Journal of Mathematics and Science Teacher
2025, 5(1), em076
e-ISSN: 2752-6054
https://www.mathsciteacher.com/

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Research Article **OPEN ACCESS**

Students' grades, growth mindset, and mathematics performance: PISA results in Southeast Asia and Australia

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Citation: Setiawan, E. P., & Kismiantini. (2025). Students' grades, growth mindset, and mathematics performance: PISA results in Southeast Asia and Australia. *Journal of Mathematics and Science Teacher, 5*(1), em076. https://doi.org/10.29333/mathsciteacher/15999

ARTICLE INFO

Received: 18 Sep 2024
Accepted: 09 Jan 2025

ABSTRACT

Mathematical ability has an important role in supporting the progress of science and technology in a country, including in Southeast Asia and Australia. This study aims to compare students' mathematical abilities at various grades in Southeast Asia and Australia countries and to see the effect of the growth mindset on this ability. The research data was obtained from the results of the 2018 PISA survey for Indonesia, Malaysia, Singapore, Thailand, the Philippines, plus Australia as an additional comparison. Quantitative analysis was carried out using linear regression models with and without interaction. The results showed that there was a significant interaction between grade and growth mindset in each country except Australia. The mathematical ability of students in Indonesia and Philippines, which were the lowest average among other countries, was strongly influenced by grade, growth mindset, and the interaction between them. Significant interaction between students' grade and growth mindset in affecting students' mathematical ability also found in Thailand and Malaysia. However, Singapore and Australia, which had average scores higher than those of the OECD, tended to have small to no effect on students' mathematical ability.

Keywords: PISA, mathematics, growth mindset, students' grade, Asia

INTRODUCTION

Advances in science and technology are one of the prerequisites for developing countries to increase economic growth and reduce dependence on other countries. It is known that mathematics is an ability that underlies the development of science and technology. Mathematics also provides a basis for everyone to think logically, think critically, and solve problems. Therefore, it can be said that the mathematical ability of the population of a country is one of the indicators to see the potential for controlling the economy, science, and technology in that country in the future.

Southeast Asia is an interesting region because it consists of countries with diverse situations and characteristics. Singapore, for example, has long been known as a country whose economy is supported by technological innovation and development (Wong & Singh, 2008). Brunei Darussalam, whose area is not much different from Singapore, has long been known as an oil-producing country (Anaman, 2004). In the mainland, there are several countries i.e. Thailand, Viet Nam, Laos, and Cambodia. Moreover, there are two archipelagos, namely Philippines and Indonesia. Today, Indonesia is the country with largest areas and highest population in the Southeast Asia.

In Southeast Asia, the Programme for International Student Assessment (PISA) survey shows the diversity of students' mathematical abilities from various countries. Since 2000, the survey that conducted by the Organization of Economics and Cultural Development (OECD) on 15-year-old students showed that Singaporean students have higher mathematical abilities than students from neighboring countries (Darmawan, 2020). Singapore is also the only country in ASEAN whose average student ability exceeds the OECD average score. The average mathematical ability of students from four other countries, namely Malaysia, Indonesia, Thailand and the Philippines, is still relatively far below the average ability of students from OECD countries. **Figure 1** shows that there is a relatively high difference between the mathematical abilities of students in Singapore and other ASEAN countries on the 2018 PISA test.

Why Southeast Asian students' exhibit various mathematics abilities? Several studies reveal that there are some differences between mathematics curricula and textbooks in these countries (eg. Ramelan & Wijaya, 2019; Safrudiannur & Rott, 2019; Yang & Sianturi, 2017). Through a systematic review, Maamin et al. (2021) show that factors of students, families, teachers, schools, and policymakers influence students' mathematical achievements in Southeast Asian countries. However, many studies discussed in that literature were conducted in only one or two separate countries (eg. Awang & Fah, 2013; Ng et al., 2012), so the results cannot be compared with the other countries. In addition, the levels of education being compared are not always equal and the number of participants is often limited.

