Exploring the Effects of Gender, Technology, and Economic Status Towards Indonesian Students' Science Performance in PISA 2022

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Abstract
Science is one of the vital subjects that assists students to develop their high order thinking skills. Correlatively, Programme for International Student Assessment (PISA) is one of impactful international studies that is also assess and evaluate students' science performance through tests and surveys that may affect their performance in science. However, studies that explore how gender, technology, and economic status is rarely found in Indonesian and global contexts. Therefore, this study aims to examine the effects of gender, information and communication technologies (ICT) resources, and index of economic, social and cultural status (ESCS) towards Indonesian students' science performance based on PISA 2022 data. This quantitative study used the whole sample (N=13,439) of 15-year-old Indonesian students who participated in the tests and surveys. Through the conduction of structural equation modelling (SEM) using AMOS software 29 version, this study found that student gender insignificantly influences science performance (β=-0.05) and also has minor correlation towards ICT resources and ESCS (β=0.02). Meanwhile, ICT resources had direct moderate effect (β=0.29) on science performance which is supported by ESCS as it is highly correlated to the availability of ICT resources (β=0.99). Although this research provides a substantial impact on the body literatures, this research is limited only based on PISA data which there could be other relationships among variables included in the study. Further investigation is recommended to include other variables to clarify whether there are different effects on science performance, particularly with diverse background of students in Indonesia.

Keywords: Science, Gender, ICT, ESCS, Indonesia, PISA

Introduction

The international standard of quality education can be measured from many aspects, and one of the largest programs named Programme for International Student Assessment (PISA) test, which is held by Organization for Economic Co-operation and Development (OECD) has measured education quality in many countries in the last two decades. The PISA test measured three main subjects, namely science, mathematics, and reading performance. In this case, science achievement becomes one of the intriguing topics among academic researchers, and there are many factors that can be examined. According to PISA 2018 results (OECD, 2019), Indonesian students' performance in science in 2018 were at low level. After pandemic corona virus disease (COVID-19) occurred, Indonesian students' science performance in PISA 2022 is lower compared to previous test in 2018 (OECD, 2023b). The situation that happened in 2020 to 2022 changed the way in which schools were conducted lesson from face-to-face to online. This situation forced students to use digital devices, such as computer, laptop, and smartphone during learning processes which can be considered as Information and Communication Technologies (ICT). The availability of ICT resources enables students to access learning material without depending on school activities, allowing them to enhance their knowledge independently.

Numerous studies have been conducted that examine factors influencing science achievement such as teaching approaches, learning media, and socioeconomic status. For example, a study by Gómez and Suárez (2020) mentioned that socioeconomic is one of the strong predictors that influence science achievement in PISA 2015. There are many potential factors that may influence student's science performance in Indonesia based on PISA 2022. In this case, it is possible that ICT resources, students' gender, and socioeconomic status are associated to one another and might become the significant factors among other variables that collected in PISA test. Besides, remote learning or online learning that conducted during the pandemic might also influence on PISA test 2022. Therefore, this study aims to explore the influence of student gender, the availability of ICT resources, and economic status regarding science performance based on PISA 2022 dataset in Indonesia. This report will contribute to the literature as the evidence from Indonesia to support the development of knowledge as there are only few studies that examine factors influence science performance in Indonesia. The findings may also contribute to the development of quality education in Indonesia and other developing countires regarding the implementation of technology in learning activities. Moreover, this report may also influence other educational researchers to explore further that related to science.

Research Question

The grand question of this study is "How is the influence of gender, ICT resources, and Index of economic, social, and cultural status towards Indonesian students' science performance in PISA 2022?"

Review of Related Literatures

There is literature that related to the scope of this study which is limited to gender, ICT, and economic status towards science performance. However, there are limited literature that focuses on Indonesia based on reputable resources. Therefore, the supporting evidence in this study is combined from various countries. Student gender can sometimes become the factor that differentiate students' academic performance at school. A study by Reilly and colleagues

(2019) which compared academic performance in science based on Trends in Mathematics and Science Study (TIMSS) found that female students achieved better than male in mathematics and science. Also, a study by Stoet and Geary (2018) on science literacy which is based on PISA data 2015 found that female students achieve higher score than male students. The previous studies are contrast with study by Jia and colleagues (2020) in China found that although female students have more interest in science, male students somehow achieve better in some section such as multiple-choice section. Likewise, Smith and colleagues (2014) claimed that male students have more confidence in science than female, meaning that male students may have more interest in science which leads to better performance. From the literature found, student gender is not always influence academic performance in science because both male and female have equal opportunity in learning.

Moving to ICT resources, this factor has massive effect in our daily activities as well as for education purposes (Al-Rahmi et al., 2020). Both female and male students may have different interest in the use of technology in their learning processes. An investigation by Dúo-Terrón and colleagues (2022) in Spain, which involved primary school students reported that male students presented higher score in using ICT than girls. It is also happened in Bangladesh, as Rashid (2016) found that female has more hurdles to use ICT although compared to male students. The use of ICT in learning may directly affect students' academic performance in various subjects. For instance, a research by Bai and colleagues (2021) revealed that ICT improves English performance which is align with Rohatgi and colleagues (2016) who claimed that ICT positively correlated to computer science performance. Similarly, some studies by Xiao and Sun (2022), and Palomares-Ruiz and colleagues (2020) also found that ICT resources are positively affects students' academic performance, meaning that the availability of ICT at school and home assists students to obtain better visualization on science resources and supports their interactive learning activities. In detail, Palomares-Ruiz and colleagues (2020) claimed that the implementation of ICT in science class increases student's motivation to learn science, and they mentioned that female student scored higher that male students. Ultimately, it is true that ICT supports students to achieve better in their academic environment and both male and female students have the equal opportunities to enhance their knowledge through ICT. Besides, there are various ICT resources either hardware or software that can be used by teachers and students in teaching and learning activities. For example, study by Zainuddin (2018) in Indonesia reported that online interactive quiz increase students' motivation in learning. However, the literature found are mostly from other countries as there is limited resources from Indonesia. Besides, pandemic that happened across the world in the last few years indirectly forced students to have ICT resources to support their learning and they were required to be able to learn independently.

