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How Economics-Socio-Cultural Status affect Indonesian Students' Performance in Mathematics? an Insight from PISA 2012-2022

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Abstract: How Economics-Socio-Cultural Status affect Indonesian students' performance in Mathematics? an Insight from PISA 2012-2022. To date, the average mathematics performance of Indonesian students in PISA tends to be unchanged, and lower than that of OECD countries. However, PISA participants in Indonesia consist of students from five to six different grades. **Objectives:** This research aims to determine how Economic-Socio-Cultural Status (ESCS) and student grades influence Indonesian students' mathematics performance. **Methods:** We apply a quantitative approach using multiple linear regression analysis methods using the PISA 2012, 2015, 2018, and 2022 datasets. In this analysis, we also use the weight of each sample and the overall plausible value for mathematics performance. **Findings**: we found a significant relation between education level and ESCS regarding students' overall mathematics performance in PISA from 2012 to 2022. The interaction coefficient increases as the level increases from grade 8 of junior secondary school to grade 11. **Conclusion:** ESCS has a contribution to the diversity of students' mathematics performance at the same grade. From 2012 to 2022, the relative position of Indonesian students' ESCS compared to all participant has declined, although its influence on student mathematics performance tends to decline.

Keywords: PISA, mathematics, Indonesia.

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INTRODUCTION

Quality Education is one of the 17 sustainable development goals (SDGs) adopted by the United Nations in 2015. Under this goal, one target is ensuring that all youth achieve literacy and numeracy (https://sdgs.un.org/goals). To ensure improvement on them, the Organization of Economic, Cultural, and Development (OECD) has conducted a Program for International Student Assessment (PISA) survey since 2000. The survey, held regularly every three years, aims to measure literacy, numeracy, and science abilities in 15-year-old youth in various countries (Stacey, 2011). Under its objectives, students aged around 15 who are chosen as a sample will take a series of tests and fill out several questionnaires (OECD, 2018). Additional information was collected from teachers and parents of these students through questionnaires.

Despite some criticism of its implementation, the PISA survey results are still considered as a valid dataset. In various countries, the results of the PISA survey have become the basis for educational policymaking (Breakspear, 2012; Baird, 2016; Araujo, 2017). PISA questions with high order thinking skills (HOTS)

characteristics are also widely used as models in the development of teaching materials and exam materials at the primary and secondary education levels (Efriani & Putri, 2021; Nusantara et al., 2020; Murtiyasa et al., 2018). These efforts are based on the understanding that improving the quality of education is the key to increasing the PISA score, which also indicates an increase in the quality of education in a country. Many people hope that future PISA outcomes will be better than outcomes of the previous one.

One of the interesting PISA-participating countries is Indonesia. Although it has not joined the OECD yet, Indonesia has participated in the PISA survey since 2000 (OECD, 2019). Yet the average results regarding mathematics performance is still under average of OECD countries. As presented in Figure 1, the Indonesian average mathematics score in PISA 2022 was not significantly different from the average results on 2003, 2009, and 2012. Compared to the previous PISA in 2018, the average score of Mathematics in PISA 2022 showed a significant decrease (OECD, 2023).

As stated in OECD (2023b), average PISA scores are not directly representing the

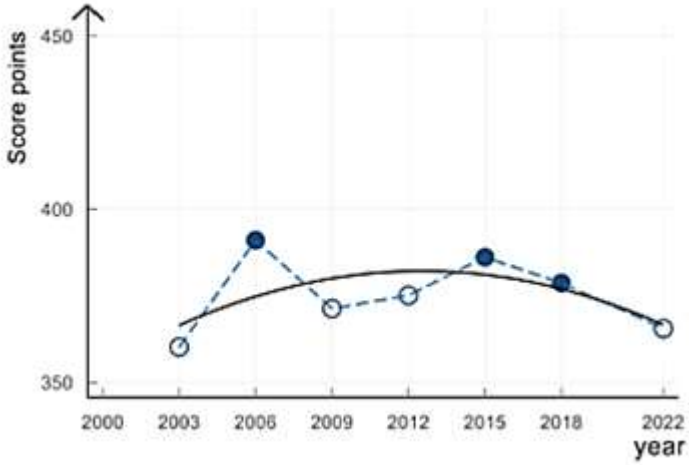

Figure 1. Average PISA score in mathematics for Indonesian students, 2003-2022. (OECD, 2023a).

effectiveness of educational system in a country. However, in Indonesia, PISA has shapen the public opinion about the quality of educational system, particularly curriculum and schools. Educational stakeholders from teachers, schools, up to the Ministry of Education often blamed when the PISA results is fail to increase.

Regarding these PISA results, several variables were found to be significantly affect Indonesian students' mathematics performance. Growth mindset, school climate, teacher support, socio-economic status, school resources, student engagement, and several other variables significantly affect students' mathematics performance in PISA 2018 (Kismiantini et al., 2021; Sari & Kismiantini, 2023; Efendi & Kismiantini, 2022; Muflihah & Kismiantini, 2023). Similarly, Indonesian students' mathematics performance in PISA 2015 were significantly affected by students' sense of belonging towards mathematics, socio-economic status of students' families, and the socio-economic status of school residents (Kartianom & Ndayizeye, 2017). Based on PISA 2012 data, it is known that student character and family socio-economic conditions, including ownership of learning aids, were significant predictors of Indonesian students' mathematics performance (Pakpahan, 2016).