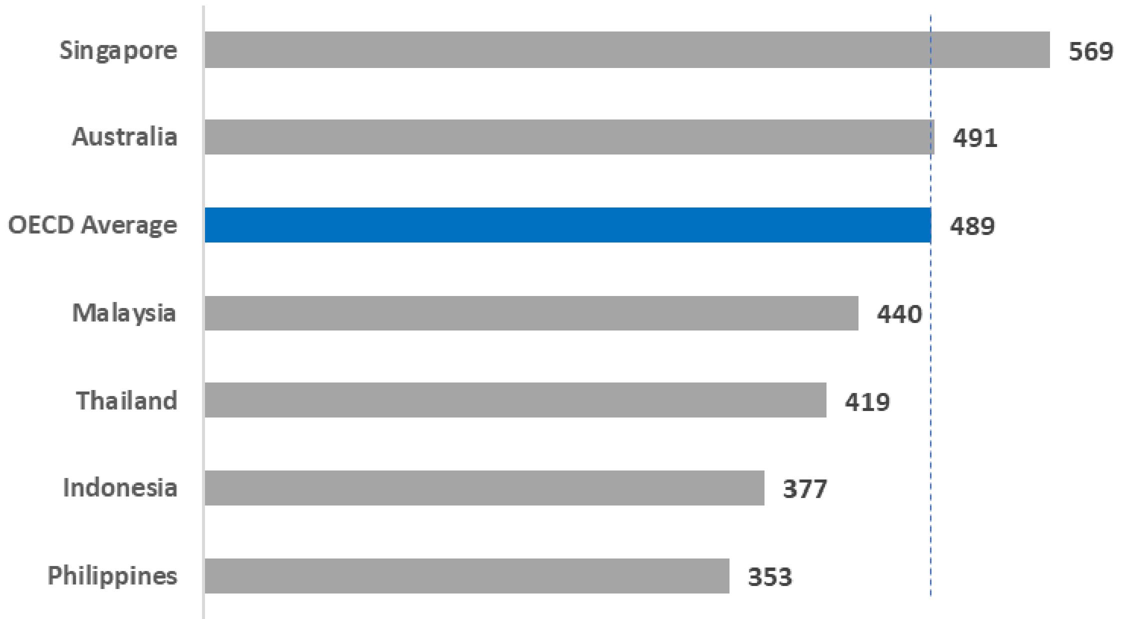

Figure 1. PISA 2018 average mathematics score for OECD and several countries (OECD, 2019)

These limitations can be overcome by using data from standardized large-scale studies, e.g. PISA and TIMSS. These studies provide scores from standardized tests and many additional data that are collected using questionnaires from students, parents, and teachers. For PISA survey, the participants have increased from 43 countries in 2000 up to 79 countries in 2018 (OECD, 2019). Therefore, results of PISA are often used as a benchmark for measuring the quality of education in a country and proposing educational policies (Hanberger, 2014; Kaur, 2021; Zulkardi & Putri, 2019). Mathematical problems in PISA also become a model for tasks and exercise used in learning activities (Ahyan et al., 2014; Kamaliyah et al., 2013; Nusantara & Putri, 2021; Rawani & Putri, 2019).

Several studies have used PISA data to compare students' mathematical abilities among various countries in the Southeast Asia region. Thien and Ong (2015) analyzed PISA 2012 data and showed that students' socio-economic status, mathematics self-efficacy, and mathematics anxiety affect students' mathematical competence in Singapore and Malaysia. With the same PISA data, Thien et al. (2015) showed that there are factors at the school and student levels that influence students' mathematical abilities in Indonesia, Malaysia and Thailand. Trinh and Weng (2017) compared the influence of gender and parental education on students' mathematical abilities in Southeast Asia. Darmawan (2020) shows a large gap between the mathematical abilities of students from Indonesia, Malaysia, Singapore, Thailand, and Vietnam at PISA 2015. This research also states that gender and ESCS have various influences on students' mathematical abilities in these countries. On the other hand, these studies have not been able to show at what level differences in students' mathematical abilities in these countries occur. It is not known whether differences in mathematical ability have occurred since the early stages of education or have only been seen in students who have completed education to a certain level. This kind of information is needed by policy makers in each country to formulate innovations and improve the quality of learning mathematics.

This study aims to compare the mathematical abilities of students of various levels in countries in Southeast Asia. More specifically, we want to know the contribution of each level of education in each country to improving students' mathematical abilities. We use the PISA 2018 dataset, considering that there were more than 30,000 respondents from five countries in Southeast Asia who participated in this survey (OECD, 2019). In addition, Australia is also included in the comparison because it is located close to Southeast Asia and has an average math ability score that is close to the OECD average. Another variable whose influence is also seen is growth mindset, which is known to affect the abilities of Indonesian students in mathematics and reading (Kismiantini et al., 2021; Sari & Setiawan, 2023) as well as the abilities of Filipino students in mathematics and science (Bernardo, 2021).

METHODS

Data and Variables

In this study, we used PISA 2018 dataset for Australia and ASEAN countries, which consists of Indonesia, Malaysia, Thailand, Philippines, and Singapore. Note that the Viet Nam's dataset was not used in this study since the comparability of Viet Nam's performance in mathematics could not be fully ensured (OECD, 2019). In total, there were 55.022 subjects from these six countries. All data were taken from OECD's website using a package "EdSurvey" (Bailey et al., 2023) that available in R software (R Core Team, 2023).

The focus of this study is students' mathematics ability, which is represented by several plausible values. As mentioned in OECD (2019), the PISA 2018 survey provides ten plausible values in mathematics, coded as PVMATH1 to PVMATH10. We calculate the average plausible score, yielding a score that represents students' ability in mathematics.