OECD also has categorized the ICT resources items that are commonly used by school communities for their learning activities both at school and home. Those devices include portable computers such as notebook and laptop, tablets, smartphones with all operating system, e-book readers. In addition, supporting facilities also required to accommodate ICT resources such as a room of your own, internet access, and television (OECD, 2023c). In this case, decent ICT resources at home is provided by their parents. Moreover, there must be integration among devices in order to work properly. For example, integrated computer consists computer, software, and internet connection in order to be used by students. The availability of ICT resources is highly correlated to family support. In this context, PISA also measured index of economic, social, and cultural status (ESCS) which is the combination of parents' occupation, parents' education, and home possession.

According to PISA 2022 dataset, there is no data of parents' professions. In this case, parents' educational background and home possession can be the indicator of financial support for students which is associated to ICT resources support at home and students' academic performance. A study by Roksa and Kinsley (2019) stated that financial support from students' family has indirect impacts on their academic attainment, which is supported by Claro and colleagues (2015) based on Chile PISA dataset, who claimed that parents' education is highly correlated to better academic performance. It is because socioeconomic status may support students with electronic devices and digital skills, allowing students to explore more information related to school activities independently. Likewise, a study conducted by Lagravinese and colleagues (2020) that explored data in PISA 2009 and 2012, also mentioned that socioeconomic is correlated to students' academic performance. Similarly, Gómez and Suárez (2020) who explored factors influence science achievement in PISA 2015, claimed that socioeconomic characteristic is strong factor that affect science performance. In addition, socioeconomic may also correlated to ICT resources at home as parents should provide budget to have technology devices at home. Hence, the different of socioeconomic status may lead to different results in science performance.

Based on the studies that found related to gender, ICT resources, and ESCS towards science performance, hypothesized path model has been formulated which is shown in Figure 1 below.

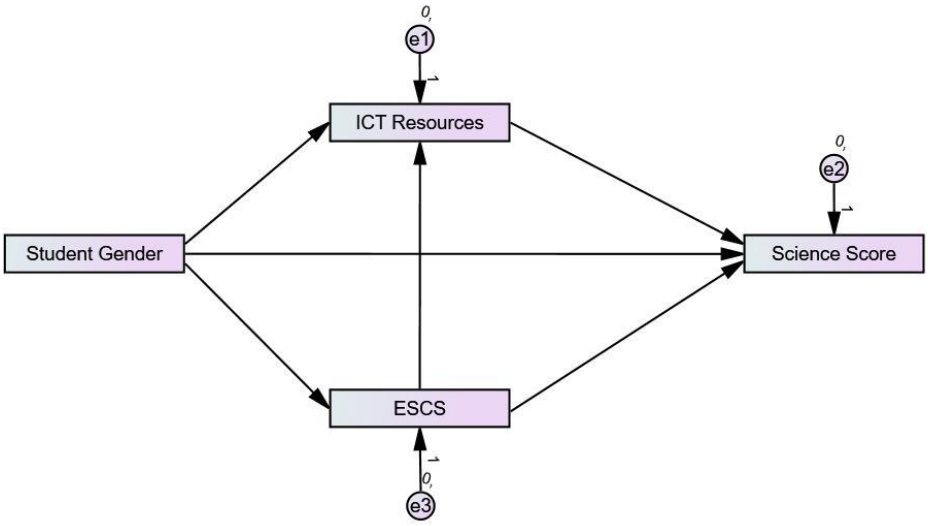

Figure 1: Hypothesized Path Model

Methodology

This quantitative research report is based on Program for International Student Assessment (PISA) data reported in 2022 which was held by OECD. Therefore, the selected data of ICT questionnaires in PISA data 2022 is based on OECD framework (OECD, 2023a). According to OECD, surveys and tests were conducted by employing questionnaires and using two methods namely paper-based and computer-based (OECD, 2023c). There are many developing countries that participated in the study and Indonesia data were chosen in this study. Indonesia participated in PISA test 2022 which 13,439 students from 410 schools were completed the test and surveys. The number of participants in this period is higher compared to PISA 2018 which is at 12,098.

