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Examining Mathematics Achievement of Students from Different Provinces: What PISA 2018 says about Indonesia?

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Abstract

Despite participating in PISA for more than 10 years, Indonesian students' mathematics achievements still tend to be low. On the other hand, PISA 2018 shows that students in two provinces, namely (1) Special Region of Yogyakarta, and (2) Special Region of Capital City Jakarta, exhibit higher mathematics achievement than students from other provinces. This research aim is to examine factors affecting students' mathematics performance in these three regions. We carried out statistical multilevel analysis with a random effects model using R software. Based on this analysis, we find differences in factors that influence students' mathematics achievement from three provinces. Variables that significantly influence students' mathematics achievement in the three regions are parent support, home support, students' mastery goals, and students' competition. The only variables that were significant outside Special Region of Yogyakarta and Special Region of Capital City Jakarta were students' beliefs and students' ESCS. In the three provinces, the variables growth mindset, gender, and father's education level did not affect students' mathematics achievement.

Keywords: PISA, mathematical literacy, numeracy, Indonesia.

Introduction

Nowadays, mathematics or numeracy ability is considered an indicator of a country's education quality. Numeracy is the basis for mastering advances in science and technology. The high level of attention to this variable has encouraged the emergence of several standardized tests to measure numeracy abilities, including the Program for International Students Assessment (PISA) survey, which is held every three years by the Organization of Economic and Cultural Development (OECD) and the Trends in International Mathematics and Science Study survey (TIMSS) organized by the International Association for the Evaluation of Educational Achievement (Rosnawati, 2013). In Indonesia, numeracy skills are also part of the Minimum Competency Assessment (AKM), held periodically for elementary to high school students (Fauziah et al., 2022; Patriana et al., 2021). Developing numeracy skills is also one of the focuses of education at that level.

Since 2000, Indonesia has participated in the PISA survey, which measures the ability of students aged around 15 years in many countries (Stacey, 2011). Until 2009, the PISA results indicated that scores for Indonesian mathematics tended to be low (Widjaja, 2011). This situation encourages various efforts to improve students' performance, such as using HOTS questions in learning, using quality teaching strategies, and developing PISA-oriented exercises.

The educational policies were also developed based on the PISA test results (Pratiwi, 2019; Suprapto, 2016). Nonetheless, the recent PISA results in 2018 show that the average score of Indonesian students' numeracy ability is still far below the average ability of OECD countries of 489 (OECD, 2019). With this performance, Indonesia is ranked 73rd, lower than Malaysia, Thailand, and Singapore, the surrounding countries.

Compared to the previous one, PISA 2018 provide more information to explain Indonesian students' results. In PISA 2018, two provinces in Indonesia were oversampled, namely the Special Region of Yogyakarta (Daerah Istimewa Yogyakarta, abbreviated as DIY) and Special Region of Capital City Jakarta (Daerah Khusus Ibukota Jakarta, abbreviated as DKI). As a result, we can examine student achievement in these two provinces separately. The Ministry of Education and Culture's release (Suprayitno, 2019) even states that the average ability of students in these two provinces is not far from the ASEAN average, which means that the average score in these two provinces is higher than the overall average score. This situation shows that the achievements of some students in Indonesia are not much different from students in surrounding countries.

When PISA 2018 was conducted, both DKI Jakarta and DIY were just two of the 34 provinces in Indonesia, which located on the island of Java and have five districts/cities. DKI Jakarta is known as the national capital and the province with the highest population density. At the same time, DIY is the province with the highest average National Exam scores and life expectancy (Suprayitno, 2019; Winardi et al., 2023). Both are also provinces with Indonesia's highest human development index (Winardi et al., 2023). The existence of significant differences between the numeracy abilities of students in DKI and DIY compared to other provinces is a symptom of educational disparities, particularly concerning students' numeracy abilities.