The predictors in this study were students' grade and growth mindset. In the PISA datasets, students' grades were presented in two variables, namely GRADES and ST001D01T. The ST001D001T variable represents the international grade from the 7th grade up to 13th

grade, while the GRADES represents the relative grade compared to the majority, with value ranging from -2 (two grade under the majority grade) up to +2 (two grade above the majority grade). In this study, we use the ST001D01T variables, since absolute international grade would have easily compared each other.

The second predictor was growth mindset, which defined as the belief that someone's ability and intelligence can develop over time (Caniëls et al., 2018). The PISA 2018 confirms the growth mindset in question coded as ST184Q01HA, in which students are asked whether they are agree or disagree with statement "Your intelligence is something about you that you can't change very much." Since lower value corresponds to disagreement, it is equal to the growth mindset instead of fixed one. Therefore, following Kismiantini et al. (2021), we transformed this variable so that higher values related to higher growth mindset.

Data Analysis

The data analysis procedure consists of two steps, namely descriptive part and inferential part. For the descriptive part, we classify PISA's participants on each country based on their grades then calculate their percentage. To ensure comparability, we drop the grade in which the participants is less than one percent. Based on the remaining data, we present the average and standard deviation of mathematics ability among students in each grade in each country for each PISA years separately. We also describe the level of growth mindset for students in each grade.

For the inferential part, we want to examine whether the grades and growth mindset affects students' mathematical ability. We also examine whether these two variables have interacted each other, since the relations between these two variables were inconsistent (Blackwell et al., 2007; Li & Bates, 2020). Therefore, we propose two different model to be estimated for each country as follows:

$$M_1: MATH_i = \beta_{0i} + \beta_{1i}Grade + \beta_{2i}Growth + \varepsilon_i, i = 1, 2, \ldots, 6 \quad (1)$$

$$M_2: MATH_i = \beta_{3i} + \beta_{4i}Grade + \beta_{5i}Growth + \beta_{6i}Grade \times Growth + \varepsilon_i, i = 1, 2, \ldots, 6 \quad (2)$$

In both M_1 and M_2, $MATH_i$ stands for mathematical ability of students from the *i*-th country, while *Grade* and *Growth* represent students' grade and students' growth mindset, respectively. Since the two variables are in ordinal scale, they should be transformed into dummy variables. Three dummy variables were used for students' growth mindsets, which represent the level 2, 3, and 4, respectively. However, for students' grade, the number of dummy variables depends on the number of grades that will be analysed. Note that the lowest grade in each country would be the reference category.

Parameter estimation of all models in each dataset were done through the ordinary least square (OLS) method, as implemented in package *stats* (R Core Team, 2023).

RESULTS AND DISCUSSION

Profiling Students' Grade and Mathematical Ability

Table 1 presents the distribution of the PISA test takers based on their grades in each Southeast Asian country. Students in the 9th grade dominated PISA test takers from the Philippines, while students in the 10th grade dominated the PISA test takers from other countries. We could not compare participants from the 12th grade in any country since the number of participants is too small. Meanwhile, analysis for students in the 7th grade can still be done carefully for two countries, namely the Philippines and Indonesia, considering that the proportion is still more than 1% of the sample.

Table 1. Distributions of students' grade in PISA 2018 dataset

Country	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11	Grade 12
Australia	0 (0.00%)	9 (0.06%)	1588 (11.13%)	11661(81.70%)	1010 (7.08%)	5 (0.04%)
Malaysia	0 (0.00%)	0 (0.00%)	273 (4.47%)	5821 (95.25%)	17 (0.28%)	0 (0.00%)
Singapore	2 (0.03%)	75 (1.12%)	476 (7.13%)	6098 (91.34%)	25 (0.37%)	0 (0.00%)
Indonesia	209 (1.73%)	921 (7.61%)	5178 (42.80%)	5382 (44.49%)	349 (2.88%)	59 (0.49%)
Philippines	316 (4.73%)	913 (12.6%)	3693 (51.06%)	2278 (31.49%)	30 (0.41%)	3 (0.04%)
Thailand	13 (0.15%)	67 (0.78%)	1806 (20.92%)	6485 (75.12%)	262 (3.03%)	0 (0.00%)

Table 1 shows that there are various grade ranges of PISA participants in Southeast Asia. Indonesia and the Philippines have PISA test participants at the same level of education, namely from the 7th to the 12th grade. Singapore and Thailand also have participants at the same level, i.e., from the 7th grade to the 11th grade. Malaysia has the smallest range, i.e., only three different grades, while participants from other countries studied in four or more different grades. The average and standard deviation of students' mathematical ability scores at each level is presented in **Table 2**.