Data for this report focuses on student gender, ICT resources, index of economic, social, and cultural status (ESCS) or Economic Status and science score in Indonesia PISA 2022 dataset. According to OECD (2024), there are some changes in the survey. ICT resources in 2018 has 21 items while in PISA 2022 only 12 items. Therefore, ICT resources items were trimmed from 12 items to nine items because only nine items that similar to previous period in 2018. Besides, data for ICT resources in Indonesia were focused on the availability at home which can be seen from the survey. Moreover, items from ICT resources that are not included were moved to ESCS items because the items of ICT resources also from ESCS in PISA survey. It can be seen from PISA technical report where ESCS consist of three main components namely parent profession, parent education, and home possession. In this case, ICT resources items were included in home possession. Furthermore, ESCS component only include parent education and home possession because parent profession items were not found in the Indonesia PISA 2022 dataset. In addition, value for each item have been checked and there are some items that its value required to be recoded. For instance, the value for ICT resources in ST250Q01JA has value number 1= Yes and 2= No, which recoded to 1=1 and 2=0 so that all factor loadings that generated by the software will become positive, in other words, all items will have the same direction of scale. Detail for the variables name, code, and recoded values that used in this report can be seen in Appendix A.

Data from PISA 2022 were analyzed by using SPSS (Statistical Package for the Social Sciences) version 29 to describe the data and explore the component of questionnaire. Moreover, AMOS (Analysis of Moment Structure) software version 29 was employed to conduct confirmatory factor analysis (CFA) which aims to assess the validity and reliability of questionnaire items in four alternative models. CFA allows researchers to identify factors, variance, and correlation between latent constructs (Hill & Hughes, 2007) cited in Yosita Ratri (2023). In addition, it is important to look at the factor loadings produced by CFA analysis before creating structural equation modelling (SEM) model. According to Hair and colleagues (2021), data analysis through SEM methods allows researchers to examine multivariate analysis where there are complex associations among various dependent and independent variables.

Results

The objective of this study is to scrutinize and estimate the influence of gender, ICT resources, and index of economic, social, and cultural status towards science performance in Indonesia. Initially, confirmatory factor analysis (CFA) on ICT resources and ESCS items reveals the best model for SEM analysis. All models and summary of goodness fit model indices is shown in Appendix B. From all models, hierarchical model is decided to be the best model of ICT resources and ESCS. Therefore, the model for SEM combines both hierarchical models. The SEM model in this study is depicted in Figure 2 below.

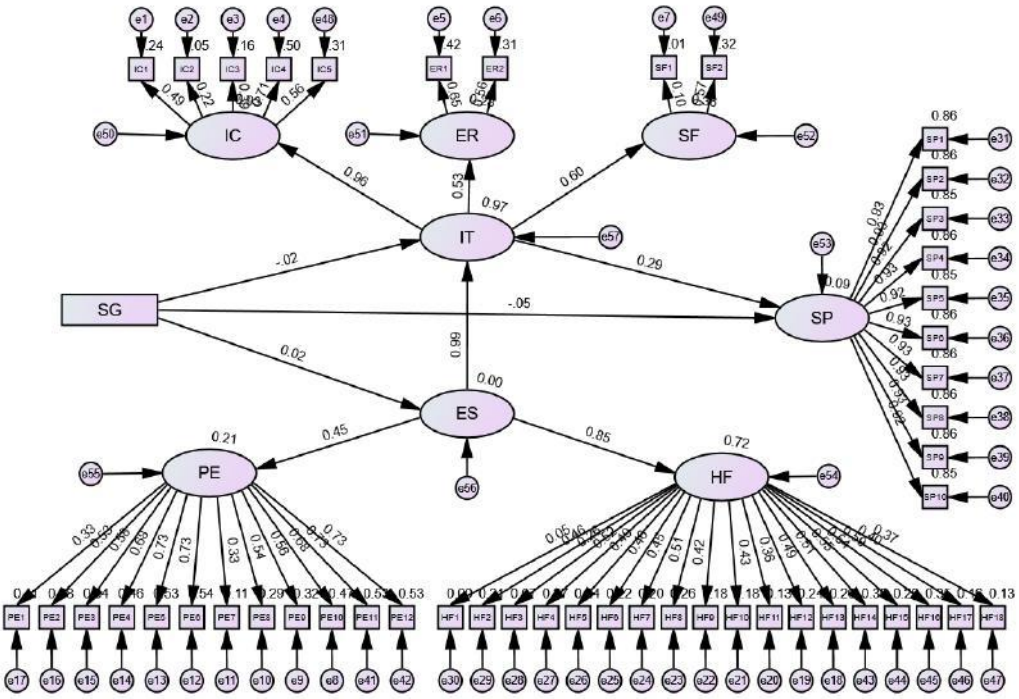

Figure 2: Final Model of SEM

Lists of abbreviation in the model:

SG= Student Gender
IT = Information Technology (ICT Resources)
ES= Economic Status (ESCS)
SP= Science Performance
IC= Integated Computer
ER= Electronic Reader
SF= Supporting Facilities
PE= Parent Education
HF= Home Facilities (Home Ownership)

The final model of SEM includes all items for each variable in order to maintain the model. It is because there is different value of RMSEA when some items that have factor loadings less than 0.30 were trimmed. When some insignificant items not included, the value of RMSEA is increasing from 0.064 to 0.068. Moreover, the path from ESCS to science performance was removed because it leads to negative value of ICT recources to science performance. The value of TLI and CFI are 0.801 and 0.818 respectively, meaning that the values still below standard level of good model fit. Detail of regression weights and significant levels is depicted in Table 1.