The phenomenon of disparities in student abilities in Indonesia is not something new. Aditomo and Felicia (2018) have highlighted the existence of educational inequality as reflected in the 2015 PISA results. Large-scale study by Mahdiansyah and Rahmawati (2014) shows that the numeracy abilities of secondary school students in Yogyakarta are more homogeneous than in other areas. However, numeracy skills are still low (Sari & Wijaya, 2017). The national exam results at the senior secondary school level also show that students' mathematical abilities vary from province to province (Suputra et al., 2021). Sumaryanta et al. (2018) even show that the average mathematics score of middle school and high school students from most provinces in Indonesia is below the national average. However, the factors causing disparities in numeracy ability have yet to be analyzed with sufficient data. By involving 1,045 student respondents in several cities, Mahdiansyah & Rahmawati (2014) uncovered several factors, namely students' perceptions and self-confidence towards mathematics, the quality of teaching by teachers, and the characteristics and educational background. Other research related to mathematics abilities by Tambunan (2006) and Dwianjani and Candiasa (2018) also involved several hundred students but was limited to one district or city.

PISA is an international competence test to measure 15 years old students' achievement in language, science, and mathematics. Therefore, this test is not related with the curriculum used in any country, including Indonesia. Based on PISA survey data, it is known that several variables significantly influence students' numeracy abilities in Indonesia. Thien et al. (2015)

analyzed the PI-SA 2012 dataset and stated that mathematics self-efficacy is the strongest predictor of Indonesian students' numeracy abilities. Pakpahan (2016) shows that identity, socio-economic and cultural conditions, and ownership of computers and books influence Indonesian students' mathematical literacy. Kartianom and Ndayizeye (2017) apply the multilevel analysis on PISA 2015 dataset, and claimed that family socio-economic status, school socio-economic average, and students' sense of belonging to mathematics influenced students' numeracy ability scores. Based on PISA 2018 data, there is a significant influence of growth mindset and socio-economic status (Kismiantini et al., 2021), the spirit of competition, cooperation, and teacher creativity (Ridwan & Kismiantini, 2023), family welfare and the availability of ICT devices (Ulkhaq, 2022), as well as students learning time and metacognition (Anggraheni et al., 2022).

These abovementioned studies were conducted on the whole data of Indonesian students participated in PISA 2018. Hence it unable to explain differences between students from specific regions or province. Regarding Indonesian situation, many schools in Indonesia uses the national curriculum, whereas several schools in large cities use international curriculum or combined curriculum. In addition, educational policies related to the standards and evaluation are determined by the national government instead of local government. Consequently, the presence of disparities in mathematics achievement between students in these two provinces needs to be investigated, since it might represent any disparities on educational quality as well as local differences between provinces.

Relying on this situation, the PISA data from Indonesian students need further analysis to explain the differences of mathematics achievement between students. We focused on finding similarities and differences on factors that determine mathematical achievement of students from DKI Jakarta, DI Yogyakarta, and other provinces. Such differences in factors determining student achievement, if any, indicate that any improvement of the education quality must be carried out by considering the specific characteristics and situations in each province.

This research aims to determine the influence of variables on students' numeracy abilities on PISA test results in three regions in Indonesia, namely DKI (Jakarta), DI Yogyakarta, and other provinces. The variables analyzed include gender, ESCS, Growth Mindset, and parental education level. Furthermore, we also analyzed variables related to parental support and learning facilities at home and some affective aspects. We hope this research will be meaningful as a reference in developing students' numeracy which lead to increasing their mathematics achievement.

Methods

Framework

This research used a quantitative approach, in which statistics was used to describe the data, analyze the data, and obtain the conclusions. The framework of this study is presented in Figure 1. The focus of this study was to examine the contribution of several factors towards students' mathematics performance in each province separately. All explanatory variables selected are at student level.

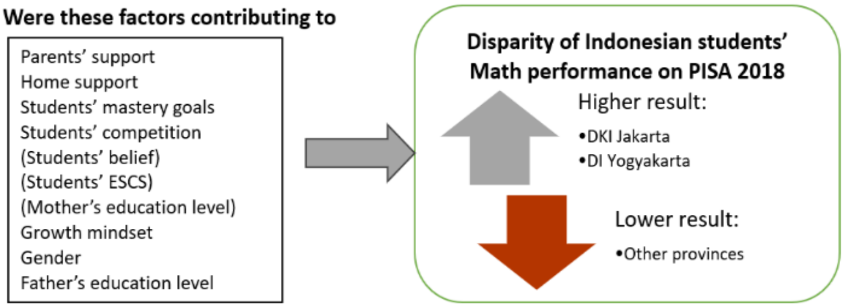

Figure 1. Framework used in this study

Data Sources

In this study, we use secondary data from the results of the 2018 PISA survey as available on the website https://www.oecd.org/pisa which consists of observations from 12,098 students and 397 schools. The response variable is the student's mathematics learning achievement, calculated as the arithmetic mean of ten plausible values (Lazarević & Orlić, 2018; You et al., 2020). Compared to more sophisticated method to deal with plausible values such as fuzzy data envelopment analysis, averaging plausible values has similar result to it (Aparicio et al., 2021).

