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Factors Affecting Indonesian Students' Science Achievement: A Multilevel Analysis of the PISA Dataset

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Abstract: Students' science achievement is one indicator of a country's progress in science and technology. Until 2022, the Programme for International Student Assessment (PISA) survey showed that Indonesian 15-year-old students' science achievement was still lower than that of OECD countries. This study aims to explore factors related to students' science achievement at the student and school levels in Indonesia. Although it dates to 10 years, we use the PISA 2015 datasets since it is focused on science and includes several variables that are not available in either PISA 2018 or 2022. We use multilevel modeling implemented in R statistical software. We find that 50.9% of the total variance in students' science achievement is attributable to differences among students (level 1), while the remaining variance is associated with school differences (level 2). In addition, the random-slope model outperformed the random-intercept and null models. Student-level variables significantly influencing students' science achievement are gender, the socioeconomic and cultural status index, science enjoyment, self-efficacy, and epistemological beliefs about science. Meanwhile, school-level variables significant for students' science ability include school type and the disciplinary climate in science classes. Further improvements and studies are needed to increase Indonesian students' science achievement in PISA 2025.

Keywords: Indonesia; Multilevel; PISA; Science achievement

Introduction

The world has entered the Industrial Revolution 4.0, marked by rapid scientific and technological progress. Advances in Internet of Things (IoT) technology have made human life easier in various fields. This progress could not have happened without the advancement of science. Science also enables humans to seek treatment and vaccination to survive the COVID-19 pandemic. The need for science worldwide has made science an essential component of the educational curriculum in many countries (Fadilah et al., 2020; Nugraha, 2022). Science ability is closely related to understanding, knowledge, skills, and values related to science (Huryah et al., 2017).

The Programme for International Student Assessment (PISA) survey, which is routinely conducted by the Organization for Economic Cooperation and Development (OECD), shows that Indonesian students perform less satisfactorily on their science achievements (Nugraha, 2022). In 2015, the latest PISA focused on science, Indonesia scored 403 and was ranked 64th out of 69 participating countries (Pratiwi, 2019). In PISA 2018, there was a decline in Indonesian students' science achievement scores, with an average score of 396, and ranked 71st out of 79 countries (OECD, 2019). This achievement score is far below the OECD average of 489 (OECD, 2019). Furthermore, in PISA 2022, there was another decline, with Indonesia scoring an average of 383 and ranking 67th out of 81 countries. The survey also stated that 66% of Indonesian students had science

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achievements at level 1, and none had science achievements at level 6 or level 7.

The low science achievement scores of Indonesian students compared to the OECD average indicate that science progress in Indonesia is poor (Huryah et al., 2017). Low science skills cause students to be unaware of problems and changes in their environment, including natural phenomena and local characteristics of the region (Safrizal et al., 2021). Therefore, it is difficult for students to solve problems and make quick decisions (Yusmar & Fadilah, 2023). This fact is regrettable because it shows the failure of Indonesia's education system (Kurniawati, 2022). Therefore, efforts are needed to find and specify the main problems that make Indonesian students fail to compete with students in other countries (Fadilah et al., 2020).

As a large-scale education survey, PISA not only provides information on the abilities of 15-year-old students in various countries. This survey also provides student demographic data, student access to learning tools, student learning experiences at school, and things in students that are thought to be related to student abilities. PISA respondents were collected in a multistage manner from several schools, allowing for comparisons on several variables at the school level, such as school status, level (junior high school/senior high school), and school location. For example, research on PISA data shows that student background, attitudes, and school characteristics influence students' science achievement (Sun et al., 2012; You et al., 2021). Indonesian students' science achievement in PISA is also directly influenced by students' socioeconomic status, reading habits, and gender (Cahyani & Setiawan, 2024). The changing focus of PISA allows for more information about science abilities when PISA focuses on these abilities, namely in 2006, 2015, and later in 2025.