Table 2. Profile of students' mathematical ability for each grade

Country	Mean (SD) of PV Mathematics				
	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11
Australia	-	375.7 (69.1)[a]	464.7 (86.2)	491.2 (83.6)	526.9 (86.1)
Malaysia	-	-	362.1 (68.0)	444.3 (74.1)	564.1 (83.1)[a]
Singapore	-	501.7 (71.5)	521.0 (99.7)	572.6 (86.2)	617.0 (65.2)[a]
Indonesia	313.7 (60.6)	340.0 (61.7)	383.0 (70.6)	430.4 (78.9)	440.2 (82.7)
Philippines	270.9 (56.2)	299.4 (57.6)	353.0 (67.7)	380.7 (63.9)	456.4 (68.1)[a]
Thailand	-	352.9 (51.9)[a]	397.2 (71.3)	447.9 (95.2)	513.9 (100.0)

[a] comes from less than 1% of samples

From **Table 2**, we can classify the countries based on the average mathematical scores into three tiers: Tier I (average score below 400), Tier II (average score between 400 and 500), and Tier III (average score above 500). In the 8th grade, students from all countries apart from Singapore are still in group I. In the 9th grade, students from Malaysia, Indonesia, the Philippines, and Thailand are in group I, Australia is in group II, and Singapore is in Group III. In the 10th grade, only the Philippines remained in Group I, while the other countries moved to group II. Furthermore, in the 11th Grade, Australia, Thailand, and Malaysia moved to group III along with Singapore, while the other two countries remained in group II.

Furthermore, **Table 2** shows that the average scores of math skills obtained by 8th grade students in all countries other than Singapore are relatively similar, which is less than 400. On the other hand, the differences in the scores of math abilities of 11th and the lowest grade (i.e. 8th in Australia and Thailand, or 9th in Malaysia) are higher than in the other countries. This situation shows that there are differences in one or more aspects of mathematics learning at these levels, that results in different students' mathematical abilities in the 11th grade.

The coefficient of variation, namely the ratio of the standard deviation to the average value expressed in percent, also shows the variability of PISA results. Calculation from **Table 2** shows that the highest coefficient of variation in grades 8 and 9 is for students from the Philippines, while grades 10 and 11 are for students from Thailand. It means that students' mathematical abilities in the two countries have more variations than students from other countries at the same level. Singapore achieved the lowest coefficient of variation for grades 8, 10, and 11. Therefore, it can be said that Singaporean students' mathematical abilities at these levels are relatively more uniform when compared to the abilities of students in other countries.

By reading **Table 1** and **Table 2**, we can interpret **Figure 1** more carefully. A country's average score might be related to the educational level of students who take the test. The high PISA scores from Australia, Malaysia, and Singapore are perhaps because more than 80% of test takers from these three countries are in grade 10. In countries with relatively lower scores, such as Indonesia and the Philippines, PISA test takers are in grades 9 and grade 10. Of course, they have different experiences in learning Mathematics. If all PISA participants were from grade 10, the average score between Indonesia and Malaysia was only 14 points, much smaller than the difference in **Figure 1**, which was 63 points.

Grades and Students' Growth Mindset

PISA 2018 measured students' growth mindset levels through a statement followed by four options from agreement to disagreement. We performed a re-coding so that categories 1 and 2 stated a fixed mindset, while categories 3 and 4 stated a growth mindset. **Figure 2** presents the distribution of growth mindset levels of the PISA test participants from the six countries.

