educational support and family size), school-level factors (like teaching quality and available resources), and broader social-environmental conditions (such as socioeconomic status and urban-rural disparities). Wang et al. (2023) conducted a comprehensive literature review, finding that student grade level, socioeconomic background, absenteeism, dropout rates, teacher shortages, and instructional strategies all significantly impact mathematics achievement. Similarly, Pitsia (2022) highlighted that students' self-beliefs, engagement, and socioeconomic status are consistently linked to high mathematics performance.

Regional studies have also highlighted the influence of cultural and contextual variables. Seta et al. (2014) emphasized that gender, socioeconomic status, and economic conditions impact students' mathematical performance. Aydiner and Kalender (2015) noted that environmental factors, particularly students' sense of belonging at school, contributed to the results of Turkish students in the 2012 PISA. According to OECD (2013), "sense of belonging" refers to students' feelings of being accepted, valued, and included in their school environment, typically measured through agreement with statements like "I feel like I belong at school" and "I feel awkward and out of place at school" (reverse coded).

Additionally, Thien (2016) found that in Malaysia, female students outperformed male students in mathematics, and students from economically advantaged schools achieved better outcomes than their peers from less privileged institutions. Areepattamannil (2014) explored factors affecting the performance of Indian students in PISA 2009, initially considering variables such as gender, family background, metacognitive learning strategies, school perceptions, language, socioeconomic status, school location, and school size. The final analysis revealed that gender, family support, metacognitive strategies, and students' perceptions of the school environment were the most influential factors.

To guide the selection of variables and interpret their influence on student performance, this study adopts an integrated theoretical framework that combines Bronfenbrenner's Ecological Systems Theory (1979) with the expectancy-value theory of achievement motivation (Eccles & Wigfield, 2002). This framework supports a multifaceted approach by considering both contextual influences (such as socioeconomic status and school environment) and internal psychological factors (such as self-efficacy, interest, and anxiety). In the PISA context, self-efficacy refers to students' beliefs in their ability to perform mathematics-related tasks successfully. It is assessed through their confidence in solving applied problems, such as interpreting graphs, calculating percentages, or solving equations (OECD, 2013). This integrated approach enables a comprehensive analysis of how these interrelated elements influence students' mathematical achievement over time, as captured in PISA 2012, 2015, and 2018.

These studies demonstrate the multifaceted nature of student performance in PISA, driven by both individual and contextual variables. However, Indonesian research has yet to effectively integrate these variables. A more comprehensive analysis, especially using longitudinal data from multiple PISA cycles, could provide valuable insights into persistent achievement gaps. International research has highlighted the importance of both internal and external factors in shaping student achievement in PISA. However, Indonesian-specific studies remain limited, underscoring the need to better leverage available data for educational policy and reform.

Accordingly, this study aims to answer the following research question: To what extent do factors such as mathematics anxiety, motivation, sense of belonging, self-efficacy, socioeconomic status, mathematics self-concept, and mathematics interest influence the performance of Indonesian students in the PISA 2012, 2015, and 2018 assessments?

Method

This study employed a quantitative approach to the ex post facto type. Ex post facto research aims to identify a cause that explains changes in behavior, phenomena caused by an event, or factors that influence changes in free variables that, collectively, have occurred (Lord, 1973). Ex post facto research was also conducted using secondary data collected at a certain time (Hapsari et al., 2017; Hanke & Wichren, 2005).

The population of this study was all Indonesian students aged 15 years at the time of the PISA test. The sampling technique used in this study is a two-stage stratified sampling method. The first stage is sampling at the school unit, and the second stage is sampling students. The number of schools used as samples for this research varies from year to year. The number of students selected as samples each year also varies. In 2012, the number of respondents was 5622. In 2015, there were 10761 respondents. In 2018, there were 10,647 respondents.

The data used in this study were secondary, namely, raw data from student questionnaire responses in 2012, 2015, and 2018 obtained from the official OECD website: http://www.oecd.org/pisa/data/. Data was collected using the documentation method by accessing all Indonesian student PISA documents stored in the OECD database from 2012 to 2018. The data were selected based on their relevance to the latent variables used in this study, namely mathematics anxiety, motivation, sense of belonging, self-efficacy, socioeconomic status, mathematics self-concept, and mathematics interest. The selection of questionnaire items was guided by their function as indicators (manifest variables) representing the latent constructs. For example, to determine the effect of student anxiety levels, the selected items were those designed to measure student anxiety in the PISA questionnaire.