Students' economic-socio-cultural status, which represented by ESCS index, is an interesting predictor of mathematics performance.

It was significantly affect Indonesian students' mathematics performance in PISA 2012 (Pakpahan, 2016), PISA 2015 (Kartianom & Ndayizeye, 2018), and PISA 2018 (Sari & Kismiantini, 2023). ESCS index also significantly affect students' mathematics performance in other countries such as Malaysia and Singapore (Thien & Ong, 2015), as well as EU15 countries (Sulis et al., 2020). The significance of ESCS index means that student achievement depends on the student's socio-economic conditions. In other words, we could not expect that students from low economic-socio-cultural conditions can had better performance than students from better situation, even that they obtain education.

To understand the effect of ESCS to students' mathematical performance, various studies have been carried out. Most of them found that ESCS is a significant predictor that influences students' mathematics performance directly (eg. Thien & Ong, 2015; Pakpahan, 2016; Kartianom & Ndayizeye, 2018; Sari & Kismiantini, 2023). On the contrary, other study shows that relationship between ESCS and student performance might be weak and less reliable (Marks & O'Connell, 2021; Pokropek et al., 2022). Other studies found that ESCS affect students' performance through mediator variables, such as expected occupational status, enjoyment of reading, mastery-approach orientation of achievement goals, and cultural capital (Michael & Kyriakides, 2023; Xie & Ma, 2019). It also found that ESCS also affect students' performance in school-level (eg. Lam & Lau, 2014; Karakolidis et al., 2015; Chen, 2016; Kartianom & Ndayizeye, 2018).

In fact, PISA participants are students aged around 15 years old, who can study at any grade. Different grades are certainly associated with different learning experience, and, different knowledge and skills. Students' grade is a significant predictor for their performance in PISA surveys (Barrera et al., 2011; Gomes et al., 2020). Therefore, even that it not become the focus, students' grade should be used as a predictor in analyzing students' performance (Fusch & Woessmann, 2008). Usage of grade as a control or predictor can give specific information for each grade, so appropriate follow-up actions can be taken for each grade or school level.

Indonesian participants of PISA survey ranging from first year junior secondary school students up to the third year of senior secondary school (Sari & Setiawan, 2023), so that there are six different grades. In this study we investigate how Indonesian students' grade and ESCS contribute to their mathematics performance. We also examine whether there is any interaction between these two variables. To obtain complete information on the interaction between ESCS and students' grades, we review the last four PISA tests, i.e. PISA 2012, 2015, 2018, and 2022. The four datasets will be analyzed separately using the same model, predictor variables, and response variable. In this way, we expect to obtain some insight about the progress of Indonesian students' mathematics performance over ten years.

METHOD

Participants and Research Design

This study uses a quantitative approach with secondary data, namely data from the 2012, 2015, 2018, and 2022 PISA surveys. As these survey were conducted by the OECD, all datasets are available and can be freely downloaded from the website (http://www.oecd.org/pisa). These datasets still contains information taken from students from various countries around the world. Therefore, we subset them to make new datasets that only contains students from Indonesia.

As stated in OECD (2023b), the population target of PISA survey is students in 15-years-old. In practice, it including students with age between 15 years 3 months and 16 years 2 months. All students asked to answer a

questionnaire which collect information about the their attitudes, dispositions, beliefs, situation on their homes, as well as their experiences at school. Another questionnaire given to the school principals, which asked some information about school management and organisation, and the learning environment. Respondents of PISA survey was taken using two-stage stratified sampling: schools as the first stage, and students as the second stage. To maintain the quality of the data, at least 150 school were selected in each country, whereas 42 students were taken from each school randomly.

Instruments

The dependent variable in this study is the mathematical performance, which represented by several plausible values (PVs). PISA 2012 provides five PVs, while the PISA 2015, 2018, and 2022 provide ten PVs for each component. PVs were calculated from students' response to PISA's given test. It should be known that participants of PISA surveys might asked to answer different questions selected from the PISA's question bank. Therefore, the number of correct answers (or "raw score") could not be compared each other. An explanation about the calculation of plausible value as well as its analysis can be found in OECD (2009).

The independent variables or predictors are students' grades and economic-socio-cultural status (ESCS), which can be explained as follows.

Grades are a variable that states a participant's class or educational level when taking the PISA test. In the PISA datasets, this information was represented in two forms: student international grade (code ST001D01T) and the relative position of a level to the level with the most participants (code GRADE). Through these variables, we can identify which student was in grades 7, 8, and 9 of junior secondary school or grades 10, 11, and 12 of senior secondary school.