Based on the 2015 PISA study, Susongko (2020) stated that four factors influence the science achievement of Indonesian students, namely student background, science learning, student scientific attitudes, and school environment. Several researchers stated that student background can be explained by gender factors (Lau & Ho, 2022; Pitsia, 2022; Rozgonjuk et al., 2023; Sun et al., 2012) and socioeconomic and cultural status indices (Lau & Ho, 2022; Suárez-Mesa & Gómez, 2024; Susongko, 2020). Students' attitudes toward science can be explained using enjoyment in science, instrumental motivation to learn science (You et al, 2021; Dean, 2023; Susongko, 2020), self-efficacy in science (Tan, 2023; Susongko, 2020), and epistemological beliefs (She et al., 2019; Susongko, 2020). Meanwhile, factors related to learning and the school environment that influence science achievement can be explained by the disciplinary climate factor in the science classroom and inquiry-based science teaching and learning practices (Bazán-Ramírez et al., 2022; Siqi et al., 2022; Susongko, 2020; Yetişir & Bati, 2021). In addition, school type is also a school environment factor that can affect science achievement (Li et al., 2024; You et al., 2021). Li et al. (2024) using the 2015 PISA dataset showed that school characteristics have a relatively high role in the variance of students' science abilities, namely 33%.

In line with Susongko (2020) research, this article aims to deepen understanding of the factors influencing Indonesian students' science achievement in PISA 2015. It is interesting to note that Susongko (2020) uses a structural equation model to see the relationship between variables, so it has not accommodated the existence of inter-level variability. Given the PISA data structure consisting of student and school levels, this study needs to accommodate the influence of variability at both levels. For this reason, we use a multilevel analysis model in line with the research of Kartianom et al. (2017) and Kismiantini et al. (2021). The findings of this study are expected to help build an understanding of the extent to which students and schools influence students' science achievement abilities.

Method

Sample

This study used PISA 2015 science data for Indonesia, which are available at https://www.oecd.org/ pisa/data/2015database/. PISA is a triennial survey of 15-year-old students worldwide. PISA assesses the extent to which students have acquired the core knowledge and skills essential for full participation in social and economic life (OECD, 2023). PISA assessments have been conducted since 2000, and although assessments are conducted in three subjects, each assessment cycle consistently prioritizes in-depth assessment of one of the three subjects. The focus of the assessment in PISA 2015 was science. PISA uses a two-stage stratified sampling method, starting with selecting schools that represent different types of schools and demographics of a region. Next, 15-year-old students in the selected schools are taken as samples (OECD, 2017). The Indonesian sample used in this study consisted of 6513 students from 236 schools with a ratio of girls (51%) and boys (49%).

Variable Definition

The dependent variable in this study is students' science achievement scores, which are calculated as the arithmetic mean of 10 plausible values in science (Aparicio et al., 2021; Lazarević & Orlić, 2018; You et al., 2021). Plausible values are reasonable scores of students' possible abilities (OECD, 2014), considering that PISA scores are not just the proportion of correct answers but rather estimates of ability. Plausible values are randomly drawn from the marginal posterior of the latent distribution for each student using item parameters based on their estimated values from international calibrations (OECD, 2014). In PISA 2015, the ten plausible values in science were coded as PV1SCIE, PV2SCIE, PV3SCIE, PV4SCIE, PV5SCIE, PV6SCIE, PV7SCIE, PV8SCIE, PV9SCIE, and PV10SCIE (OECD, 2014). The selection of independent variables in this study was based on the results of previous studies. Table 1 present the names of the variables used in this study along with their explanations.