The predictors in this study can be separated into two groups: variables that are already defined in the dataset (see Table 1) and variables that generated by the researcher based on the PISA dataset (Table 2).

Table 1. Predictors used in this study that currently available in PISA datasets.

Variables	Abbreviation	Range	Operationalization
Students' sex	SEX	0-1	0 = Female, 1 = Male
Economics and Socio-Cultural status.	ESCS	-5.78-2.97	Measure of student access to family resources which determines the social position of the student's family or household (Avvisati, 2020).
Growth mindset	GROWTH	1-4	Your intelligence is something about you that you can't change very much (reversing code as 1:strongly agree, 2: agree, 3: disagree, 4:strongly disagree)
Mothers' higher education	MOTDEG	0-1	Mother has higher education (diploma/bachelor/master/doctoral) or no (1= yes, 0 = no)
Fathers' higher education	FATDEG	0-1	Father has higher education (diploma/bachelor/master/doctoral) or no (1= yes, 0 = no)

Table 2. Predictors used in this study that calculated by the researchers based on the PISA 2018 datasets.

Variables	Abbreviation	N of Item	Range	Operationalization
Parents support	PASUPPORT	3	3-12	Student reports about parents' support on educational efforts, difficulties at school, and encouragement for confidence.
Studying facilities at home	HOMESUPPORT	8	0-8	Student reports regarding home learning facilities include a study desk, own room, a quiet place to study, a computer for school assignments, educational

Variables	Abbreviation	N of Item	Range	Operationalization
				software, internet access, books to help with school assignments, and reference books.
Students' effort to learn	LEARNEFFORT	4	4-16	Student reports about satisfaction in working hard, desire to complete assignments, pleasure in improving performance, effort to learn to master something
Students' self-belief	BELIEF	5	5-20	Student reports of managing one way or another, feeling proud of achievements, feeling like they can handle things, trusting themselves to get through difficult times, finding a way out of difficult situations
Students' mastery goal	MASTGOAL	3	3-15	Student reports about goals in learning as much as possible, goals in fully mastering the material presented in class, goals in understanding class content as completely as possible
Students' competition	COMPETE	3	3-12	Students report pleasure in working in competitive situations with others, performing better than others in a task, trying harder when competing with others

The process of forming several predictors in this research was inspired by Thien et al. (2015). Furthermore, the dimensions of students' goals, competition, and effort were also used in the analysis of PISA 2018 data from several countries (Govorova et al., 2020; Khine et al., 2023).

Data Analysis

The data analysis was carried out in several steps as follows. First, we conduct a preliminary analysis that consists of pre-processing data and descriptive statistics analysis. In the pre-processing stage, we eliminate some incomplete or missing data. Therefore, we only used some data that were complete for all studied variables. The PISA data consists of two levels: students and schools, therefore, the relations between predictor and response variables should be analyzed through multilevel analysis. Use of multilevel analysis in the PISA dataset has been done by Sun et al. (2012), Kartianom & Ndayizeye (2017), Thien et al. (2015), Kismiantini et al. (2021) as well as Efendi & Kismiantini (2022).

In this study, we use multilevel analysis which consists of two models, namely the null model and the random intercept model. The null model is a linear model that contains no predictor. Let Y_{ij} denotes mathematics achievement of the ith students in the jth schools, whereas β_{0j} denote average mathematics achievement of students in the jth schools. Using these notations, the null model in this study can be written for the first level as:

$$Y_{ij} = \beta_{0j} + \epsilon_{ij} \tag{1}$$

and for the second level:

$$\beta_{0j} = \gamma_{00} + U_{0j} \tag{2}$$

with $U_{0j} \sim N(0, r_{00})$ and $\epsilon_{ij} \sim N(0, \sigma^2)$ where ϵ_{ij} is an error term which represents individual student differences around the mean of school j, U_{0j} is a school-specific deviation from the grand mean, γ_{00} represents a grand-mean of mathematics score, r_{00} reflects the variation in mathematics scores at school level, and σ^2 reflects the variation in mathematics scores at student level.