Economic-Socio-Cultural Status (ESCS) in the PISA survey is defined as a measure of student access to family resources (financial capital, social capital, cultural capital, and human capital) which determines the social position of the student's family or household (Avvisati, 2020). The calculation of this variable is based on the student's parents' highest educational level (PARED), the student's parents' highest employment status (HISEI), and the ownership of several items (HOMEPOS). Employment status is constructed according to the "International Socio-Economic Index of occupational status" developed by Ganzeboom (2010). Ownership of items are represented by several questions about possessions of study desk, study room, quiet place to study, computer, educational software, internet, classic literature, books of poetry, works of arts, books for schoolwork, technical reference books, dictionary, television, cars, bathroom with bath or shower, smart phone, portable computers, tablets, e-book reader, and musical instrument (Avvisati, 2020). The ESCS is represented as standardized values with mean 0 and standard deviation 1 (OECD, 2019). An ESCS score valued zero (0) can be interpreted as the same economic-socio-cultural condition to most PISA participants around the world.

Note that PISA survey provides many variables regarding students' profile, such as availability of computer (and/or internet) at home, parents' education, students' activities, students' growth mindset, students' age when starting primary school, and many more. However, since the focus of this study is on students' grade and ESCS, we did not analyze these other variables.

Data Analysis

We conducted a descriptive analysis of the number of PISA participants at each level and their mathematical performances. Since students' grade is a categorical variable and ESCS is a

numerical variable, we can ignore the multicollinearity testing.

Following the research objectives, inferential analysis was conducted to determine the relationship between educational level and ESCS on students' mathematical abilities. Since grades are categorical variable, several dummy variables were formed by placing grade = 7 (the lowest grade of PISA participants in Indonesia) as the reference category. With these dummy variables, two models are defined, namely Model 1 and model 2:

$$MATH = \beta_0 + \beta_1 D_8 + \beta_2 D_9 + \beta_3 D_{10} + \beta_4 D_{11} + \beta_5 D_{12} + \beta_6 ESCS + \varepsilon \quad (1)$$

$$MATH = \beta_0 + \beta_1 D_8 + \beta_2 D_9 + \beta_3 D_{10} + \beta_4 D_{11} + \beta_5 D_{12} + \beta_6 ESCS + \beta_7 ESCS \times D_8 + \beta_8 ESCS \times D_9 + \beta_9 ESCS \times D_{10} + \beta_{10} ESCS \times D_{11} + \beta_{11} ESCS \times D_{12} + \varepsilon$$

In these two models, D_i, for $i = 8, 9, 10, 11$, and 12 is a dummy variable valued 1 for subject in grade i and 0 otherwise. Model 1 contains main effect only, whereas model 2 contains both main effect and interaction effects. Using these four datasets, the parameters of each linear model are estimated separately for each mathematics PVs as the dependent variables. We use the ordinary least squares method (OLS) to obtain the estimated value of regression coefficients by considering the weight of each student (Watanabe, 2009). Therefore, in real we estimate ten regression coefficients for each model and each dataset.

All estimation and analysis procedures were carried out by using R software (R Core Team, 2021) through R studio framework. To analyze the data, we use several libraries especially *EdSurvey* (Bailey et al., 2023) and *intsvy* (Caro & Biecek, 2017).

■ RESULT AND DISCUSSION

The number of Indonesian students who became participants to the 2022 and 2018 PISA survey was 13,439 and 12,058, respectively. These participants were twice that of the 2015 and 2012 PISA surveys. Referring to the 2018 PISA guidelines (OECD, 2018), this additional number of students aims to oversample the provinces of DI Yogyakarta and DKI Jakarta so that further analysis can be made related to the two provinces. On PISA 2022, oversampling was carried out at these two provinces and Bangka Belitung (OECD, 2023). A comparison of the number of participants in the four recent PISA surveys in Indonesia is presented in Figure 2.

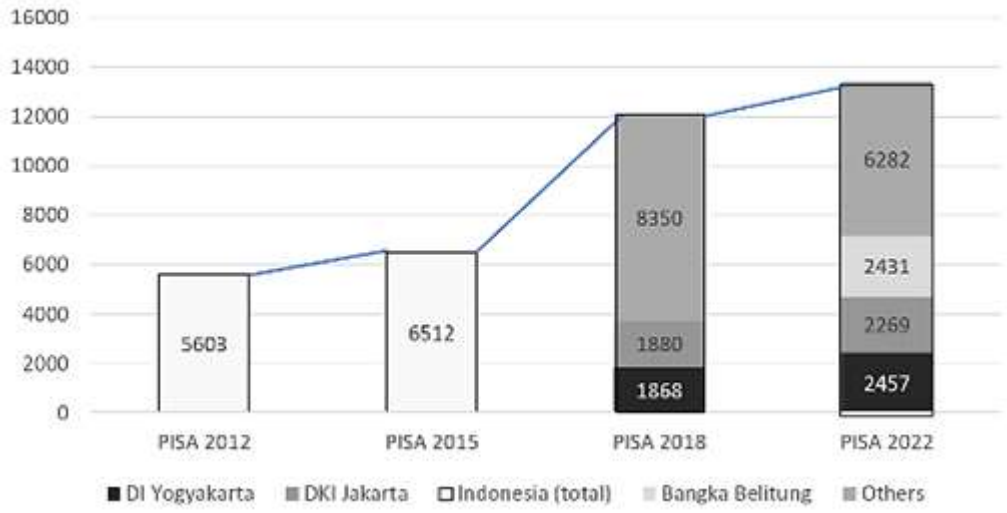

Figure 2. Number of Indonesian students participated in PISA 2012 to 2022

In addition, participants of PISA 2022 and PISA 2018 were taken from 410 and 397 school, respectively. These school consists of public and private school, located in various area (village, district, cities, etc.). It should be noted that number of students involved in PISA from each school are not necessarily same.