Table 1. Independent Variables Used in This Study

Variable name	Explanation	Code
Student-level variables		
Gender	A (re-coded) dummy for students' gender: (0 = male; 1 = female)	ST004D01T
Economic, Social, and Cultural Status	A standardized index representing students' background that consists of parents' higher education (HISEI), parents' occupation (PARED), and house possession (HOMEPOS) (OECD, 2019)	ESCS
Enjoyment of Science	A standardized index representing how students' enjoy on doing and learning science (OECD, 2016a). Student with enjoyment of science will feel enjoy and happy when learning science (Anggraini & Perdana, 2019).	JOYSCIE
Self-efficacy on science	A standardized index representing students' competence to reach the goal in a specific context that need scientific ability (OECD, 2016a). Self-efficacy on science can also be seen as a subjective grading on person's ability on doing and reaching the goal that related to science (Aditomo & Klieme, 2020).	SCIEEFF
Instrumental motivation on science	A standardized index representing students' view toward learning science as a practical and useful things for their future studies and carrier (OECD, 2016a). Instrumental motivation is a part of extrinsic motivation, with emphasis on the future goal and target (Huang et al., 2021).	INSTSCIE
Epistemic beliefs about science	A standardized index, expressing an individual's representation of the nature, organization, and sources of knowledge about what is considered true and the determination of the validity of an argument (OECD, 2016a). Epistemic beliefs about science can also be defined as students' ideas about the nature of scientific knowledge and the methods for producing and evaluating scientific knowledge (Sandoval, 2005).	EPIST
School-level variables		
School type	A dummy for school type: 1 = public (Government), or 0 = private (OECD, 2017).	SCHTYPE
Disciplinary climate in science class	A standardized index, indicating the level of regularity in science classes as well as classroom conditions that allow students to immediately engage in activities after learning begins (Grabau et al., 2021; OECD, 2017).	DISCLISCI
Inquiry-based science teaching and learning practices	A standardized index, measuring the extent to which science teachers use inquiry learning, that is, encouraging students to learn actively and engage in solving science problems using scientific methods including experiments (OECD, 2016b).	IBTEACH

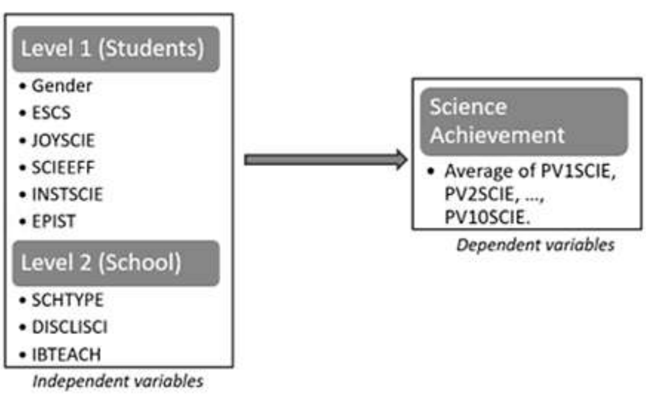

Figure 1. Framework used in this study

Enjoyment of science, self-efficacy in science, instrumental motivation to learn science, epistemological beliefs about science, disciplinary climate in science classrooms, and inquiry-based science teaching and learning practices are variables related to science learning constructed from items or student responses using a four-point Likert scale. The statement items that make up the scale and the answer choices on each scale can be seen in OECD (2017). The index of this variable about science was created using Item Response Theory (IRT) with weighted likelihood estimate (WLE) estimation (OECD, 2017). Figure 1 shows the relations between variables used in this study.

Data Analysis

PISA selects its sample based on a two-stage process involving schools as the primary sampling unit and students as the secondary sampling unit (OECD, 2017). This sampling method results in the PISA data for each country being hierarchically structured at two levels (students and schools). Multilevel modeling can account for the hierarchically structured data in the PISA dataset (Finch et al., 2024; O'Connell et al., 2022). Multilevel modeling aims to model the relationship between dependent and independent variables using observation units at different levels (Rabe-Hesketh & Skrondal, 2012). Specifically, student-related variables are treated at the first level, while school-related variables are treated at the second level. Restricted maximum likelihood (REML) is used for parameter estimation because the REML method corrects the bias arising from intercept and slope estimation by considering both as variables that must be estimated from the data so that in the comparison of multilevel models, the REML method provides a more precise estimate of the variance (Zuur et al., 2009).