To ensure that the data were valid and suitable for analysis, a multi-stage data validation protocol was implemented as follows. (1) Initial screening – All available questionnaire items were reviewed, and only items aligned with the theoretical constructs were selected. Items with missing labels or non-standard coding were excluded. (2) Reverse-coding – Negatively worded items were reverse-coded to maintain consistency in scale direction. (3) Outlier detection – Extreme or inconsistent responses were detected using boxplots and Z-score methods and were reviewed for possible removal. (4) Data cleaning – The cleansing process involved identifying errors and correcting, updating, or deleting data as needed. Data (5) Final dataset construction – After all cleaning and validation steps, the final sample sizes used in the analysis were 5,173 (2012), 9,882 (2015), and 9,964 (2018), reflecting the removal of incomplete or invalid responses.

The data were analyzed statistically. The Indonesian Student PISA data trend models for 2012, 2015, and 2018 were analyzed descriptively. Meanwhile, the factors influencing students' mathematics achievement in the Indonesian PISA data were analyzed using two statistical methods: factor analysis and path analysis. The software used for analysis included Microsoft Excel 2010, SPSS 24, and AMOS 24.

It is important to note that PISA data is based on a complex sampling design and includes features such as sampling weights, replicate weights, and plausible values to account for measurement uncertainty and ensure population-level representativeness (Rutkowski, et.al, 2010). This study, however, did not fully apply the plausible value methodology or re-sampling techniques recommended for analyzing PISA cognitive test scores. As such, estimates derived from student background questionnaire data were used without adjustment for these complexities. This limitation may result in slight deviations in population parameter estimates and should be considered when interpreting the findings.

Results and Discussion

Based on the data analysis results, descriptive statistics are obtained, as shown in Table 1.

Table 1. Descriptive analysis result

		Data 2012	Data 2015	Data 2018
N	Valid	5622 (4332)	6513(5747)	12098 (10569)
	Missing	1290	766	1529
Mean		375.622	393.033	401.3764
Median		370.86	385.742	395.7616
Mode		340.87	375.13	327.57
Std.Deviation		65.653	72.547	80.45423
Minimum		159.69	168.35	85.82
Maximum		650.26	676.35	720.96

Table 1. shows that there are 1290 missing data in 2012 data, 766 missing data in 2015, and 1529 missing data in 2018 data. Given the large size of the dataset, cases with missing data were excluded from the analysis. The results of the description in the valid data show the lowest average PISA mathematics score (375,622) compared to the other two years, 393,033 for 2015 and 401,376 for 2018. Related to the minimum value, the lowest minimum value is in the 2018 data (85.82). The highest score is also in 2018 (720.96). The average and median scores every year are almost the same, so the distribution of data is close to the normal distribution.

Figure 1. shows that the average mathematical achievement of Indonesian students in 2012, 2015, and 2018 is below the average of the OECD. The difference between the average achievement of Indonesian students and the average OECD in each year is 119, 114, and 110. The average value of PISA Indonesia in 2015 increased by 11 points compared to 2012; however, it returned to a decline of 7 points in 2018. This is influenced by factors such as gender, mathematical interest, mathematical concepts, mathematical anxiety, socioeconomic status, self-efficacy, motivation, and sense of belonging. Student mathematical achievement data compared to the average mathematics OECD value for each year is presented in Table 2.

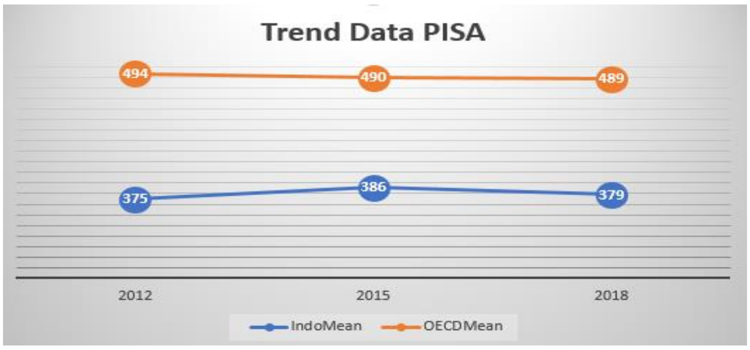

Figure 1. Trend of average Indonesian student's achievement

Table 2. Student achievement percentage based on OECD data

	2012		2015		2018	
	F	%	f	%	f	%
Above OECD average	273	4.86%	676	12%	1777	14.7%
Below the OECD average	5349	95.14%	5837	88%	10321	85.3%
Total	5622	100%	6513	100%	12098	100%