By adding some predictors as listed in Table 1 and Table 2, we obtain a random intercepts model as follows. For the student level, equation (1) become

$$Y_{ij} = \beta_{0j} + \beta_1\text{MALE}_{ij} + \beta_2\text{ESCS}_{ij} + \beta_3\text{GROWTH}_{ij} + \beta_4\text{MOTDEG}_{ij} + \beta_5\text{FATDEG}_{ij} + \beta_6\text{PASUPORT}_{ij} + \beta_7\text{HOMESUPPORT}_{ij} + \beta_8\text{LEARNEFFORT}_{ij} + \beta_9\text{BELIEF}_{ij} + \beta_{10}\text{MASTGOAL}_{ij} + \beta_{11}\text{COMPETE}_{ij} + \epsilon_{ij}$$

while the equation (2) remains the same.

Parameter estimation for the multilevel model in this study was carried out using the restricted maximum likelihood (REML) method. This REML method assumes that the regression coefficient is an unknown parameter and is estimated based on sample data and a denominator of $N - 1$ is used to calculate the variance estimator. This REML method has a more accurate estimated variance in a small sample size compared to other estimation methods, namely full information maximum likelihood (FIML). The estimation procedures were carried out separately for the three areas, namely DKI Jakarta province, DI Yogyakarta province, and other provinces. Therefore, we can obtain several coefficients and compare them each other.

Intraclass correlation (ICC) is an important tool because it indicates the degree to which the multilevel data structure influences the response variable of interest. Larger ICC value indicates the greater the influence of the grouping. According to Muthén (1991, 1994) and Spybrook et al (2008), ICC values between 0.05 and 0.20 are common values in multilevel modeling applications in social research studies. In this study, ICC can be defined as the proportion between the variation in mathematics achievement scores that occurs between schools (level 2) and the expected correlation between mathematics achievement scores for two students (level 1) from the same school.

All statistical analyses in this study were carried out through R software version 4.3.0 (R Core Team, 2020), especially with the help of library nlme (Pinheiro, 2020), EdSurvey (Bailey et al., 2023), lmeInfo (Pustejovsky & Chen, 2023), lme4 (Bates et al., 2015), and msm (Jackson, 2022).

Results and Discussion

Descriptive Analysis

The total number of PISA 2018's participants from Indonesia is 12,098. After carefully removing some incomplete data, we obtained total number of students was 8,822 from 396 schools as presented in Table 3. This student provided exhaustive responses to all the questions of concern in the study.

Table 3. Distribution of PISA 2018 participants from three areas.

Province	Number of schools	Number of Students		
		Female	Male	Total
DIY	57	748	721	1469
DKI Jakarta	60	742	703	1445
Others	279	3112	2796	5908
TOTAL	396	4602	4220	8822

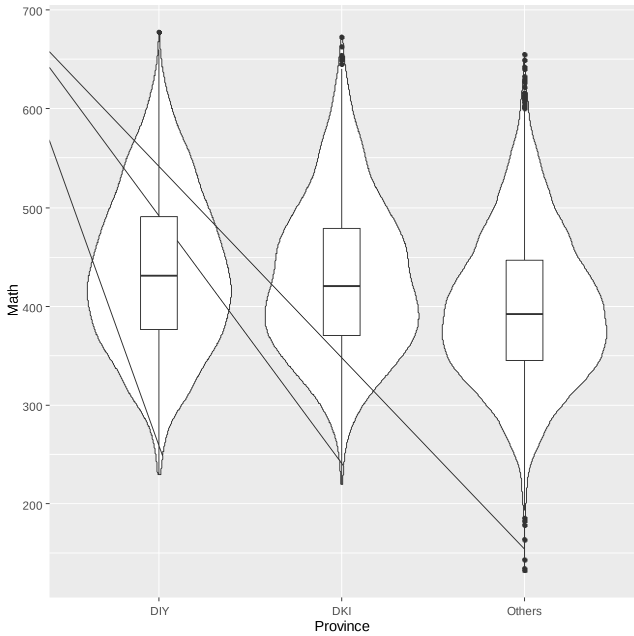

Figure 2. Violin and boxplot of students' mathematics scores from the three provinces

The calculation shows that the average mathematics achievement score in DIY province is the highest (M = 430.49, SD = 82.01) compared to DKI Jakarta (M = 421.80, SD = 80.44) and other provinces (M = 390.27, SD = 77.53). Similarly, Figure 2 show that the median scores of students from other provinces is lower than both DKI and DIY, and has higher range than these two provinces. Considering that PISA standardizes mathematics scores with an average of 487 (SD = 89) in all OECD countries, the average achievements of students from all of these provinces are lower than the average of OECD countries.