Multilevel analysis was conducted to test the relationship between student and school factors related to science and their influence on students' science achievement. The null model was first constructed to examine the variance distributed at the school and student levels. The null model can be formulated as follows (Berridge & Crouchley, 2011; Finch et al., 2024; O'Connell et al., 2022):

$$Y_{ij} = \gamma_{00} + u_{0j} + \varepsilon_{ij} \quad (1)$$

where Y_{ij} represents the dependent variable (i.e., science achievement) of the i^{th} student from the j^{th} group (school), γ_{00} represents the intercept, u_{0j} is the random effect for level-two intercept, and ε_{ij} is the random effect for the i^{th} sample in the j^{th} group.

Since students were grouped within in their school, the correlation between students' scores in a school can be derived using the intraclass correlation (ICC), which can be calculated as (Berridge & Crouchley, 2011; Gelman & Hill, 2007; O'Connell et al., 2022):

$$ICC = \frac{\tau_{00}}{\tau_{00} + \sigma^2} \quad (2)$$

where τ_{00} is the between-group population variance, and σ^2 is the within-group population variance. If the ICC > 0.05, we say that the between-group population variance is larger than expected (Sorra & Dyer, 2010). In addition to the ICC, we evaluate the *design effect*, which measures how far the individual sampling error on the two-level design differs from the expected sampling error in simple random sampling, where any subject has the same probability of being chosen as a sample (Heck & Thomas, 2020). *Design effect* can be calculated as follows (Finch et al., 2024):

$$DE = 1 + (n_c - 1)\rho \quad (3)$$

where n_c is the average number of subjects in each group, and ρ is the estimated intraclass correlation. If DE > 2, we say that a multilevel model is required (Peugh, 2010).

On level 1 (student), we hypothesize that independent variables might affect students' science achievement. Therefore, we add these independent variables to the null model (1) and obtain the random intercept model. The random intercept model can be formulated as follows (Finch et al., 2024; O'Connell et al., 2022):

$$Y_{ij} = \gamma_{00} + u_{0j} + \gamma_{10}X_{ij} + \varepsilon_{ij}. \quad (4)$$

Here, γ_{00} denotes the 2[nd] level intercept, u_{0j} represents the random effect on group j, γ_{10} represents the regression coefficient, X_{ij} represents independent variables for the i^{th} subject (ie. student) in the j^{th} group, and ε_{ij} is the random effect for the i^{th} subject (ie. student) in the j^{th} group.

The 2[nd] level of independent variables (i.e. schools) was then included to obtain the random slope model. The formula of this random slope model (O'Connell et al., 2022) is as follows:

$$Y_{ij} = \gamma_{00} + \gamma_{10}X_{ij} + u_{0j} + u_{1j}X_{ij} + \varepsilon_{ij} \quad (5)$$

where $[\gamma_{00} + \gamma_{10}X_{ij}]$ represents the fixed effect and term $[u_{0j} + u_{1j}X_{ij} + \varepsilon_{ij}]$ specifies the random effect (Finch et al., 2024; O'Connell et al., 2022).

In summary, we estimate and interpret three multilevel models, namely (1) the null model, (2) the random intercept model, and (3) the random slope model. A likelihood ratio test was conducted to choose the best model based on the deviance. All estimation and calculations were implemented through R statistical software (R core team, 2023), especially using the library plyr (Wickham, 2011), dplyr (Wickham *et al.*, 2023), ggplot2 (Wickham, 2016), and intsvy (Caro & Biecek, 2017).

Result and Discussion

Descriptive Statistics

This study was conducted using PISA 2015 data involving a sample of 5,891 students from 236 schools in Indonesia. In terms of gender, the sample consisted of 3,053 (51.8%) females and 2,838 (48.2%) males. Regarding school origin, the number consisted of 3,746 (63.6%) public school students and 2,145 (36.4%) private school students. Figure 2 presents the distribution of Indonesian students' average science achievement scores in PISA 2015.