Table 1: Standardized Significant Levels and Regression Weights of the Final Model

	Standardized Regression Weights	S.E	P level
SG -> ES	0.016 (0.02)	0.002	0.144
SG -> IT	-0.023 (-0.02)	0.004	0.014
ES -> IT	0.986 (0.99)	0.069	***
SG -> SP	-0.045 (-0.05)	1.104	***
IT -> SP	0.291 (0.29)	3.068	***

Based on the table above, it can be seen that science performance in Indonesia PISA 2022 dataset can be influenced by gender, ICT resources, and ESCS. Student gender in PISA 2022 seems has insignificant impact on science performance as the effects value is very small which indicate that male perform better than female students. Compared to gender, ICT resources directly affect students' performance (β=0.29) and ESCS directly affect ICT resources with path loading extremely high at β= 0.99. Furthermore, ESCS has positive affects towards ICT resources, meaning that a high-income family will be able to provide more ICT resources for learning. On the other hand, low income family will provide limited resources for the students.

Looking more details, each item has different value on how it influences students' performance in science. For example, in ICT resources, the availability of laptop computer and notebooks becomes the most influence among other items while private room becomes the less influential aspects with factor loadings at 0.71 and 0.10, respectively. Moreover, parents educational background has the biggest influence in index of economic, social, and cultural status with factor loadings at 0.73. However, it seems that most parents in Indonesia has low educational level because the International Standard Classification of Education (ISCED) indicate that they are at level 4 and 5. Also, those levels have highest factor loading for both mother and father education. Detail factor loadings for each item is shown in Appendix C.

Discussion

The results of this study indicate that Indonesian students' academic performance in science can be influenced by gender, ICT resources and economic status. However, student gender has poor impact science performance in PISA 2022 which is align with the literature found where both female and male students have equal opportunity in their learning activities which are indicated by their academic performance. Besides, the correlation between student gender and science performance in this study is not is not significant which can be seen from the value less than 0.30.

In terms of ICT resources, the result of analysis is positively aligned with the literature found where it supports learning activities, in this case, science subject (β= 0.29). In detail, electronic device that popular among Indonesian students is laptop computer or notebooks which has significant factor loadings at 0.71. On the other hand, it seems that most students in Indonesia has no private study room in their house as the factor loadings is extremely small at 0.10 and they also do not depend on educational software to support their study because the factor loadings only 0.22. The results are positively correlated with the situation at school where computer or laptop is the most reliable device that can be used in learning activities. For example, working on assignments and quiz, online group meeting, and access online material from the teachers. In addition, Indonesia is a developing country where many students are from low-income family, meaning that their family may have limited budget to provide ICT resources facilities. Furthermore, learning activities in Indonesia may not depend on educational software as the learning management system (LMS) such as Canvas (Mpungose & Khoza, 2022)**,** as teachers may use software that both students and teachers are already familiar with. For instance, they can use free platform such as Google classroom or social media such as WhatsApp to manage classroom activities. Hence, ICT resources is directly influence Indonesian students' performance in science based on PISA 2022 dataset.

Probing further, the results of this study indicate that economic status (ESCS) results is not aligned with the hypothesized as ESCS has indirect impact on students' science performance in Indonesia through ICT resources (β= 0.99). In detail, the data from Indonesia PISA 2022 depicts that not all parents have higher degree education (ISCED level 7-8) which can be seen from the factor loadings that lower compared to education level 4-6. In this case, low performance in science may because of lack of parent educational level. Parent educational level is important especially when pandemic COVID-19 occurred, and students were studying with their family at home. Parent education background enables students to received support when they face difficulties in learning. Moreover, socioeconomic status also consists of home possession or facilities that students can be used to study. The result shows that books play an important role to support academic achievement, either physical book or electronic book which can be accessed through computer, tablet, and e-book readers. The factor loadings for the availability of technical book and science book are higher at 0.59 and 0.55 respectively compared to other items on home facilities. However, other aspects also important and correlated each other. Ultimately, parents with higher education level may have higher income, meaning that they will be able to provides all facilities at home, including ICT resources to be used by students. In other words, the higher ESCS level may lead to better academic outcome, particularly in science score. The results of this study are aligned with previous investigation such as the report from Lagravinese and colleagues (2020).

Conclusion

To sum up, the present study aims to explore the impact of gender, ICT resources, and index of economic, social, and cultural status towards students' science performance in Indonesia based on PISA 2022 dataset. The study employed CFA and followed by multivariate analysis through SEM in AMOS software. The results indicate that student gender almost has no influence towards science performance, while ICT resources directly affect science performance in PISA 2022, which is highly supported by socioeconomic status. The availability of computer laptop becomes the most significant items that influence of students' performance in science which is supported by parents' educational background and home facilities such as science books. The findings may contribute to educational policies, particularly on how government assists school activities by providing decent educational resources in ICT devices for students. In addition, Lagravinese and colleagues (2020) mentioned that there should be public policies in education sector that are able to reduce inequalities among students that are from various socioeconomic level. For example, provide activities to improve students' literacy skills which also supported with adequate facilities such as books and free access learning materials to students. However, this study is based on Indonesia PISA 2022 dataset, which is limited to quantitative data by OECD surveys. According to OECD, test and surveys in PISA 2022 were collected through surveys which is only using quantitative approaches (OECD, 2023c). Further investigation is required, particularly with factors that are related to science performance such as science enjoyment and support from family for students' learning activities. Also, employing qualitative approach will allow to obtain more details factors that affect Indonesian students' performance in science.