Multilevel Analysis

Table 4 shows the results of MLM analysis with the null model. The intraclass correlation coefficient (ICC) expresses the ratio between the magnitude of the variance at the school level and the total variance at the student and school levels.

Table 4. Estimation results of multilevel null model

Province	Effects	Variable	Estimated parameter	SE	ICC
DIY	Fixed	Math achievement, γ_{00}	432.47	8.38	0.61
	Random	Between-school variance, r_{00}	3852.14	62.07	
		Within school variance, σ^2	2483.06	49.83	
DKI Jakarta	Fixed	Math achievement, γ_{00}	422.17	8.05	0.63
	Random	Between-school variance, r_{00}	3749.73	61.24	
		Within school variance, σ^2	2232.03	47.24	
Others	Fixed	Math achievement, γ_{00}	388.75	3.46	0.56
	Random	Between-school variance, r_{00}	3147.40	56.10	
		Within school variance, σ^2	2493.01	49.93	

Note: SE for the random effect equal to the standard deviation (SD), ICC represents the intraclass coefficient (=variance between schools/(variance between school + variance between students in same school))

Table 5. Estimation of random intercept model for PISA 2018 data

Variables	DIY			DKI Jakarta			Other		
	Coef.	**SE**	**Sig.**	**Coef.**	**SE**	**Sig.**	**Coef.**	**SE**	**Sig.**
Fixed Effect									
Intercept	**306.50**	**22.62**	**0.00**	**345.62**	**25.37**	**0.00**	**305.95**	**10.47**	**0.00**
MALE	-2.16	2.96	0.46	-2.25	2.66	0.40	-1.29	1.34	0.33
ESCS	1.70	1.96	0.39	1.09	1.94	0.58	5.50	0.88	0.00
GROWTH	0.66	1.45	0.65	1.04	1.46	0.47	0.54	0.74	0.47
MOTDEG	49.30	14.95	0.00	25.31	22.63	0.26	34.13	8.53	0.00
FATDEG	17.52	12.82	0.17	11.04	17.72	0.53	5.10	7.97	0.52
PASUPPORT	2.04	0.65	0.00	2.65	0.64	0.00	1.84	0.31	0.00
HOMESUPPORT	-3.08	1.02	0.00	-1.59	0.84	0.06	-2.36	0.48	0.00
LEARNEFFORT	2.10	0.81	0.01	1.88	0.77	0.01	2.96	0.36	0.00
BELIEF	0.27	0.78	0.72	-0.10	0.71	0.89	-0.84	0.35	0.02
MASTGOAL	-1.25	0.60	0.04	-1.69	0.57	0.00	-0.82	0.30	0.01
COMPETE	3.75	0.90	0.00	1.76	0.88	0.04	3.17	0.42	0.00
Random effect									
Residual (σ^2)	2358.39			2178.35			2350.86		
Intercept (r_{00})	3125.84			3261.74			2396.37		

Table 4 shows that 61% of the total variance in mathematics achievement is associated with schools in DIY, around 63% in DKI Jakarta, and around 56% in other provinces. These percentage show that the variability of the average mathematics achievement between schools in DIY and DKI Jakarta provinces in Indonesia is quite large as well as for other provinces. These results emphasize the importance of investigating the relationship between student and school level variables, and mathematics achievement for each province using a multilevel approach. The overall average of mathematics achievement from the provinces of DIY, DKI Jakarta and others is significant with respectively $\hat{\gamma}_{00}$= 432.47, p <0.001; $\hat{\gamma}_{00}$ = 422.17, p <0.001; and $\hat{\gamma}_{00}$ = 388.75, p < 0.001. The overall average value of mathematics achievement is almost the same as the average mathematics achievement by province.

The estimation results of the random intercept model for each province are presented in Table 5.