Grades and Students' Mathematical performance

In general, PISA test takers in Indonesia are at six different levels of education: first to third year in junior secondary school (Grades 7 to 9) and first to third year in senior secondary school (grades 10 to 12). Table 1 shows that the proportion of participants from Grade 7, Grade 8, and Grade 11 in the 2012 PISA survey was relatively the same. Significant differences were found in Grade 9 and Grade 10 PISA participants, which fluctuated between 3% and 5%, respectively. Interestingly, in 2015 and 2022, almost 50% of PISA survey participants were in grade 10. Furthermore, Grade 12 on the PISA test results cannot be compared statistically because the percentage of students is never more than 1%.

Table 1. Grade distribution of Indonesian students participated in PISA 2012-2022

PISA Year	Number (percentage) of participants in					
	Grade 7	**Grade 8**	**Grade 9**	**Grade 10**	**Grade 11**	**Grade 12**
2012	100 (1.78%)	436 (7.77%)	2249 (40.12%)	2587 (46.15%)	215 (3 .83%)	19 (0.34%)
2015	110 (1.69%)	425 (6.53%)	2581 (39.63%)	3245 (49.82%)	151 (2.32%)	1 (0.02%)
2018	209 (1.73%)	921 (7.61%)	5178 (42.80%)	5382 (44.49%)	349 (2.88%)	59 (0.49%)
2022	91 (0.68%)	625 (4.65%)	5352 (39.82%)	7025 (52.27%)	327 (2.43%)	19 (0.14%)

Table 2 shows a relatively sharp difference in mathematical abilities between students in grades 8 and 9 and grades 9 and 10. Except in PISA 2022, the difference in the average scores for these two levels is around 30 or even more. On the other hand, the difference in scores between students in grades 7 and 8 and 10 and 11 is relatively small, which is always less than 15. In PISA 2012 and 2022, grade 11 students' mathematics scores were even lower than Grade 10. It can be inferred that students' mathematics performanc at these levels are relatively the same.

Table 2. Weighted mean (and standard deviation) of mathematics performance score from Indonesian students in each grade

PISA Year	Mean (SD) of Plausible Value in Mathematics					
	Grade 7	**Grade 8**	**Grade 9**	**Grade 10**	**Grade 11**	**Grade 12**
2012	320.4 (59.2)	330.0 (55.6)	364.9 (59.6)	393.1 (65.5)	391.6 (68.8)	409.3 (38.3)
2015	330.1 (55.9)	338.9 (53.4)	374.1 (62.9)	415.4 (73.1)	430.9 (67.9)	581.9 (-)*
2018	313.7 (61.7)	340.0 (61.7)	383.0 (70.6)	430.4 (78.9)	440.2 (82.7)	410.3 (94.1)
2022	318.3 (54.6)	334.2 (53.7)	355.2 (56.1)	377.6 (64.7)	366.7 (62.8)	305.9 (46.8)