The science achievement score of Indonesian students in PISA 2015, as measured by the average plausible value, has a mean of 411, a minimum score of 226, and a maximum score of 641. As seen in Figure 2, more than 50% of Indonesian students scored below the average. When compared to the OECD average of 485, only 13% of Indonesian students had an average achievement above the OECD average. These statistics support the claim that Indonesian students' science achievement in PISA 2015 was lower than that of several other countries.

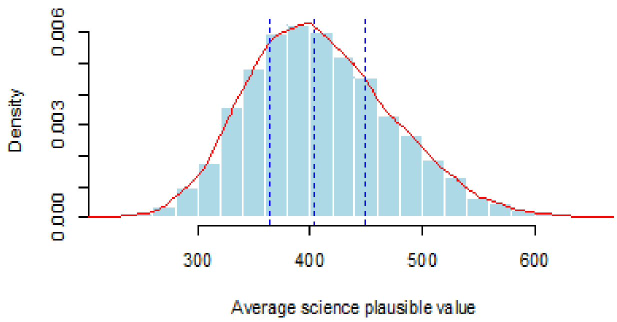

Figure 2. Distribution of average science plausible score from Indonesian students in PISA 2015. Vertical dashed line, from left to right, represents the lower quartile, median, and upper quartile, respectively

Table 2 presents descriptive statistics for the predictor variables in the form of standardized indices. Based on the overall data of PISA survey participants, the average value of each of these variables is zero, and the standard deviation is 1. Thus, on average, the socio-economic-cultural status of Indonesian students is lower than that of PISA participants from around the world. Regarding self-efficacy in science, it appears that the average and median values are negative, so it can be said that more than 50% of Indonesian students have lower self-efficacy in science compared to all students from around the world. Interestingly, the variables of self-efficacy on science and socio-economic-cultural status have more significant standard deviations and ranges than other variables, indicating high variability among PISA respondent students in Indonesia.

Table 2. Descriptive statistics of standardized index-type independent variables

Variable Name	Mean	SD	Min	Median	Max
Student-level variables					
Economic, Social, and Cultural Status (ESCS)	-1.8	1.1	-5.5	-1.9	1.9
Enjoyment of Science	0.6	0.7	-2.1	0.5	2.2
Self-efficacy on science	-0.5	1.01	-3.8	-0.5	3.3
Instrumental motivation on science	0.8	0.7	-1.9	0.8	1.7
Epistemic beliefs about science	-0.2	0.7	-2.8	-0.2	2.1
School-level variables					
Disciplinary climate in science class	0.2	0.3	-0.7	0.2	1.9
Inquiry-based science teaching and learning practices	0.2	0.2	-0.8	0.3	0.96

Multilevel Analysis

The inference analysis in this study was conducted using multilevel modeling to investigate the role of student and school factors in students' science achievement abilities. The complete results of the multilevel analysis are presented in Table 3.

The model without independent variables (null) shows a significant mean student science achievement score, $\hat{\gamma}_{00} = 407.692$ (p<0.001). The estimated student-level variance component shows the magnitude of the variation in science achievement scores across students within a school, $\hat{\sigma}^2 = 2037.069$ (p<0.001). The variance component in the mean student science achievement across schools is $\hat{\tau}_{00} = 1963.076$ (p-value=0.000<0.0). The ICC estimate of 0.491 indicates that 50.9% of the total variance in student science achievement is attributable to differences between students (level 1), and the remaining 49.1% is attributable to differences between schools (level 2). The estimated design effect result (13.358) is greater than 2, so identifying the influence of school factors on science achievement performance and identifying determinants of variability at the school level can be conducted.