Table 2. shows that the percentage of students who achieved an average value above the OECD average remained very low, at 4.86% (273 people) in 2012, 12% (676 people) in 2015, and 14.7% (1,777 people) in 2018. Based on PISA 2012 data, out of 273 students who graduated, 120 of them were female students, and 153 others were male students. At the same time, the number of students who have an average value below the OECD average is 5,348 students (2,740 women and 2,609 men). PISA 2015 data shows that of 676 students who graduated, 365 were female students, and 311 were male. While those with an average value below the OECD average are 5,837 students (2,978 women and 2,859 men). PISA 2018 data show that of 1,777 students with grades above the average OECD, 995 are women, and 782 are men. While the number of students with an average value below the OECD average is 10,321 (5,245 women and 5,076 men).

Path models or path diagrams also show how much influence an exogenous latent variable has on endogenous variables. Kline (2005) argued that the standardized coefficient value is below 0.3 ($\beta < 0$), indicating that the associationrmed is relatively small. If the standardized coefficient value is between 0.3 and 0.5 ($0.3 \leq \beta \leq 0.5$), it means that the Hungungan formed is formed in the relative medium. Whereas if the standardized coefficient is above 0.5 ($\beta > 0.5$) means, the relationship formed is relatively large. Figure 2. presents a path model illustrating the factors that influence the mathematical achievements of Indonesian students, based on PISA 2012 data.

Figure 2. shows the motivational variables, sense of belonging, self-efficacy, socioeconomic status, mathematics self-concept, and mathematics interest have a positive relationship with math achievement, namely ($\beta = 0.01, p < 0.01$) for motivation, ($\beta = 0.21, p < 0.01$) for a sense of belonging, ($\beta = 0.20, p < 0.01$) for socioeconomic status, ($\beta = 0.39, p < 0.01$) for mathematics self-concept, ($\beta = 0.02, p < 0.01$) for mathematics interest. Whereas anxiety and self-efficacy have a negative relationship with mathematics

achievement, namely ($\beta = -0.10, p < 0.01$) for anxiety and ($\beta = -0.41, p < 0.01$) for self-efficacy. Standardized regression coefficient negative values for the anxiety variables show 1 unit of decline in student anxiety, causing an increase of 0.10 units of mathematics achievement. Models related to factors influencing Indonesian student achievement, based on PISA 2012 data, are as follows.

$$\text{Math Achievement} = -0{,}097*\textit{anxiety} + 0{,}017*\textit{motivation} + 0{,}205*\textit{sense of belonging} - 0{,}395*\textit{self-efficacy} + 0{,}203*\textit{sosioeconomic status} + 0{,}389*\textit{mathematics self concept} + 0{,}015*\textit{mathematics interest}$$

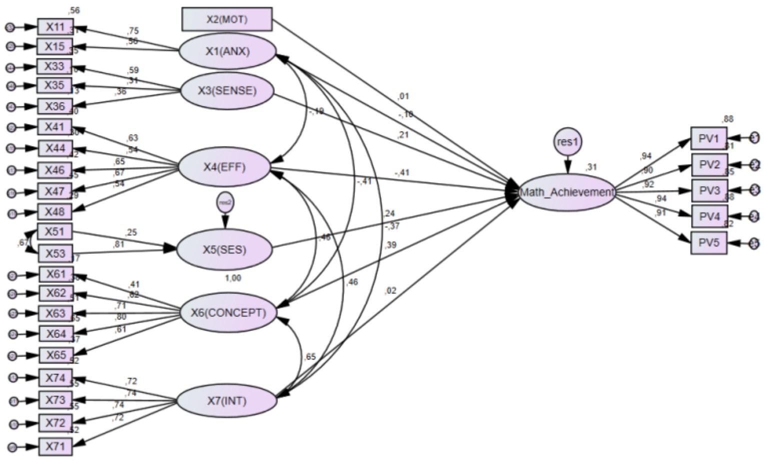

Figure 2. Path model for factors affecting Indonesian student's achievement based on PISA 2012

The model fit index indicates how well a path model fits the data that has been input. These indexes are CMIN, goodness of fit index (GFI), and root mean square error approximation (RSMEA). The results for each index are presented in Table 3. It shows that the path model that has been deemed to be a good fit. This is because the value of each index in the model is in the range of dang values recommended to state a model fit.