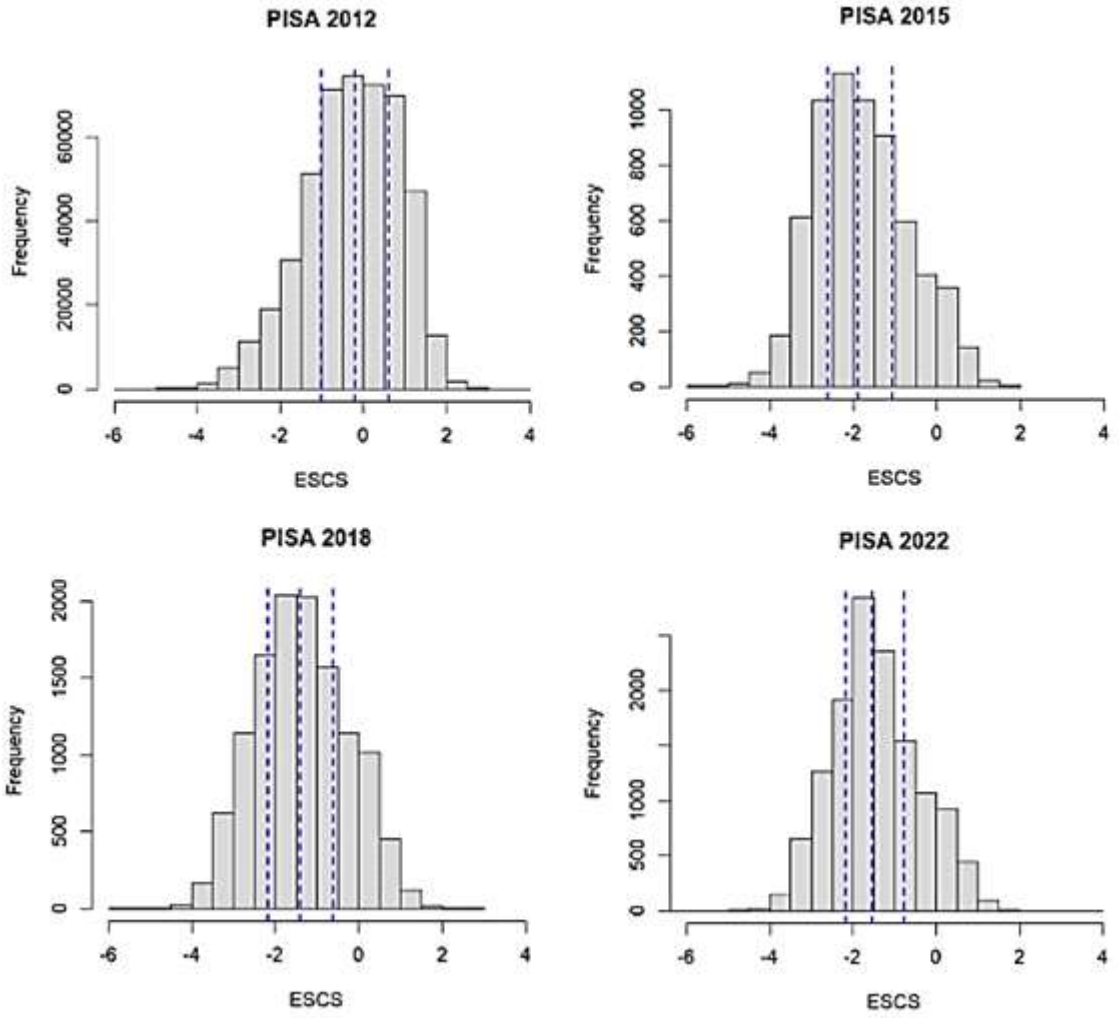

Figure 3. Distribution of ESCS score of Indonesian students participated in PISA 2012 to 2022. Blue dashed line, from the left to right, represents the lower quartile (Q1), median (Q2), and upper quartile (Q3) of the data

From PISA 2012 to 2018, the average score in Grade 8 to Grade 11 has consistently increased. The most significant increase was found in Grade 10, with the difference in the average score between the PISA tests not less than 15. There was also an increase in grade 9 students, indicating that students' mathematical abilities at this level tended to increase from one period to the next. In PISA 2018, the difference in the average mathematical performance of grades 7 and 8, grades 8 and 9, and grades 9 and 10 has increased compared to the results of the previous PISA survey.

Despite this promising situation on PISA 2012 to 2018, Covid-19 pandemic seems to have large impact on students' mathematics performance. In PISA 2022, the average PISA score was much lower than in PISA 2018. Highest decrease occurred in Grade 10 and Grade 11, with average score lower than in PISA 2012. Interestingly, the decrease of average PISA score was accompanied by decrease of standard deviation. For Grade 8 to 11, the standard deviation of PISA score become the lowest among other PISA surveys, which can be interpret that students' mathematics performance is less

varying. This is not a good news, since the reduction of variation is occurred in low score instead of high score, which means that more students obtain low score.

Regarding students' Economic-Socio-Cultural Status (ESCS), Figure 3 show large difference on ESCS of Indonesian students in PISA 2012 compared to the later PISA. In PISA 2012, the median ESCS score of Indonesian students is about zero, which means that the economic and socio-cultural condition of Indonesian students is similar to students from other countries. However, since PISA 2015, more than 75% ESCS of Indonesian students is lower than zero. In addition, more than 25% Indonesian students obtain ESCS score lower than -2. This result can be interpreted that the economic, social, and cultural status of Indonesian students is mostly lower than average economic-socio-cultural condition of students from all countries participated in PISA survey in these years.

ESCS, Grade, and Student Mathematics Performance

To see the relationship between educational level, ESCS, and students' mathematical performance, the estimation results of Model 1 and Model 2 are presented in Table 3. We confirm that all classical assumptions were fulfilled, and residual examinations were carried out.

Table 3 shows that of the four PISA datasets, the coefficient of determination for the Model 2 (with interaction) is always higher than Model 1 (without interaction). It means that the Model 2 performs better on explaining the variability of students' mathematical performance in PISA surveys. However, interpretation will be carried out for both of the two models.

The intercept in Model 1 and 2 represents the mathematics ability of grade 7 students with an ESCS score of zero. For example, according to Model 1, a grade 7 student with ESCS score zero that following PISA 2022 obtain score of 316.55 in average. Changes in intercept values from the 2012 to 2022 PISA tests, as presented in Table 3, could not be interpreted as changes in students' mathematical abilities in Indonesia. When interpreting the intercept, we must remember that a zero ESCS score equals the average socio-cultural-economic condition of PISA test takers from all over the world. Since only less than 20% Indonesian students has ESCS about zero, the coefficient of ESCS must be used in predicting students' average mathematics performance.

Regarding students' grade, the regression coefficients should be interpret as the the difference of average students' mathematics performance on a specific grade compared to the students in grade 7. Positive coefficients means that in average, students' in this grade has higher mathematics performance than students' in grade 7, vice versa. Thoretically, students in higher grade has longer experiences on learning mathematics, so that they had higher mathematics performance which implies positive coefficients.