Daerah Istimewa Yogyakarta

Table 4 shows that mother's higher education, parental support, student learning effort, and students' competitive spirit have a positive and statistically significant effect on mathematics achievement at the student level in DIY. Mother's higher education is the strongest predictor of mathematics achievement. After controlling all other variables, students with high-er mother's education have higher mathematics achievement for about 49.30 points. One point increase in parental support was associated with a 2.04 point increase in math achievement after controlling for all other variables. A one-point increase in student learning effort corresponds to a 2.10 point increase in math achievement after controlling for all other variables. Last, one point increase in students' competitive spirit associated with an increase in math achievement by 3.75 points after controlling for all other variables.

Home facilities and student goals have a negative and statistically significant influence on mathematics achievement at the student level in DIY. Meanwhile, gender, ESCS, growth mindset, father's higher education, and student self-confidence were not significant predictors related to mathematics achievement at the student level in DIY. This shows that there is no difference in the average mathematics achievement between male and female students after controlling for all other variables. Likewise, there was no difference in average mathematics achievement between students whose fathers had higher education and not after controlling for all other variables. Relative to the null model, the final model explained approximately 39% of the variance at the school level and 5% of the variance at the student level.

DKI Jakarta

Table 4 shows that parental support, student learning efforts, and students' competitive spirit have a positive and statistically significant influence on mathematics achievement at the student level in DKI Jakarta. Parental support is the strongest predictor of mathematics achievement, if the parental support increases, then the increase in mathematics achievement is around 2.65 points after controlling for all other variables. A one-point increase in student learning effort is associated with an increase in mathematics achievement of 1.88 points after controlling for all other variables. And a one-point increase in students' competitive spirit is associated with an increase in mathematics achievement of 1.76 points after controlling for all other variables.

Home facilities and student goals have a negative and statistically significant influence on mathematics achievement at the student level in DKI Jakarta. Meanwhile, gender, ESCS, growth mindset, mother's and father's higher education, and student self-confidence are predictors that are not significantly related to mathematics achievement at the student level in DIY. This shows that there is no difference in the average mathematics achievement between male and female students after controlling for all other variables. Likewise, there is no difference in average mathematics achievement between students who have mothers and fathers with higher education or not after controlling for all other variables. Relative to the null model, the final model explains about 13% of the variance at the school level and 2% of the variance at the student level.

Other Provinces

Table 4 shows that ESCs, mother's higher education, parental support, student learning effort, and students' competitive spirit have a positive and statistically significant effect on mathematics achievement at the student level in DIY. Mother's higher education is the strongest predictor of mathematics achievement, if the mother's education is high then the increase in mathematics achievement is around 34.13 points after controlling for all other variables. One point increase in the ESCS corresponds to an increase in mathematics achievement of 5.50. One point increase in parental support was associated with a 1.84 point increase in math achievement after controlling for all other variables. One point increase in student learning effort corresponds to a 2.96 point increase in math achievement after controlling for all other variables. As well as one point increase in students' competitive spirit associated with an increase in mathematics achievement by 3.17 points after controlling for all other variables.

Home facilities, student self-confidence, and student goals have a negative and statistically significant effect on mathematics achievement at the student level in other provinces. Meanwhile, gender, growth mindset, and father's higher education were not significant predictors related to mathematics achievement at the student level in other provinces. This shows that there is no difference in the average mathematics achievement between male and female students after controlling for all other variables. Likewise, there was no difference in average mathematics achievement between students whose fathers had higher education and not after controlling for all other variables. Relative to the null model, the final model explained approximately 24% of the variance at the school level and 6% of the variance at the student level.

Discussion and Recommendation

The final multilevel model for the provinces of DIY, DKI Jakarta, and others reveals that the negative coefficient for MALE indicates that female students are somewhat better than male students in mathematics accomplishment. This result is supported by preceding research literature that, based on the 2015 Trends in International Mathematics and Science Study (TIMSS), girls have 10 points higher than boys in mathematics achievement (Luschei, 2017). While previous 2012 PISA results show the significance of gender on students' mathematics learning achievement (Pakpahan, 2016), this study shows that the difference between genders is not significant.