Table 3. Model fit indices

No.	Model Fit Indicators	Recommended score	Result	Level
1.	CMIN	Close to 1.00	1973.758	
2.	RMSEA	≤ 0.05	0.93	Good Fit
3.	GFI	0.08 – 0.10	0.93	Good Fit
4.	CFI	0.08 – 0.10	0.943	Good Fit
5.	AGFI	0.08 – 0.10	0.92	Good Fit

Figure 3. illustrates the relationships between sense of belonging, self-efficacy, and socioeconomic status with mathematics achievement based on the 2015 PISA data. Although the standardized path coefficients for sense of belonging and self-efficacy are relatively small (both at 0.02), they still indicate a positive association with mathematics performance. Socioeconomic status, on the other hand, shows a stronger effect, with a standardized regression coefficient of 0.24. This means that a one-unit increase in students' socioeconomic status is associated with a 0.24-unit increase in their mathematics achievement. The model highlights these three factors -

sense of belonging, self-efficacy, and socioeconomic status - as contributing positively, though to varying degrees, to students' mathematical performance in Indonesia based on the 2015 PISA cycle.

Math Achievement = 0,024**sense of belonging* + 0,024**self efficacy* + 0,492**sosioeconomic status*

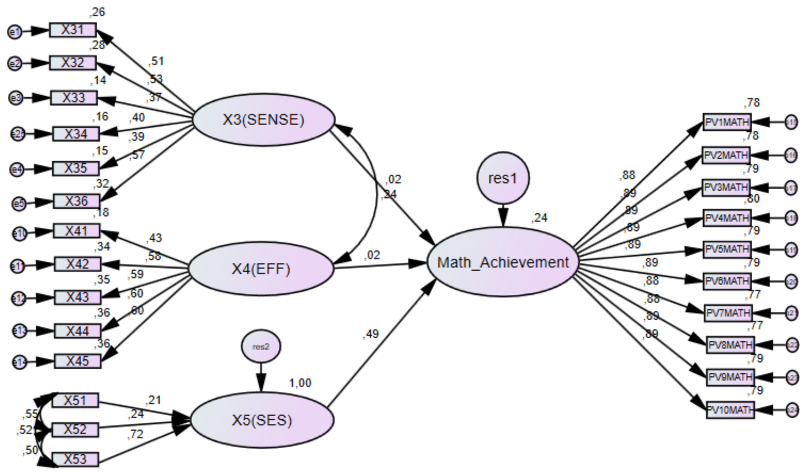

Figure 3. Path model for factors affecting Indonesian student's achievement based on PISA 2015

The model fit index indicates how well a path model fits the data that has been input. These indexes are CMIN, goodness of fit index (GFI), and root mean square error approximation (RSMEA). The results for each index are presented in Table 4.

Table 4. Model fit indices

No.	Model Fit Indicators	Recommended score	Result	Level
1.	CMIN	Closer 1.00	1521,115	
2.	RMSEA	≤ 0.05	0.92	Good Fit
3.	GFI	0.08 – 0.10	0.98	Good Fit
4.	CFI	0.08 – 0.10	0.97	Good Fit
5.	AGFI	0.08 – 0.10	0.98	Good Fit

Table 4. presents the path model that has been deemed to be a good fit. This is because the value of each index in the model is in the range of dang values recommended to state a model fit. Figure 4. presents a SEM model for factors influencing the mathematical achievements of Indonesian students, based on PISA 2018 data.

Figure 4. shows that motivation, sense of belonging, self-efficacy, socioeconomic status, mathematics self-concept, and mathematics interest have a positive relationship with math achievement, namely ($\beta = 0.01, p < 0.01$) for motivation, ($\beta = 0.21, p < 0.01$) for a sense of belonging, ($\beta = 0.20, p < 0.01$) for socioeconomic status, ($\beta = 0.39, p < 0.01$) for mathematics self-concept, ($\beta = 0.02, p < 0.01$) for mathematics interest. Whereas anxiety and self-efficacy have a negative relationship with mathematics achievement, namely ($\beta = -0.10, p < 0.01$) for anxiety and ($\beta = -0.41, p < 0.01$) for self-efficacy. Standardized

regression coefficient negative values for the anxiety variables show 1 unit of decline in student anxiety, causing an increase of 0.10 units of mathematics achievement. Models that produce factors that influence the achievements of Indonesian students based on PISA in 2018 are:

$$\text{Math Achievement} = -0{,}057{*}\textit{anxiety} + 0{,}239{*}\textit{motivation} + 0{,}050{*}\textit{sense of belonging} + 0{,}091{*}\textit{self efficacy} + 0{,}442{*}\textit{sosioeconomic status}$$