Table 3. Result of Parameter Estimation on Multilevel Model

Parameter	Parameter estimation (standard error)		
	Null model	Random intercept model	Random slope model
Fixed Effects			
Level 1			
Intercept (γ_{00})	407.692 (3.030)***	412.359 (3.314)***	402.499 (5.113)***
Gender (male)		3.983 (1.242)**	4.007 (1.241)**
ESCS		5.806 (0.721)***	5.936 (0.720)***
Enjoyment of science		6.567 (0.903)***	6.513 (0.904)***
Science self-efficacy		-1.267 (0.608)*	-1.270 (0.608)*
Instrumental motivation		1.111(0.881)	1.101 (0.881)

Parameter	Parameter estimation (standard error)		
	Null model	Random intercept model	Random slope model
Epistemic belief on science		6.417 (0.902)***	6.421 (0.902)**
Level 2			
School type (public)			14,975 (5,576)**
Disciplinary climate			17,470 (7,597)*
Inquiry-based learning science			-11,256 (10,620)
	Random Effect (Variance)		
Variance on Level 1 (σ^2)	2037.069 (45.134)	1973.113 (44.420)	1973.740 (44.427)
Variance on Level 2 (τ_{00})	1963.076 (44.307)	1657.209 (40.709)	1372.014 (37.041)
Level 2			
School type (public)			1678.995 (40.975)
Disciplinary climate			303.935 (17.434)
Inquiry-based learning science			379.285 (19.475)

*** significant at α <0,001; ** significant at α < 0.01; * significant at α < 0.05

To investigate factors at the student and school levels, we include student-level independent variables in the random intercept model and include school-level independent variables in the random slope model. The results of testing the best model using the likelihood ratio test indicate that the prediction of Indonesian students' science achievement with the random slope model is significantly more in line with the data. The random slope model determines student-level and school-level factors affecting students' science achievement scores in Indonesia. Therefore, further interpretation will be carried out on the random slope model estimation results.

Student-level Factor Affecting Science Achievement

Table 3 shows a significant effect of gender on students' science achievement performance ($\hat{\beta} = 4{,}007, p < 0.01$). In other conditions, other variables being the same, male students have an average science achievement score that is 4.007 higher than female students. This finding is consistent with research conducted by (Hu et al., 2018) in Hong Kong, (Rozgonjuk et al., 2023) in Estonia, and (You et al., 2021) in the United States which showed that gender differences have a significant effect on students' science achievement. In their research in Germany, Jansen et al. (2014) also stated that male students tend to have better science achievement because female students tend to underestimate their abilities.

Regarding the economic and socio-cultural status (ESCS) index, a coefficient estimate of ($\hat{\beta} = 5{,}936, p < 0.001$) was obtained, which was also significant. The positive relationship between the ESCS index and students' science achievement indicates that students with higher socioeconomic and cultural status have higher science achievement scores. These results are in line with the research of Pitsia (2022) in Ireland, You et al. (2021) in the United States, and Ulkhaq (2023) in Indonesia. In general, when compared to middle-class or high-income students, low-income students are less likely to engage in learning-supportive activities, lack support in the growth process, and have poorer cognitive function early in life (Blums et al., 2017). In addition, Conley et al. (2004) stated that students with low socioeconomic and cultural status indices have less advanced and innovative beliefs than students with higher socioeconomic and cultural status.

Students' enjoyment of science is significantly positively related to students' science achievement performance ($\hat{\beta} = 6.512, p < 0.001$). This result is in line with research by Dean (2023) in the United Arab Emirates, Lau et al. (2022) in China and the West, Yong et al. (2023) in China, You et al. (2021) in the United States, and Yu et al. (2015) in Asia which stated that enjoyment of science is an important predictor of science achievement. In the Indonesian sample, Ulkhaq (2023) also showed that the higher the index of students' enjoyment of science, the higher the students' achievement scores. The high enjoyment of students in science motivates them to seek more knowledge in the field of science, and this encourages students' concentration and helps the learning process and students' science achievements (Anggraini & Perdana, 2019). High enjoyment in learning science, which includes stimulation and attention to important emotional aspects of enjoyment, can positively influence students' understanding in class and improve students' achievement in science (Jack & Lin, 2018). Tan (2023) showed that students who enjoy and are interested in learning science and various topics in modern science tend to be more able to understand scientific principles more efficiently and thus have high scientific achievement.