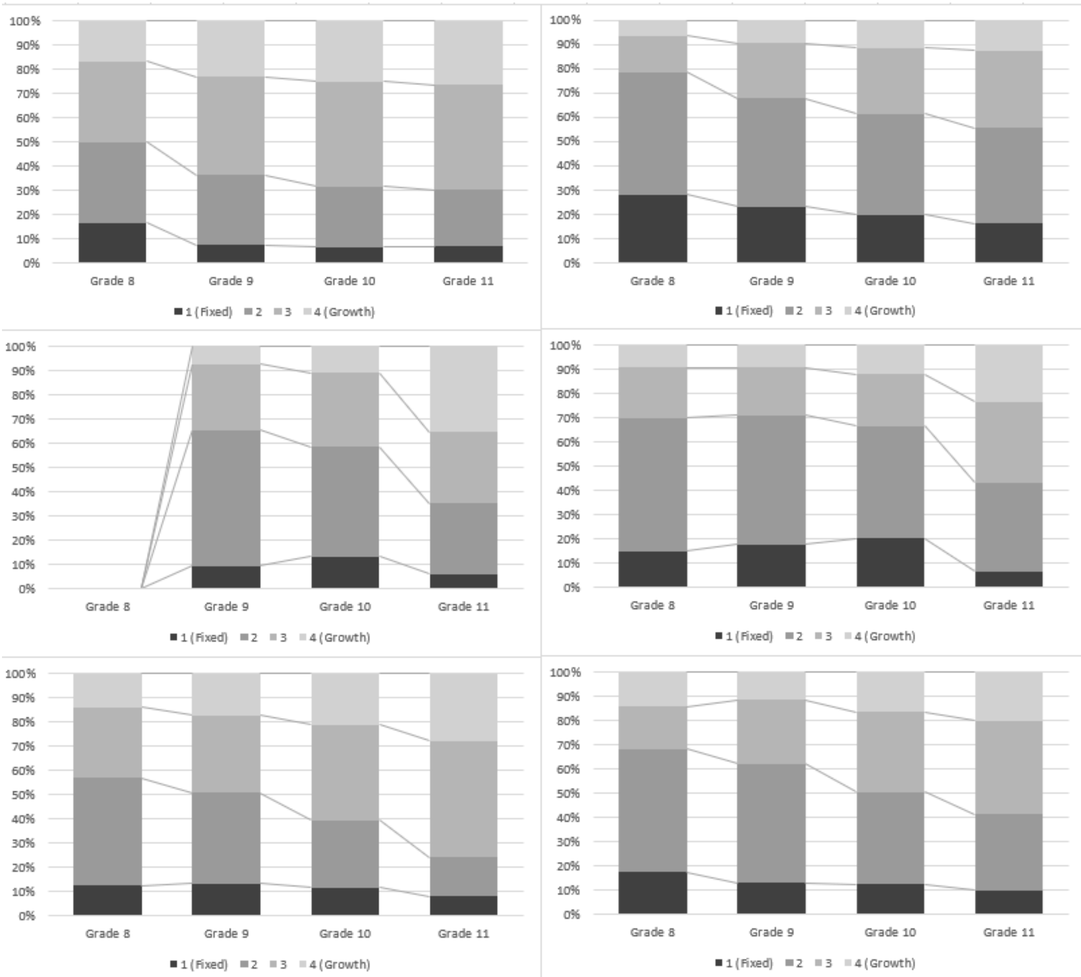

Figure 2. Profile of students' growth mindsets. Left (from above): Australia, Malaysia, and Singapore; Right (from above): Indonesia, Philippines, and Thailand (Source: Authors' own elaboration)

More than 50% of grade 8 students in Singapore, Indonesia, the Philippines, Thailand, and more than 50% of grade 9 students in Malaysia exhibit a fixed mindset. In grade 11, a fixed mindset can still be found in more than 50% of students in Indonesia alone, while in other countries, this proportion has decreased, even to below 40%. Australia is a country whose students have a growth mindset from the start, bearing in mind that the proportion of students with a fixed mindset at each level is never more than 50%.

Figure 2 also indicates that the proportion of students with a growth mindset has increased with increasing grades. Significant increases occurred in Singapore and Malaysia, with the difference in the proportion of growth mindset in grades 11 and 8 reaching 30%. In other countries, the difference in the proportion of growth mindset in these two grades is only around 20%. Even so, the interpretation of changes in these proportions did not imply changes in students' mindsets at each grade, bearing in mind that the samples taken at each grade differ. The results of the PISA survey were insufficient to identify whether the learning process at a higher grade encourages more students to have a growth mindset or, conversely, that students with a growth mindset start school at a younger age so they have reached a higher level at the same age. Further research with primary data is needed to distinguish them.

Grades, Growth Mindset, and Mathematical Ability

This section will discuss the results of the inference analysis performed using the regression method, which can be interpreted since the classical assumptions are met. The estimation results of the M1 (without interaction) and M2 (with interaction) models on student data from each country are presented in **Table 3** and **Table 4**, respectively.

Table 3. Estimation results of model M1 (without interaction)

Countries	Intercept	Growth Mindset		Grade		Adj
		Value	Coefficient	Value	Coefficient	R^2
Australia	344.69*	2	4.36	9	87.93*	9.56%
		3	48.45*	10	111.75*	
		4	57.71*	11	147.65*	
Malaysia[a]	345.72*	2	5.17	10	79.67*	12.13%
		3	36.83*	11	186.72*	
		4	54.65*			
Singapore	484.77*	2	2.31	9	17.07	6.5%
		3	35.94*	10	65.87*	
		4	36.16*	11	104.54*	
Indonesia[b]	301.41*	2	-0.324	8	28.69*	23.16%
		3	48.86*	9	67.02*	
		4	44.81*	10	111.17*	
				11	117.99*	
Philippines[b]	272.92*	2	-15.42*	8	29.63*	23.27%
		3	15.69*	9	83.26*	
		4	33.60*	10	108.16*	
				11	176.08*	
Thailand	341.45*	2	-10.71*	9	41.04*	19.19%
		3	45.49*	10	83.99*	
		4	72.32*	11	143.64*	

[a] Grade 9 is used as a reference category, so there is no estimated coefficient for this grade
[b] Grade 7 is used as a reference category, so we have estimated coefficient for grade 8

Table 3 shows that, in general, students with a growth mindset have higher mathematical abilities than students with a fixed mindset. The coefficient that is not significant or significant with a negative sign on the growth mindset dummy variable = 2 indicates that students who believe or strongly believe that one's mind is fixed have relatively the same mathematical abilities. In various countries, students from higher grades have significantly higher mathematical abilities than students from lower grades.