References

Al-Rahmi, W. M., Alzahrani, A. I., Yahaya, N., Alalwan, N., & Kamin, Y. Bin. (2020). Digital communication: Information and communication technology (ICT) usage for education sustainability. *Sustainability (Switzerland)*, *12*(12). https://doi.org/10.3390/su12125052

Bai, B., Wang, J., & Chai, C. S. (2021). Understanding Hong Kong primary school English teachers' continuance intention to teach with ICT. *Computer Assisted Language Learning*, *34*(4), 528–551. https://doi.org/10.1080/09588221.2019.1627459

Claro, M., Cabello, T., San Martín, E., & Nussbaum, M. (2015). Comparing marginal effects of Chilean students' economic, social and cultural status on digital versus reading and mathematics performance. *Computers and Education*, *82*, 1–10. https://doi.org/10.1016/j.compedu.2014.10.018

Dúo-Terrón, P., Moreno-Guerrero, A. J., & Marín-Marín, J. A. (2022). ICT Motivation in Sixth-Grade Students in Pandemic Times—The Influence of Gender and Age. *Education Sciences*, *12*(3). https://doi.org/10.3390/educsci12030183

Gómez, R. L., & Suárez, A. M. (2020). Do inquiry-based teaching and school climate influence science achievement and critical thinking? Evidence from PISA 2015. *International Journal of STEM Education*, *7*(1). https://doi.org/10.1186/s40594-020-00240-5

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). *An Introduction to Structural Equation Modeling* (pp. 1–29). Springer. https://doi.org/10.1007/978-3-030-80519-7_1

Jia, C., Yang, T., Qian, Y., & Wu, X. (2020). The Gender Differences in Science Achievement, Interest, Habit, and Creativity. *Science Education International*, *31*(2), 195–202. https://doi.org/10.33828/sei.v31.i2.9

Lagravinese, R., Liberati, P., & Resce, G. (2020). The impact of economic, social and cultural conditions on educational attainments. *Journal of Policy Modeling*, *42*(1), 112–132. https://doi.org/10.1016/j.jpolmod.2019.03.007

Mpungose, C. B., & Khoza, S. B. (2022). Postgraduate Students' Experiences on the Use of Moodle and Canvas Learning Management System. *Technology, Knowledge and Learning*, *27*(1). https://doi.org/10.1007/s10758-020-09475-1

OECD. (2019). *PISA 2018 Insight and Intepretation*. OECD Publishing.

OECD. (2023a). *PISA 2022 Assessment and Analytical Framework*. OECD Publishing. https://doi.org/10.1787/dfe0bf9c-en

OECD. (2023b). *PISA 2022 Results Factsheets Indonesia*. OECD Publishing. https://oecdch.art/a40de1dbaf/C108

OECD. (2023c). *PISA 2022 Technical Report*. OECD Publishing.

OECD. (2024). *PISA 2022 Technical Report*. OECD Publishing. https://doi.org/10.1787/01820d6d-en

Palomares-Ruiz, A., Cebrián, A., López-Parra, E., & García-Toledano, E. (2020). ICT integration into science education and its relationship to the digital gender gap. *Sustainability (Switzerland)*, *12*(13). https://doi.org/10.3390/su12135286

Rashid, A. T. (2016). Digital Inclusion and Social Inequality: Gender Differences in ICT Access and Use in Five Developing Countries. *Gender, Technology and Development*, *20*(3), 306–332. https://doi.org/10.1177/0971852416660651

Reilly, D., Neumann, D. L., & Andrews, G. (2019). Investigating Gender Differences in Mathematics and Science: Results from the 2011 Trends in Mathematics and Science Survey. *Research in Science Education*, *49*(1), 25–50. https://doi.org/10.1007/s11165-017-9630-6

Rohatgi, A., Scherer, R., & Hatlevik, O. E. (2016). The role of ICT self-efficacy for students' ICT use and their achievement in a computer and information literacy test. *Computers and Education*, *102*, 103–116. https://doi.org/10.1016/j.compedu.2016.08.001

Roksa, J., & Kinsley, P. (2019). The Role of Family Support in Facilitating Academic Success of Low-Income Students. *Research in Higher Education*, *60*(4), 415–436. https://doi.org/10.1007/s11162-018-9517-z

Smith, T. J., Pasero, S. L., & McKenna, C. M. (2014). Gender Effects on Student Attitude Toward Science. *Bulletin of Science, Technology & Society*, *34*(1–2), 7–12. https://doi.org/10.1177/0270467614542806

Stoet, G., & Geary, D. C. (2018). The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education. *Psychological Science*, *29*(4), 581–593. https://doi.org/10.1177/0956797617741719

Yosita Ratri, S. (2023). *Exploring the Predictors of Indonesian Reading Literacy based on PISA Data*. The University of Adelaide.

Zainuddin, Z. (2018). Students' learning performance and perceived motivation in gamified flipped-class instruction. *Computers and Education*, *126*, 75–88. https://doi.org/10.1016/j.compedu.2018.07.003