Epistemic beliefs in science significantly contribute to students' science achievement performance ($\hat{\beta} = 6.421, p < 0.001$). This finding aligns with research by Karakolidis et al. (2019) in Greece, Chai et al. (2021) in Singapore, Hong Kong, Canada, and Finland, and Guo et al. (2021) in 72 countries. The stronger students' understanding that ideas in science change over time and that scientific experiments provide a good way to verify the truth of knowledge, the better students' science achievement (She et al., 2019). Students have more positive attitudes toward science when they believe that knowledge can come from authority and that knowledge is not specific (Fulmer, 2014). Students' views that knowledge can be developed will motivate students to be active in learning, adopt a deep approach, and increase their chances of success in science achievement (Pamuk et al., 2017).

In line with Susongko (2020), the estimation of this multilevel model shows that students' self-efficacy in science has a statistically negative effect on students' science achievement performance ($\hat{\beta} = 1.267, p < 0.05$). This result may seem surprising, considering the studies of Lau et al. (2022) in China and Western, Liou (2021) and She et al. (2019) in Taiwan, Suárez-Mesa et al. (2024) in Colombia, and Lee (2023) and Tan et al. (2023) stated that self-efficacy in science is a predictor that has a positive effect on students' science achievement. Therefore, further research is needed to deepen the explanation of the relationship between self-efficacy in science and students' science achievement, especially in Indonesia.

Instrumental motivation to learn science is a statistically insignificant predictor of students' science achievement ($\hat{\beta} = 1.101, p > 0.05$). These results are in line with research by Huang et al. (2021) in East Asia, Lau et al. (2022) in China and Western, and Areepattamannil et al. (2011) in Canada. One reason for the insignificant relationship is that instrumental motivation to learn science focuses too much on obtaining external rewards (Lee et al., 2016). Students motivated by external rewards do not always perform better than their peers (Karakolidis et al., 2019), given that motivation from external rewards tends not to arouse students' interest in science (Kwarikunda et al., 2021). Instrumental motivation to learn science can also be influenced by external circumstances such as parental or teacher expectations and peer pressure (Wang & Neihart, 2015). In addition, environmental conditions may also encourage students to engage in science activities without having an interest in science, which causes the insignificance of instrumental motivation to learn science and science achievement because students may not be fully engaged in the science learning process (Areepattamannil et al., 2023).

School-level Factor Affecting Science Achievement

After analyzing and discussing student factors related to students' science achievement, the second multilevel model was applied to investigate school factors related to students' science achievement. The results of this analysis have also been presented in the random slope column in Table 3.

School type is a significant predictor of science achievement performance ($\hat{\beta} = 4.975, p < 0.01$). It appears that students from public schools have significantly higher science achievement than students from private schools. This phenomenon is also found in the United States (You et al., 2021; Lubienski et al. 2008). In Indonesia, the superiority of public schools is associated with higher quality inputs, both in terms of funding, teacher education, and other factors (Newhouse & Beegle, 2006). In addition, most public schools have certified teachers and participate more in professional development (Lubienski et al., 2008).

The science discipline climate index statistically significantly predicts students' science achievement performance ($\hat{\beta} = 17.470, p < 0.001$). These results are in line with the research of Grabau et al. (2021) in Finland and Yetişir et al. (2021) in Turkey, which stated that the emphasis on improving the disciplinary climate in learning science has the potential to be a productive approach to improving science achievement in a national context.