By comparing the Adjusted R-square values of the regression models in **Table 3** and **Table 4**, we know that the regression model with an interaction between grades and growth mindset has a higher ability to explain variations in students' mathematical ability scores. The exception occurred in Australia, where there was no significant interaction. However, the magnitude of the regression coefficient of the model with interaction was not the same as the model without interaction.

Table 4. Estimation results of model M2 (with interaction). Note that insignificant interactions are not displayed

Countries	Intercept	Growth Mindset		Grade		Grade x Growth[c]		Adj
		Value	Coefficient	Value	Coefficient	Interaction	Coefficient	R^2
Australia	306.78*	2	43.48	9	129.06		Not significant at all	9.7%
		3	39.44*	10				
		4	224.94*	11				
Malaysia[a]	358.72*	2	8.45	10	66.04*	3-10	37.45*	12.7%
		3	0.87	11	317.37*	4-10	71.93*	
		4	-14.66			2-11	-175.36*	
Singapore	513.10*	2	-33.97	9	-34.68	4-9	102.76*	7.1%
		3	21.75	10	39.14			
		4	-21.96	11	112.58			
Indonesia[b]	316.08*	2	1.52	8	21.94*	3-9	42.92*	23.8%
		3	4.37	9	53.14*	4-9	64.28*	
		4	-26.85	10	93.34*	3-10	49.92*	
				11	97.19*	4-10	85.55*	
						3-11	58.97*	
						4-11	85.84*	
Philippines[b]	286.93*	2	-8.89	8	28.26*	3-9	28.38*	25.9%
		3	-13.22	9	69.95*	4-9	98.33*	
		4	-53.33	10	88.14*	3-10	44.49*	
				11	203.83*	4-10	105.69*	
Thailand	375.89*	2	-26.88	9	16.71	4-9	82.45*	19.7%
		3	-12.70	10	46.63	4-10	119.96*	
		4	-40.33	11	94.43*	4-11	130.95*	

[a] Grade 9 is used as a reference category, so there is no estimated coefficient for this grade
[b] Grade 7 is used as a reference category, so we have estimated coefficient for grade 8
[c] Only significant interaction was presented; the others were not significant

The intercept values in each regression model can be interpreted as the lowest grade average score owned by students with a fixed mindset. Indonesia's intercept is about 30 points higher than the Philippines. It means that the average mathematical ability of 7th grade students in Indonesia is higher than in the Philippines, with the same grade. Furthermore, **Table 4** shows that grade 8 students with a fixed mindset in Australia have lower mathematical abilities than students with the same grade and mindset in Thailand and Singapore.

The coefficients on the grade variable show the contribution of each level of education to mathematics ability in each country. Interestingly, almost all the grade coefficients in **Table 3** are significant, while **Table 4** is not. By comparing **Table 3** and **Table 4**, the grade variable alone significantly affects the mathematical abilities of students in Malaysia, Indonesia and the Philippines. The negative grade coefficients, like in Singapore, are insignificant, so it can be interpreted that students' math abilities at both levels in that country are similar.

Further analysis can be carried out by looking at the results of the estimated coefficients for each grade. **Table 4** shows that at grade 11, the highest grade, the largest and smallest coefficients are found in Malaysia and Indonesia, respectively. This result indicates that if the growth mindset is ignored, the average increase in students' math skills from grade 8 to grade 11 in Malaysia is higher than in Indonesia. The largest difference between levels occurred in students from Australia, while the lowest difference between levels was found in Indonesia.

Table 4 shows that most significant interactions occur at high growth mindsets (3 or 4) and high grades (10 or 11). Furthermore, it is also known that the growth mindset and grade variables, which are significant in models without interaction, sometimes turn out to be insignificant in models with interaction. Significant and positive interactions, such as in Indonesia and the Philippines, indicate that the growth mindset's contribution to students' mathematical abilities at that level is greater than its contribution to students' mathematical abilities at other levels. Meanwhile, in Thailand, interactions showed that students who strongly believed that their abilities could change had significantly higher math ability scores than those who lacked such belief.