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Appendices

Appendix A. Study Items From Indonesia PISA 2022 Dataset

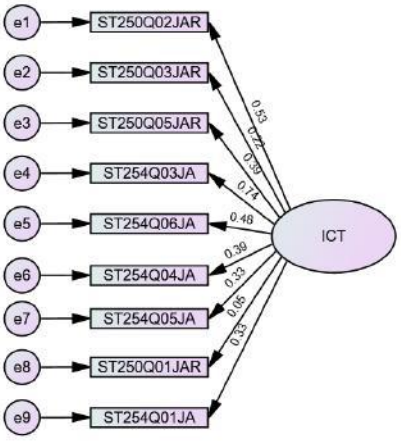
No.	Variables	Item name	Label	Code in the study	Values	Recoded Values
1.	Student gender (SG)	ST004D01T	Student (standardized) Gender	SG	1 = Female 2 = Male 5 = Valid Skip 7 = Not Applicable 8 = Invalid 9 = No Response	
2	ICT Resources **(IT)** **(9 Items)**	ST250Q01JA**R**	Which of the following are in your [home]: A room of your own	IT1	1= Yes 2= No 5= Valid Skip 7= Not Applicable 8= Invalid 9= No Response	**1=1** **2=0** 5=5 7=7 8= 8 9= 9
		ST250Q02JA**R**	Which of the following are in your [home]: A computer (laptop, desktop, or tablet) that you can use for school work	IT2		
		ST250Q03JA**R**	Which of the following are in your [home]: Educational Software or Apps	IT3		
		ST250Q05JA**R**	Which of the following are in your [home]: Internet access (e.g. Wi-fi) (excluding through smartphones)	IT4		
		ST254Q01JA	How many of the following [digital devices] are in your [home]: Televisions	IT5	1= None 2= 1 or 2 3= 3-5 4= More than 5 5= I don't know 95= Valid Skip 97= Not Applicable 98= Invalid 99- No Response	
		ST254Q03JA	How many of the following [digital devices] are in your [home]: Laptop computers or notebooks	IT6		
		ST254Q04JA	How many of the following [digital devices] are in your [home]: Tablets (e.g. [iPad®], [BlackBerry® Playbook™])	IT7		
		ST254Q05JA	How many of the following [digital devices] are in your [home]: E-book readers (e.g. [Kindle™], [Kobo], [Bookeen])	IT8		
		ST254Q06JA	How many of the following [digital devices] are in your [home]: [Cell phones] with Internet access (i.e. smartphones)	IT9		
3	Index of economic, social, and cultural status (ES) (**30 item**)	ST250Q04JA**R**	**Which of the following are in your [home]: Your own [cell phone] with Internet access (e.g. smartphone)**	ES1	**1= Yes** **2= No** **5= Valid Skip** **7= Not Applicable** **8= Invalid** **9= No Response**	**1=1** **2=0** 5=5 7=7 8= 8 9= 9
		ST251Q01JA	How many of these items are there at your [home]: Cars, vans, or trucks	ES2	**1=** None **2=** One 3= Two 4= Three or more 95= Valid Skip 97= Not Applicable 98= Invalid 99= No Response	
		ST251Q02JA	How many of these items are there at your [home]: Mopeds or motorcycles	ES3		
		ST251Q03JA	How many of these items are there at your [home]: Rooms with a bath or shower	ES4		
		ST251Q04JA	How many of these items are there at your [home]: Rooms with a [flush toilet]	ES5		
		ST251Q06JA	How many of these items are there at your [home]: Musical instruments (e.g. guitar, piano, [country-specific example])	ES6		
		ST251Q07JA	How many of these items are there at your [home]: Works of art (e.g. paintings, sculptures, [country-specific example])	ES7		
		ST253Q01JA	How many [digital devices] with screens are there in your [home]?	ES8	**1=** There are no (digital devices) with screens 2= One 3= Two 4= Three 5= Four 6= Five 7= 6 to 10 8= More than 10 95= Valid Skip 97= Not Applicable 98= Invalid 99= No Response	
		ST254Q02JA	How many of the following [digital devices] are in your [home]: Desktop computers	ES9	**1=** None **2=** 1 or 2 3= 3-5	
					4= More than 5 5= I don't know 95= Valid Skip 97= Not Applicable 98= Invalid 99- No Response	
		ST255Q01JA	How many books are there in your [home]?	ES10	1= There are no books 2= 1-10 3= 11-25 4= 26-100 5=101-200 6= 201-500 7= more than 500 books 95= valid skip 97= not applicable 98= invalid 99= no response	
		ST256Q01JA	How many of these books at [home]: Religious books (e.g. [Bible], [Example 2])	ES11	1= None 2= 1-5 3= 6-10 4= More than 10 5= I don't know 95= Valid Skip 97= Not Applicable 98= Invalid 99= No Response	
		ST256Q02JA	How many of these books at [home]: Classical literature (e.g.[Shakespeare],[Example 2])	ES12		
		ST256Q03JA	How many of these books at [home]: Contemporary literature	ES13		
		ST256Q06JA	How many of these books at [home]: Books on science	ES14		
		ST256Q07JA	How many of these books at [home]: Books on art, music, or design	ES15		
		ST256Q08JA	How many of these books at [home]: [Technical reference books]	ES16		
		ST256Q09JA	How many of these books at [home]: Dictionaries	ES17		
		ST256Q10JA	How many of these books at [home]: Books to help with your school work	ES18		
		ST005Q01JA**R**	What is the [highest level of schooling] completed by your mother?	ES19	1= ISCED level 3.4> 2= ISCED level 3B, 3.3> 3= ISCED level 2> 4= ISCED level 1> 5= She did not complete ISCED level 1> 95= Valid Skip 97= Not Applicable 98= Invalid 99= No Response	**1=5** **2=4** **3=3** **4=2** **5=1** 95=95 97=97 98=98 99=99
		ST006Q01JA**R**	Does your mother have any of the following qualifications: [ISCED level 8]	ES20	1= Yes 2= No 95= Valid Skip 97= Not Applicable 98= Invalid 99= No Response	**1=1** **2=0** 95=95 97=97 98= 98 99= 99
		ST006Q02JA**R**	Does your mother have any of the following qualifications: [ISCED level 7]	ES21		
		ST006Q03JA**R**	Does your mother have any of the following qualifications: [ISCED level 6]	ES22		
		ST006Q04JA**R**	Does your mother have any of the following qualifications: [ISCED level 5]	ES23		
		ST006Q05JA**R**	Does your mother have any of the following qualifications: [ISCED level 4]	ES24		
		ST007Q01JA**R**	What is the [highest level of schooling] completed by your father?	ES25	1= ISCED level 3.4> 2= ISCED level 3B, 3.3> 3= ISCED level 2> 4= ISCED level 1> 5= He did not complete	**1=5** **2=4** **3=3** **4=2** **5=1** 95=95 97=97 98=98 99=99