The finding that increasing ESCS for students in other provinces resulted in higher mathematics achievement is in line with Thien et al. (2015), Cheng and Hsu (2016), and Fung et al. (2018). However, ESCS is not a significant factor for DIY and DKI Jakarta provinces, which shows that students' economic abilities do not affect mathematics achievement. Even though they have almost the same median, ESCS values in DIY and DKI Jakarta vary less than in other provinces. The relatively large ESCS coefficient value in other provinces, even higher than the coefficient estimated using overall Indonesia data (Kismiantini et al., 2021), shows that differences in students' socio-economic conditions have a significant influence on students' mathematical abilities in these regions.

This analysis also shows that students' efforts influence students' mathematical abilities in the three provinces. The relationship between students' effort and student ability is a general pattern in many countries participating in the PISA test (Anaya & Zamarro, 2023; Zamarro et al., 2019). However, the significant coefficient of students' effort in other provinces compared to DKI Jakarta shows that students' efforts have a more substantial influence on their mathematical abilities. Further research can be carried out to understand the influence of effort on students' abilities and utilize this high level of effort to improve students' mathematical abilities.

Other psychological variables influencing students' mathematical abilities in the three provinces are students' goals and competition. In all three provinces, the coefficient for students' goals is negative. Karaman (2022) shows that student goals negatively affect students' reading ability in Turkey. This is interesting to study in more depth because, generally, someone with a goal will perform better. In East Asian countries, students' goals influence student resilience (Zhan et al., 2023).

Regarding students' competition, it is known that this variable significantly contributes positively to mathematics abilities in the three provinces. This is in line with research by Agasisti (2011) in Italy. Echazarra (2020) also shows that competition can improve academic abilities and learning speed if students are motivated and enjoy it. On the other hand, student self-belief, which has long been considered to influence students' mathematical abilities (Maulidya & Nugraheni, 2021; Rohmat & Lestari, 2019; Khoirunnisa & Malasari, 2018), turns out to have no significant influence on students' mathematical abilities in DIY and DKI Jakarta. Interestingly, this variable significantly negatively affects students in other provinces.

Regarding parents’ higher education, we find that the father's higher education does not have a significant effect on students' mathematical achievement. On the other hand, mothers’ higher education has a significant effect on students' mathematical achievement in DIY and other provinces. The estimated coefficient, which were larger than 30, shows that the mathematical ability of children whose mothers have received a diploma, bachelor's degree or higher education is much higher than children whose mothers have never taken that level. On the other hand, in PISA 2012, the influence of maternal education level on Indonesian students' mathematics achievement was not clearly understood (Pakpahan, 2017). Further research is needed to reveal the high contribution of mothers' higher education to their children's mathematical achievement.

The highest proportion of variance explained at the school level was found in DIY and the lowest in DKI Jakarta. Meanwhile, the highest proportion of variance explained at the student level was found in other provinces and the lowest in DKI Jakarta. DKI Jakarta has the lowest proportion of variance at the school level and student level. This shows that students in DKI Jakarta have almost diverse abilities at the school level and student level. The existence of variations in students' mathematical abilities between schools and between students within one school needs to be further confirmed through other study, for example by examining the results of national exam (before 2019) and minimum competency assessment results (after 2021).

This research has the following limitations. First, this research is based on PISA scores which were done voluntarily by students. It is not known whether students have tried their best when working on the PISA questions. However, so far, many parties have treated PISA results seriously as a basis for developing the quality of learning and making education policies (Ismawati et al., 2023; Maroco, 2021; Suprayitno, 2019). This shows that the information from PISA data remains reliable, especially because PISA is based on quite a large sample. Second, there is no information regarding the student's province of origin for the "other provinces" category. This causes researchers to be unable to provide recommendations for improving the quality of learning in each province appropriately. Further research is needed to explore the specific factors determining students' mathematics abilities in each province as a basis for improving the quality of mathematics learning. In addition, further research may use other methods to obtain information from the plausible value as suggested by Huang (2024).

Conclusion

The 2018 PISA results show differences in the mathematics achievement of Indonesian students in the Special Region of Yogyakarta (DIY), DKI Jakarta, and other provinces. This study shows that there are differences in factors that influence students' mathematics achievement from three regions in Indonesia. Variables that significantly influence the three areas are parent support, home support, students' mastery goals, and students' competition. The only variables that were significant in other provinces were students' beliefs and students' ESCS. In the three regions, the variables growth mindset, gender, and father's education level did not affect students' mathematical abilities.

Further research on students' mathematical abilities in PISA 2018 data can be carried out by adding more predictor variables or analyzing the interactions or mediation between these variables.

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