Regression coefficients for ESCS could be interpret as a measure on how the ESCS affect students' mathematics performance. We expect a coefficients near to zero, which means that the economic-socio-cultural status does not affect their mathematics performance. We also say that small coefficients indicate that mathematics performance are equal among students; i.e. almost all students have similar level of understanding mathematics despite their economic or socio-cultural status. Positive coefficients of ESCS indicate that students with higher status have higher mathematics performance. As the coefficient become higher, it indicate that the disparity or differences in average mathematics performance between students from different status become large.

Table 3. Results of OLS estimation for regression coefficients of Model 1 and Model 2 based on PISA 2012, PISA 2015, PISA 2018, and PISA 2022 dataset, by considering sample weight

Variable	Model 1				Model 2			
	2012	2015	2018	2022	2012	2015	2018	2022
Constant	354.33*	382.70*	338.48*	339.02*	311.90*	348.59*	313.58*	316.55*
ESCS	15.26*	23.82*	16.99*	12.68*	-3.84	10.16	1.21	-1.25
Grade 8	8.57	11.08	30.00	17.49	29.46	4.57	22.82	24.00
Grade 9	39.34*	37.50*	53.79*	37.20*	75.33*	64.49*	66.78*	48.65*
Grade 10	63.63*	65.37*	86.24*	57.38*	113.14*	108.02*	120.79*	87.81*
Grade 11	59.37*	74.52*	87.46*	46.42*	114.87*	103.59*	127.39*	73.76*
Grade 12	86.39*	177.62*	22.61*	-13.46	87.12*	224.12*	42.71	-37.56*
ESCS* Grade 8	-	-	-	-	9.11	-3.66	-1.69	4.85
ESCS* Grade 9	-	-	-	-	15.69*	10.33	8.95	7.27
ESCS* Grade 10	-	-	-	-	23.49*	19.19*	22.51*	19.38*
ESCS* Grade 11	-	-	-	-	28.14*	10.03*	26.40*	17.22
ESCS* Grade 12	-	-	-	-	-1.18	-	10.04	-16.07
R^2	15.99%	21.31%	15.67%	9.6%	16.80%	22.14%	17.08%	10.7%

The estimation of Model 1 shows that there is an additively significant effect of ESCS and grades on students' mathematical performance. However, the estimation results of Model 2 shows that the additive effect is insignificant, but there was a significant interaction between ESCS and grades influencing students' mathematical performance. These interaction means that students from different socio-economic-cultural conditions have different abilities even though they are studying at the same level. By comparing the coefficients for the ESCS interaction in grades 8 to 10, it appears that the higher a student's grade, the more significant the difference in math scores caused by differences in ESCS. The coefficient of interaction terms is increasing between the 2012 to 2018 PISA results, but then decreasing in PISA 2022. In addition, Grade 10 become the only grade that has significant interactions with ESCS on all period of PISA. This indicates that difference in ESCS will appear on Grade 10 students' mathematics performance, which are the first grade in the senior secondary school.

How does grade affect students' mathematics performance? In four consecutive PISA, the coefficient of the dummy variable for grade in Model 2 is significant, except for Grade 8 (D8). It means that for the similar ESCS, the mathematics performance of Grade 8 students and Grade 7 students are not differed significantly. In addition, dummy variable coefficients for Grade 8, Grade 9, and Grade 10 in PISA 2018 are higher than PISA 2015, which are also higher than PISA 2012 and 2022. In line with Table 2, we can say that for the same level of ESCS, the average difference in mathematical performance among students at different levels is become increasing until 2018. However, in 2022, the average difference become decreasing, which might be related to the learning loss during the Covid-19 pandemic situation.

The difference in estimated coefficients for dummy variables can be explained as follows. In PISA 2012 and 2015, the difference in coefficients for the Grade 9 and Grade 8 is the largest, followed by the difference in the coefficients for Grade 10 and Grade 9 as well as Grade 8 and Grade 7. It means that the PISA participants who have completed learning mathematics in Grades 7, 8, and 9 have different mathematical abilities from those studying at that level. Another explanation is that students in grade 7 or 8 in their age (15 year old) are slow learner or one who repeating a grade, which makes them exhibit lower mathematics performance. In PISA 2018 and 2022, the highest difference is found between Grade 10 and Grade 9, followed by Grade 9 and Grade 8. Among these four consecutive PISA, the difference between the coefficients of Grade 11 and Grade 10 always relatively small compared to other grades. Therefore, we may conclude that students who have finished studying at Grade 10 and those currently studying at that grade has similar mathematical performances.

Concerning Grade 12, the exceptionally high coefficient (and the vast difference to the grade 11 coefficient) in PISA 2015 is meaningless because it only comes from a participant with a high ESCS. Based on PISA data for 2012 and 2018, we obtained an estimate of the coefficient of the Grade 12 variable, which is less than the coefficient of the Grade 10 variable. Surprisingly, in PISA 2022, the estimated coefficient is negative, although it comes from 19 participants. In Indonesia, a student aged around 15 who sits in Grade 12 means starting elementary school at around four years of age or attending an accelerated program (or skip a certain level). Even though they sit at a higher grade level, these students' numeracy skills are not always higher than those currently studying at a lower level. Considering that there were only 59 participants in the PISA 2018 at this level, further research can be conducted to identify the causes of these students' low mathematical abilities.