					ISCED level 1> 95= Valid Skip 97= Not Applicable 98= Invalid 99= No Response	
		ST008Q01JA**R**	Does your father have any of the following qualifications: [ISCED level 8]	ES26	1= Yes 2= No 95= Valid Skip 97= Not Applicable 98= Invalid 99= No Response	**1=1** **2=0** 95=95 97=97 98= 98 99= 99
		ST008Q02JA**R**	Does your father have any of the following qualifications: [ISCED level 7]	ES27		
		ST008Q03JA**R**	Does your father have any of the following qualifications: [ISCED level 6]	ES28		
		ST008Q04JA**R**	Does your father have any of the following qualifications: [ISCED level 5]	ES29		
		ST008Q05JA**R**	Does your father have any of the following qualifications: [ISCED level 4]	ES30		
4	Science Performance (SP)	PV1Science	Plausible value 1 in science	SP1		
		PV2Science	Plausible value 2 in science	SP2		
		PV3Science	Plausible value 3 in science	SP3		
		PV4Science	Plausible value 4 in science	SP4		
		PV5Science	Plausible value 5 in science	SP5		
		PV6Science	Plausible value 6 in science	SP6		
		PV7Science	Plausible value 7 in science	SP7		
		PV8Science	Plausible value 8 in science	SP8		
		PV9Science	Plausible value 9 in science	SP9		
		PV10Science	Plausible value 10 in science	SP10		

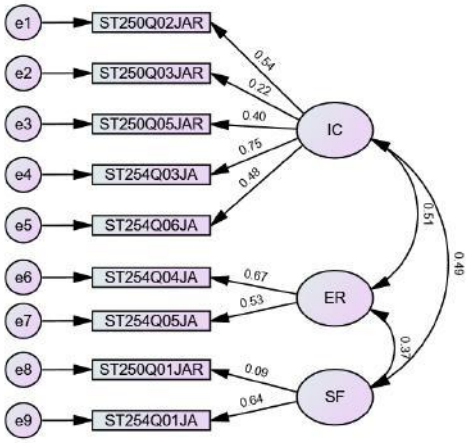
Appendix B. Confirmatory Factor Analysis of ICT Resources and ESCS

1. CFA results of ICT Resources

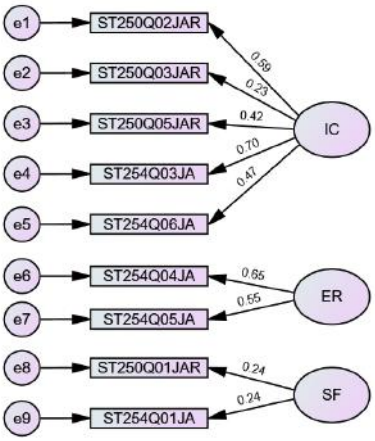
2. One Factor Model



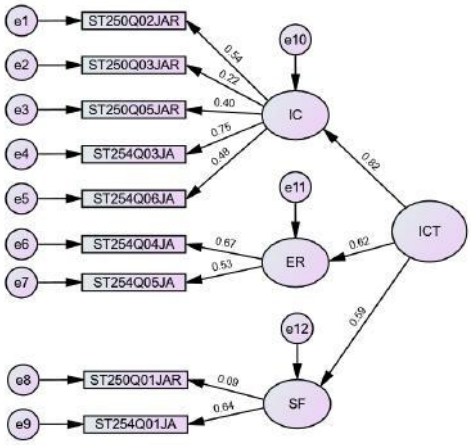
4. 3-Factor Correlated Model



3. 3-Factor Orthogonal Model



5. Hierarchical Model

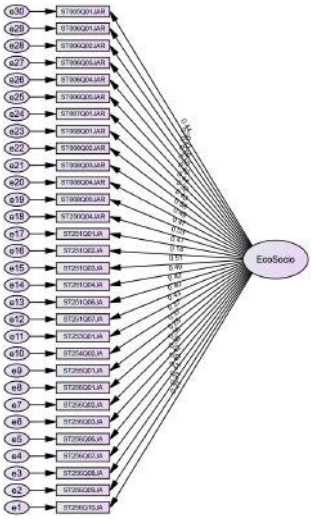


2. Table Summary of goodness fit indices for ICT resources 2022

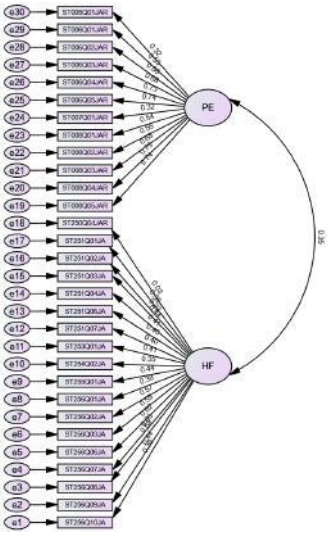
Model	Chi-square	df	Chi-square/df	RMSEA	CFI	TLI
One factor model	2017.998	27	74.741	.074	.816	.693
3-factor model uncorrelated	3234.037	30	107.801	.089	.704	.555
3-factor model correlated	958.523	24	39.938	.054	.914	.838
Hierarchical model	958.523	24	39.938	.054	.914	.838