By comparing the interaction coefficient and growth mindset coefficient in **Table 3** and **Table 4**, a growth mindset alone does not always have a significant effect on students' mathematical ability. In the Philippines and Thailand, the growth mindset coefficient has a negative sign which is not significant, while the interaction coefficient between growth mindset and grade is significant. It means that the effect of a growth mindset on students' mathematical abilities at the lowest grade is insignificant. Still, it is significant in other grades, as indicated by this interaction. It is also interesting that in Malaysia and the Philippines, the higher the growth mindset, the lower the regression coefficient. However, the relationship between the growth mindset and students' mathematical ability remains unclear in other countries.

By confirming the interaction plot in **Figure 3**, in grades 8 or 9, students with a growth mindset only sometimes have higher mathematical abilities than students with a fixed mindset. Observations in the six countries show that students with a growth mindset tend to have higher abilities at higher grades than students with a fixed mindset. This trend was also found in grade 11 for students from Australia, Indonesia and Thailand but not in the other three countries. This result might result from the different numbers of grade 11 participants in these countries.

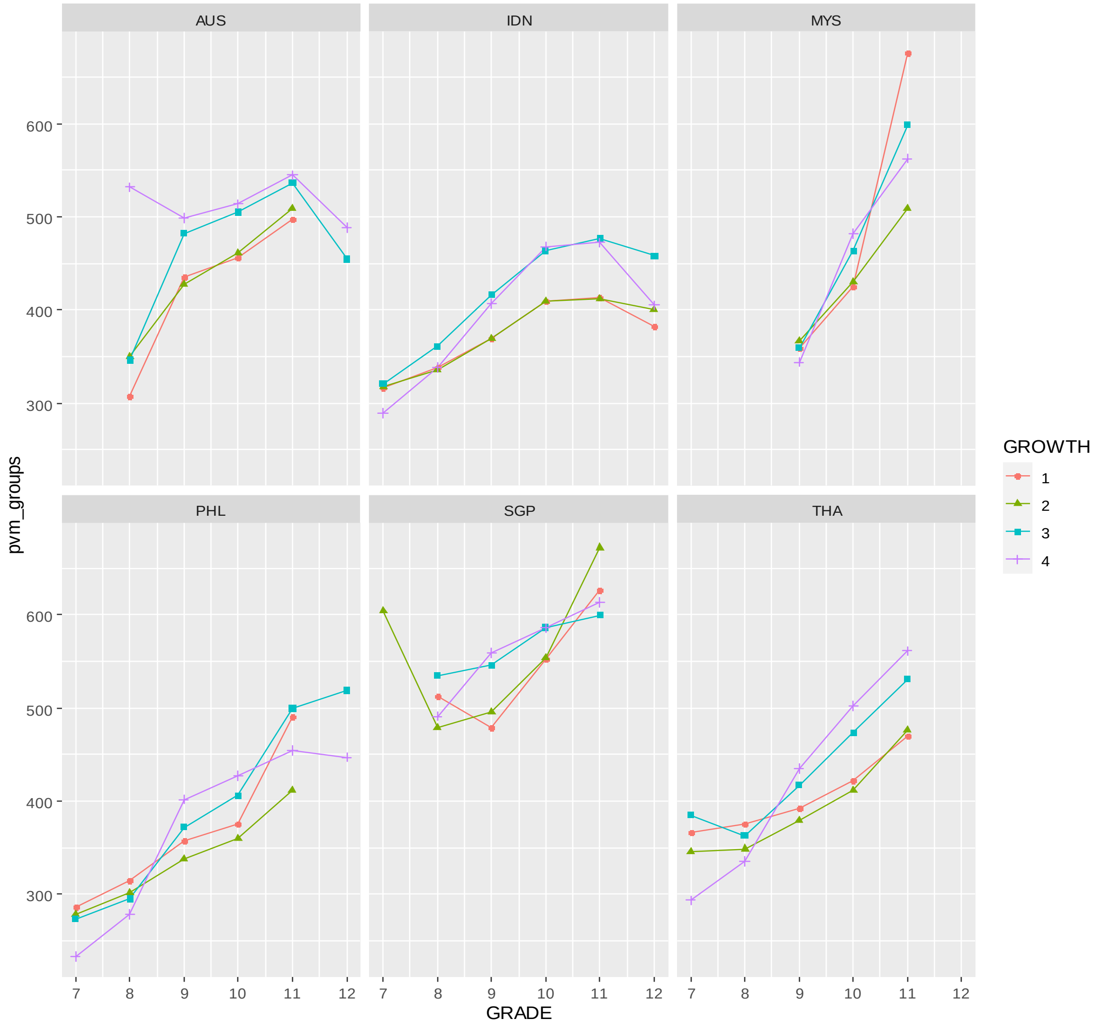

Figure 3. Interaction between growth mindset and grade in various countries (Source: Authors' own elaboration)

DISCUSSION

As a large-scale educational survey, the PISA 2018 was attended by thousands of students from various countries around the world. Since its establishment, this survey was designed to be followed by students aged around 15 years (Stacey, 2011). Differences in education systems between countries cause the PISA respondents to be at different grades of education. This is a peculiarity of PISA that distinguishes it from the TIMSS survey which only focused on specific grades (Wu, 2009).