In-depth Analysis: PISA 2018 and 2022

The existence of oversampling in the PISA 2018 data allows us to compare the performance of PISA participants in Indonesia from three regions: the Special Region of Yogyakarta (DIY), the Special Capital Region (DKI) Jakarta, and other provinces. In PISA 2022, the oversampling was conducted for the two province plus one another province, i.e. Bangka Belitung.

Table 4 shows the estimation results of Model 2 for each province based on the PISA 2018 and 2022, respectively. Model 2 was used here because it has higher coefficient of determination compared to the Model 1. In general, there are some variations of estimated intercept and coefficients for each province, although the data is obtained from the same survey. The coefficients of determination for this model is also highly varied, meaning that the contribution of these variables to students' mathematics performance is not same.

For PISA 2018 dataset, Table 4 show that estimation of the dummy variable coefficient grades 8 to Grade 11 for DI Yogyakarta are higher than DKI Jakarta and other regions. This result indicates that students' mathematical performance from other regions at that level is lower than DKI Jakarta and DI Yogyakarta Provinces. In addition, there is a significant interaction between the ESCS and the grade. For DKI, the coefficient on the interaction component of ESCS with Grade 10 and Grade 11 even reaches twice the same coefficient in data from other provinces. We can say that compared to other regions, the performance of students in DKI is strongly affected by the socioeconomic status of these students. Those with low socioeconomic status will have negative ESCS and might obtain a much lower PISA score than other students whose socio-economic-cultural status were near

Table 4. Results of OLS estimation for Model 2 coefficients based on PISA 2018 and PISA 2022 for each province, by considering sample weight

Variables	PISA 2018			PISA 2022			
	DIY	DKI	Others	DIY	DKI	Bangka Belitung	Others
Constant	269.99*	214.27*	313.93*	281.52*	320.92*	287.22*	316.75*
ESCS	-29.68	-58.92*	1.56	-17.87	-5.86	-7.52	-1.05
Grade 8	94.48*	132.66*	21.78	69.03*	34.49	31.48	23.21*
Grade 9	195.21*	182.64*	63.48*	154.46*	88.53*	66.70*	44.15*
Grade 10	204.28*	256.96*	116.68*	141.88*	123.10*	120.40*	84.83*
Grade 11	233.61*	301.31*	121.25*	179.42*	142.68*	170.37*	71.31*
Grade 12	66.49*	274.01*	33.35	-	-199.80	163.86*	-52.05
ESCS*Grade 8	30.88	61.54*	-2.14	16.21	12.37	6.10	4.54
ESCS*Grade 9	60.13*	68.93*	7.73	43.15*	29.14	10.21	5.54
ESCS*Grade 10	55.03*	94.55*	20.88*	28.35	37.83	22.92*	18.24*
ESCS*Grade 11	47.81*	102.16*	23.87*	34.32	46.67*	34.61*	16.11
ESCS*Grade 12	-	82.48*	5.30	-	-192.91	45.49*	-21.88
R^2	20.44%	30.24%	16.19%	12.76%	25.68%	21.03%	10.16%

the OECD average. Compared to DKI and DIY, the interaction between ESCS and grade for students from other provinces is relatively weaker.

In PISA 2022, we find that the estimated coefficients of grades 9, 10, and 11 were significant for all the three provinces and the other one. For grade 8 to 11, the estimated coefficient on DIY was higher than the others. However, it has an anomaly where estimated coefficient for grade 10 is lower than grade 9 and grade 11. Largest differences of coefficient between grade 8 and 9 was found in DIY, while largest differences between grade 9 and 10 as well as grade 10 and 11 was found in Bangka Belitung. Compared to the category 'other provinces', these three provinces exhibit higher coefficients for students' grade, which show a large discrepancy of students' mathematics performance. In addition, we found that the significant interaction occurred in various grade, such as grade 9 in DIY, grade 11 in DKI, and grade 10 in other provinces. For Bangka Belitung, significant interactions are found in grade 10 and grade 11.

Table 4 also show that compared to the PISA 2018, the estimated grade coefficient of PISA 2022 is lower. This result explains how the average mathematics performance score of PISA 2022 become lower than PISA 2018: decrease was occurred in almost all grades. It also noted that the estimated grade coefficients for 'DKI' and 'other provinces' in PISA 2022 is nearly half of their grade coefficients in PISA 2018, which might show a higher 'learning loss' during pandemic time. However, good news in PISA 2022 is that many coefficients of interaction terms between students' grade and ESCS in this survey become smaller and insignificant.

An interesting result among four PISA survey is that the interaction coefficient between ESCS and grade 10 or first-year senior secondary school is always significant. For PISA 2018, the significant interaction coefficient also found in all provinces. However, in PISA 2022, this situation only found in Bangka Belitung and other provinces, although the coefficient in DIY and DKI is somewhat large. Further study especially on the first year of senior secondary school

should be carried out to identify the effect of ESCS on students' performance in this grade.