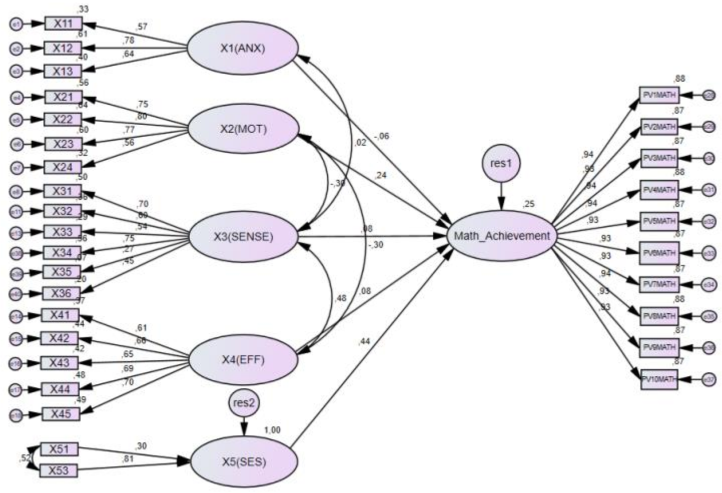

Figure 4. Path model for factors affecting Indonesian student's achievement based On PISA 2018

The model fit index indicates how well a path model fits the data that has been input. These indexes are CMIN, goodness of fit index (GFI), and root mean square error approximation (RSMEA). The results for each index are dislayed in Table 5. The path model is considered a good fit, as the value of each index falls within the recommended range for model fit.

Table 5. Model fit indices

No.	Model Fit Indicators	Recommended score	Result	Level
1.	CMIN	Dekat ke 1.00	1973,758	
2.	RMSEA	$\leq$ 0.05	0.093	Good Fit
3.	GFI	0.08 – 0.10	0.93	Good Fit
4.	CFI	0.08 – 0.10	0.943	Good Fit
5.	AGFI	0.08 – 0.10	0.92	Good Fit

The results indicate that students' anxiety hurt Indonesian students' mathematics achievement in PISA 2012 (-0.097) and PISA 2018 (-0.057), suggesting that higher anxiety levels are associated with lower academic performance, albeit with a small effect size. These findings align with Sengul (2015), who reported a stronger negative effect of anxiety (-0.30) on Turkish students' achievement. Similarly, D'Agostino et al. (2022) found that anxiety significantly influenced the performance of Italian students in mathematics and other subjects.

The relatively smaller impact observed among Indonesian students may reflect the normalization of test anxiety within an education culture that emphasizes high-stakes assessments without sufficient psychological support mechanisms. One possible explanation for these patterns lies in the structure of Indonesia's education system. Despite recent reforms, including the transition to the Kurikulum Merdeka, which promotes student-centered learning, some teachers continue to prioritize rote memorization over conceptual understanding and critical thinking.

Although the 2013 Curriculum introduced a Scientific Approach to encourage active learning, its implementation has been inconsistent, with teacher-centered methods and memorization still prevalent. This is partly due to infrastructure and resource limitations that hinder the widespread adoption of interactive pedagogies (Muhammad et al., 2023). The Kurikulum Merdeka, introduced in 2021, also emphasizes student-centered learning and aims to enhance critical thinking and problem-solving skills, yet its effectiveness is constrained by logistical and resource challenges (Hunaepi & Suharta, 2024; Ismaya & Yusritawati, 2023). These systemic shortcomings may contribute to heightened anxiety and lower student engagement in mathematics.

By contrast, Vietnam - one of Southeast Asia's highest performers in PISA, has implemented comprehensive reforms focused on curriculum development, teacher training, and higher-order thinking skills (OECD, 2018). The Vietnamese education system also prioritizes educational equity, with policies aimed at "redistribution," "representation," and "recognition" to support ethnic minority students (Luong & DeJaeghere, 2024). Indonesia continues to face significant challenges in these areas.

In Indonesia, educational equity is undermined by socioeconomic disparities, inadequate infrastructure, and systemic policy inefficiencies. While initiatives to improve access for low-income families have been introduced, their implementation remains inconsistent and often ineffective. Students from wealthier backgrounds tend to dominate top public universities, while those from low socioeconomic status (SES) backgrounds are underrepresented, despite the presence of inclusion policies (Fadhil & Sabic-El-Rayess, 2021). Although financial assistance programs exist, they frequently fall short of closing the access gap for marginalized communities (Supianto et al., 2023). In remote areas, limited educational facilities and inadequate transportation contribute to reduced student participation and retention (Supianto et al., 2023). Budget constraints and a shortage of qualified educators further compromise the quality of education (Fadhil & Sabic-El-Rayess, 2021).