In this study, we examined the mathematical abilities of students from Australia, Malaysia, Indonesia, the Philippines, Singapore, and Thailand on the 2018 PISA test. Based on **Table 1**, in Australia, Malaysia, and Singapore, more than 80% of the PISA test takers are taking or have taken education in grade 10. As for in Indonesia and the Philippines, less than 50% of PISA test takers are currently studying or have studied in that class. In fact, the data in **Table 2** shows that there is a significant difference in average scores between students in class 10 and the previous class. Thus, it can be said that the relatively low scores of Indonesia and the Philippines on the 2018 PISA were also influenced by the educational level of the test takers. Criticism of the diversity of education levels in the results of PISA scores has long been conveyed (Prais, 2003; Zhao, 2020a). Therefore, the interpretation of PISA results as an indicator of the quality of a country's education should be done by eliminating the influence of grade. This is in line with research by Fuchs and Wößmann (2008) who suggested using grade as a control variable in PISA data analysis. Comparisons of PISA test results between countries should only be made on participants from the same level (Perelman & Santin, 2011; Yu et al., 2012).

This study also shows that the percentage of growth mindset in the 2018 PISA test participants tends to increase in line with students' grade. In countries other than Australia and Singapore, growth mindset and grade variables tend to interact in influencing students' mathematical abilities. As displayed in **Figure 3**, grade 9 students with a growth mindset tend to have higher mathematical abilities than students at the same level without a growth mindset. This relationship was also seen in grades 10 and 11 for students from Australia, Thailand and Indonesia, but not for the other countries. It can be said that the influence of the growth mindset on students' mathematical abilities tends to be local. Therefore, studies on this topic should be carried out separately for each country (eg. Bernardo, 2021; Kismiantini et al., 2021; Sun et al., 2021; Zhao, 2020b). Further research with more specific instruments should be conducted to measure the contribution of the growth mindset to students' mathematical competence in each grade (Huang et al., 2022).

A statistically significant relationship between each level of education and students' mathematical abilities was only found in three countries, namely Indonesia, Malaysia and the Philippines. Among these three countries, it appears that the largest difference in coefficients for the dummy variable in the regression model is between grades 8 and 9 for the Philippines, between grades 9 and 10 for Indonesia, and between grades 10 and 11 for Malaysia. Compared to other countries, the difference in the average scores of Grades 9 and 10 students in Malaysia become the largest. Therefore, efforts to improve students' mathematical abilities in each country can be focused on specific grades where differences in mathematics scores tend to be small.

In countries with relatively high scores such as Australia and Singapore, it turns out that the variable level of education has almost no effect on students' mathematical abilities. This is indicated by the results of the partial test of each dummy variable coefficient which tends to be insignificant, as well as the low value of the adjusted coefficient of determination. In Australia and Singapore, the M2 model can only explain less than 10% of the variation in students' math ability scores. In fact, in Indonesia and the Philippines, the same model can explain more than 20% of the variation in scores. Further research can be done by adding variables that also determine a student's grade, such as age at first entering school and experience of living in a classroom.

CONCLUSION

This study shows that the score of a country's mathematical ability in the PISA test cannot be separated from the grade of the students who take the test. Analyzing PISA 2018 survey data from Southeast Asia and Australia, we found that most students with a fixed mindset attend in low educational level, but as the educational level increased, the proportion of students with a growth mindset increased. This study also found that students in those countries with a growth mindset have higher mathematical abilities than students with a fixed mindset. In Indonesia and the Philippines, whose students have relatively low scores, students' mathematical ability is significantly influenced by education grade, growth mindset, and the interaction between grade and growth mindset. For Thailand, there are significant interaction between grade and growth mindset especially for the highest level of growth mindset. Meanwhile, for Singapore and Australia, which average scores higher than OECD's, these variables tend to have no significant effect on student mathematical ability.

Author contributions: EPS: conceptualization, literature survey, data analysis, writing – original draft; **K:** conceptualization, data cleaning and preprocessing, writing – review & editing.

Acknowledgments: The authors thank the anonymous reviewers for their insightful suggestions and careful reading of the manuscript. This research was funded and supported through the Research Group (RG) Scheme from the Faculty of Mathematics and Natural Science, Universitas Negeri Yogyakarta, Indonesia**.**

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that the study did not require ethics committee approval. The data used in this study is collected by OECD through PISA survey, therefore the ethical requirements has been fulfilled by them.

Declaration of interest: The authors declare no potential conflict of interest in this study.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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