Several literatures show that ESCS is a variable that influences students' mathematics performance, both directly and indirectly (Michael & Kyriakides, 2023; Kismiantini et al., 2021; Çiftçi & Cin, 2017). On the other hand, there is also literature that shows a weak relationship between ESCS and student abilities (eg. Pokropek et al., 2022). In this study, we show that the significant influence of ESCS on students' mathematical performance only occurs when the model does not contain an interaction between ESCS and grade. When we use model with interactions, then ESCS itself is no longer significant, while the interaction between ESCS and grade has a significant effect on students' mathematical performance. Although not always significant, the interaction coefficient of ESCS with level of education become increase along with students' grade.

The significant interaction between ESCS and grade on students' mathematics performance can be explained as follows. Students with high ESCS generally have more adequate facilities for studying, so they can participate in good learning even from an early age. The learning facilities might include a quiet place to study at home, books, computers, and support for learning such as additional lessons. As a result, they are better able to take part in mathematics learning at a higher level. In contrast, students with lower ESCS tend to have poorer relationships with teachers and thus achieve lower outcomes (Hughes et al., 2012; Roorda et al., 2017; Xuan et al., 2019). Students with low ESCS also tend to have lower self-efficacy (Yildirim & Yildirim, 2019; Usher et al., 2019; Liu et al., 2023), which results in lower mathematics performance (Peters, 2013; Xu & Qi, 2019). As the level of education increases, students who from the start have low mathematics ability are at risk of falling behind. In the end, despite advancing to a higher level, these students have relatively lower mathematics performance.

Practical Implication and Limitation

Significant coefficient of ESCS implies that students economic status and/or socio-cultural status plays important role in determining their mathematics knowledge and skill. Remember that the PISA score is not a measure of students' learning process in a specific grade, but a measure of what students' had learn (cumulatively) from their childhood up to the age of 15, when they participated in PISA survey. In addition, significant interaction between ESCS and students' grade indicate that in each grade, students from higher economic or socio-cultural status might develop more mathematical skills during their life, compared to the students from lower one. Consequently, efforts should be made to minimize the interaction so that students at the same level have similar mathematical performance. Providing free internet access is an alternative, considering the internet can be a relatively complete source of learning mathematics (Suwarno, 2017; Pohan, 2020). The Government can also increase funding assistance for school operations, especially for schools whose students come from low-income backgrounds. It is difficult for schools like this to raise funds from students' parents, so additional funding from the Government can be used to improve the quality of learning.

Why the interaction of ESCS and grade on PISA 2022 become larger than the revious PISA? In practical situation, we might deduce that students from higher socio-economic status might obtain support from various technology and/or support teacher (e.g. additional private support paid by the parents) in understanding mathematics. However, students from different socio-economic or cultural status also exhibit different psychological conditions such on their growth mindset, self-efficacy, anxiety, plan of continuing to higher education, and many more. These explanations should be examined through further analysis of PISA 2022 dataset, which focused on students' mathematics performance and contains more information related students' experience in learning mathematics.

This study also result on recommendation for primary and junior secondary school mathematics teacher. For them, it is important to ensure that all students, despite their socio-economic-cultural status, enjoy learning mathematics. They should able to master similar level of knowledge and skills on mathematics without dependence to expensive technology as well as (paid) additional support. They must be able to solve mathematics problem, even if they only learn mathematics from their course at school. Any use of recent technology, if needed, must be limited into that are freely available and accessible by all students in the school. For example, asking students to install an educational software in their private gadget, notebook, or laptop is recommended only if all students have gadget or laptop that support the use of such software. Enrichment material, if available, might be given to several students based on their achievement instead of their socio-economic and cultural status.

This study has limitations because it only looks at the economic-socio-cultural (ESCS) as a single variable. The data used is also not transformed, so the zero value for this variable does not reflect the average ESCS of Indonesian students. Furthermore, the contribution of each ESCS component, such as parent's education, parent's occupation, and ownership of several facilities at students' homes, to students' mathematical performance can also be analyzed one by one so that we can identify profiles of students who still need to improve their mathematical performance. This approach will be in-line with Prabawa *et al.* (2024), which show the importance of appropriate teaching methods to improve students' achievement on PISA. ESCS at the school level, which is known to affect students' mathematical performance (Kartianom & Ndayizeye, 2017), as well as various variables on school level also can be added to the model. In addition, PISA 2022 also provide more data on plausible value, i.e. on specific mathematics subscale based on domains (uncertainty and data, space and shape, quantity, change and relationship) as well as subscale based on process (formulate, employ, interpret and evaluate, mathematics reasoning). Further analysis can be carried out in these subscale. Last but not least, analysis can also be conducted to examine the influence of these variables on reading performance and science performance, which are also available in the PISA survey.

■ CONCLUSION

The Program for International Students Assessment (PISA) is a three-year survey followed by students aged around 15 years from various levels of education. PISA data for 2012, 2015, 2018, and 2022 shows that students' grade and its interaction with ESCS affect Indonesian students' mathematical performance. In PISA 2018, the magnitude of the interaction effect tends to increase as the grade increases, contributing to the higher variability of the Indonesian students' scores compared to the previous ones. In contrast, the interaction seems to be weaker in PISA 2022 due to lower scores and lower variability of the data. Further research should describe the relationship between the components comprising the ESCS and students' mathematical performance, as well as design appropriate steps to increase the average while reducing PISA score variability especially in Indonesia.

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