Interestingly, the practice of inquiry-based science teaching and learning in schools does not significantly affect students' science achievement performance, even with a negative coefficient ($\hat{\beta} = -11.256, p > 0.05$). Research by She et al. (2019) in Taiwan shows that inquiry-based practices tend to be rarely implemented in schools, so they are challenging to be a decisive factor in predicting students' science achievement performance. The negative relationship between inquiry-based science teaching and learning practices is most likely caused by a combination of undirected inquiries (Aditomo & Klieme, 2020). In addition, teachers often do not apply inquiry teaching science due to lack of time, confidence, effective inquiry materials, time-consuming pedagogical limitations, and management problems (Cheung, 2007). As a result, inquiry learning is considered ineffective enough to be used as a method and model in science learning (Areepattamannil et al., 2011; Rustaman, 2005). Kirschner et al. (2006) argue that inquiry-based teaching practices under inadequate teacher support can lead to excessive cognitive load, thereby distracting students from learning.

Implication, Limitation, and Future Studies

This study shows that several variables significantly influence students' science achievement in Indonesia. At the student level, five variables were identified as significant, namely gender, socio-economic status, enjoyment of science, self-efficacy in science, and epistemological beliefs about science. By looking at the magnitude of the coefficient, the variables of enjoyment in science and students' epistemological beliefs about science have a more significant contribution to students' science achievement. This result indicates that efforts to improve students' science achievement must be accompanied by increasing students' enjoyment of learning science, for example, by implementing fun science learning strategies (Nurfalaq et al., 2022; Maghfiroh & Arifin, 2021). Students' epistemological beliefs are not easily changed (Conley et al., 2004), so it is necessary to improve students' epistemological beliefs in science, for example, by correcting incorrect mindsets (Lestari et al., 2015) or other strategies (Johnson & Willoughby, 2018). These two efforts are much more important than simply increasing students' motivation towards science. About the school level, the high coefficient of disciplinary climate indicates that every teacher needs to strive to foster a disciplinary climate to improve science achievement. The significance of the school-type variable becomes less meaningful because it is influenced by the school selected as a sample. The justification of whether school type influences student achievement needs to be strengthened by further research, for example, in the 2018 or 2022 PISA data, which include oversampling in several provinces in Indonesia. Although not focused on science ability, variables such as school type, socio-economic status, student gender, and plausible value of science achievement were also found in these two surveys.

This study has several limitations as follows. First, PISA data are cross-sectional, so the causal relationship between variables cannot be tested. This causal relationship can only be proven accurately through longitudinal research. Second, the PISA data results are still prone to bias caused by the ability of participants to understand the questions given or the participants' willingness to respond according to actual conditions. Third, the lack of research on PISA data makes the results of this study not easy to compare with other studies. Other variables contributing to students' science achievement can be explored further by multilevel analysis or structural equation modeling. Finally, this study's focus is limited to PISA Indonesia's results, so further research can expand its scope by comparing science achievement in several countries.

Conclusion

A multilevel analysis of PISA data in Indonesia shows that 49.1% of the variance in students' science achievement can be explained by variation between schools. Indonesian male students have a higher average science achievement than female students. At the student level, students' economic and socio-cultural status, enjoyment of science, and epistemological beliefs about science show significant positive relationships with their science achievement. The effect of these variables was greater than that of students' instrumental motivation. In contrast to previous studies, we find that students' self-efficacy in science is negatively associated with their science achievement. At the school level, the disciplinary climate in science exhibits a significant positive relationship with students' science achievement. Regarding school type, Indonesian students from public schools score higher in science than students from private schools. Based on these results, we suggest that science teachers foster a favorable disciplinary climate in their classes, enhance students' enjoyment of science, and guide students in developing correct epistemic beliefs about science. Further studies are needed to understand why science self-efficacy negatively affects science achievement, as well as to develop learning activities that help students enjoy science and improve their achievement.

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Author Contributions

Conceptualization, T.A.I. and E.P.S.; methodology, T.A.I.; software, T.A.I.; validation, E.P.S.; formal analysis, T.A.I and E.P.S.; investigation, T.A.I.; writing—original draft preparation, T.A.I.; writing-review and editing, E.P.S.; visualization, E.P.S.; supervision, E.P.S.; All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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