Additionally, the effectiveness of policies is impeded by legal and systemic barriers (Irawan et al., 2024), and non public servant teachers face unequal compensation and job insecurity, weakening the education system (Budiman et al., 2025). Despite these obstacles, some scholars are optimistic that government reforms and community engagement could foster improvement. However, meaningful and lasting progress will require sustained commitment, innovative strategies, and inclusive policy design. The second factor, student motivation, showed a small effect on Indonesian students' performance in 2012 (0.017) but a more substantial impact in 2018 (0.239). This finding is consistent with Lee and Stankov (2013), who reported a significant effect of motivation on Australian students' PISA performance (0.12). Students who are intrinsically motivated are generally more engaged in learning, particularly in mathematics (Wang et al., 2023). The third factor, students' sense of belonging, had a modest effect on achievement, 0.205 in both 2012 and 2018 but only 0.024 in 2015. A strong sense of school connectedness can reduce stress and improve focus, ultimately benefiting academic outcomes (Aydiner & Kalender, 2015). This is consistent with Sengul (2015), who also observed a small but positive effect of belonging among Turkish students.

The fourth factor, self-efficacy, showed a large negative effect in 2012 (-0.394) but small positive effects in 2015 (0.024) and 2018 (0.091). While international studies, such as Schulz (2005), often report positive associations between self-efficacy and achievement, Indonesian students may misjudge their abilities due to underdeveloped self-regulation, resulting in overconfidence without corresponding performance (Vancouver et al., 2002). This is especially problematic given that PISA mathematics tasks emphasize reasoning over rote memorization (Firdaus et al., 2015).

Socioeconomic status (SES) emerged as another influential factor, with increasing positive effects over time, 0.203 in 2012, 0.492 in 2015, and 0.442 in 2018. SES strongly predicts access to educational resources, parental involvement, and enrichment opportunities. Similar patterns have been observed in Malaysia (Thien, 2016) and other Southeast Asian contexts. Nonetheless, individual resilience and school-level interventions, such as scholarships and targeted support—can help mitigate the disadvantages of low SES (Hansen & Strietholt, 2018).

Parental involvement also plays a critical role in academic achievement and emotional well-being (Cai, 2003; Epstein, 1986). Students whose parents value mathematics tend to persist and perform better in the subject (Hunt & Hu, 2011). This highlights the importance of educational outreach programs that encourage active parental engagement.

In 2012, the strongest predictor of mathematics achievement was students' self-concept. Students who perceive themselves as competent in mathematics generally perform better, a finding consistent with research from Turkey (Sengul, 2015) and more recent literature (Ding et al., 2022). Interest in mathematics also had a small but positive impact (0.015), echoing prior research that shows students with greater interest tend to spend more time engaging with mathematics, which can enhance their achievement. This trend was also noted by Sengul (2015) in the Turkish context.

Indonesia’s consistent underperformance in PISA emphasizes the urgent need for sustained and systemic educational reform. In the 2018 PISA cycle, Indonesia ranked 72nd out of 79 countries in mathematics, underscoring ongoing challenges in teacher quality, curriculum design, and socioeconomic inequality. Addressing these concerns requires timely and evidence-based policy responses.

The findings from this study offer several key policy recommendations. First, curriculum reform must prioritize critical thinking and problem-solving rather than rote memorization. Second, teacher training programs should emphasize classroom strategies that support student self-efficacy and alleviate anxiety. Third, equitable funding must be ensured to reduce the influence of socioeconomic disparities. Additionally, national initiatives should promote parental involvement, particularly in mathematics, to support learning at home. Lastly, psychosocial support services in schools should be expanded to address test-related stress. Vietnam's integrated strategy, which combines equitable access, teacher incentives, and curriculum alignment, serves as a valuable model for Indonesia's education policy reform.

One limitation of this study is the treatment of the PISA dataset. Although the PISA data includes a complex sampling design involving sampling and replicate weights, as well as plausible values for test performance, this study did not fully incorporate these features into the analysis. While this may not substantially alter descriptive patterns, it can affect the precision and generalizability of the findings. Future studies are encouraged to use appropriate weighting and plausible value methodologies to enhance the accuracy of their estimates.

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