3. CFA ESCS

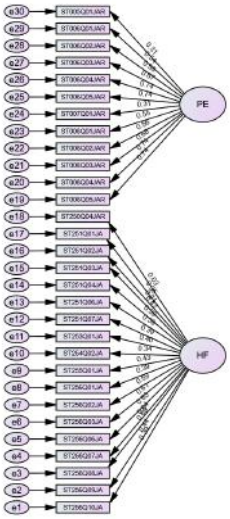
1. One Factor Model



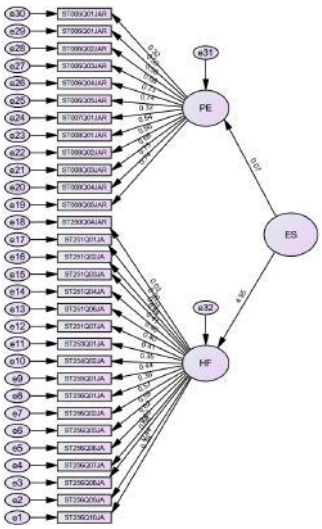
3. 2-Factor Correlated Model



2. 2-Factor Orthogonal Model



4. Hierarchical Model



4. Table Summary of goodness fit indices for ESCS 2022

Model	Chi-square	df	Chi-square/df	RMSEA	CFI	TLI
One factor model	66987.017	405	165.400	.111	.398	.309
2-factor model uncorrelated	49858.126	405	123.106	.095	.553	.487
2-factor model correlated	48690.873	404	120.522	.094	.564	.498
Hierarchical model	48690.873	404	120.522	.094	.564	.498

Appendix C. Detail Factor Loadings of Observed Variable

No	Variables		
	Latent	Observed	Loadings
1	ICT Resources	Which of the following are in your [home]: A room of your own	0.10
2		Which of the following are in your [home]: A computer (laptop, desktop, or tablet) that you can use for school work	0.49
3		Which of the following are in your [home]: Educational Software or Apps	0.22
4		Which of the following are in your [home]: Internet access (e.g. Wi-fi) (excluding through smartphones)	0.39
5		How many of the following [digital devices] are in your [home]: Televisions	0.57
6		How many of the following [digital devices] are in your [home]: Laptop computers or notebooks	0.71
7		How many of the following [digital devices] are in your [home]: Tablets (e.g. [iPad®], [BlackBerry® Playbook™])	0.65
8		How many of the following [digital devices] are in your [home]: E-book readers (e.g. [Kindle™], [Kobo], [Bookeen])	0.56
9		How many of the following [digital devices] are in your [home]: [Cell phones] with Internet access (i.e. smartphones)	0.56
10	ESCS	Which of the following are in your [home]: Your own [cell phone] with Internet access (e.g. smartphone)	0.05
11		How many of these items are there at your [home]: Cars, vans, or trucks	0.46
12		How many of these items are there at your [home]: Mopeds or motorcycles	0.26
13		How many of these items are there at your [home]: Rooms with a bath or shower	0.52
14		How many of these items are there at your [home]: Rooms with a [flush toilet]	0.49
15		How many of these items are there at your [home]: Musical instruments (e.g. guitar, piano, [country-specific example])	0.46
16		How many of these items are there at your [home]: Works of art (e.g. paintings, sculptures, [country-specific example])	0.45
17		How many [digital devices] with screens are there in your [home]?	0.51
18		How many of the following [digital devices] are in your [home]: Desktop computers	0.42
19		How many books are there in your [home]?	0.43
20		How many of these books at [home]: Religious books (e.g. [Bible], [Example 2])	0.36
21		How many of these books at [home]: Classical literature (e.g. [Shakespeare], [Example 2])	0.49
22		How many of these books at [home]: Contemporary literature	0.51
23		How many of these books at [home]: Books on science	0.55
24		How many of these books at [home]: Books on art, music, or design	0.54
25		How many of these books at [home]: [Technical reference books]	0.59
26		How many of these books at [home]: Dictionaries	0.40
27		How many of these books at [home]: Books to help with your school work	0.37
28		What is the [highest level of schooling] completed by your mother?	0.33
29		Does your mother have any of the following qualifications: [ISCED level 8]	0.53
30		Does your mother have any of the following qualifications: [ISCED level 7]	0.58
31		Does your mother have any of the following qualifications: [ISCED level 6]	0.68
32		Does your mother have any of the following qualifications: [ISCED level 5]	0.73
33		Does your mother have any of the following qualifications: [ISCED level 4]	0.73
34		What is the [highest level of schooling] completed by your father?	0.33
35		Does your father have any of the following qualifications: [ISCED level 8]	0.54
36		Does your father have any of the following qualifications: [ISCED level 7]	0.56
37		Does your father have any of the following qualifications: [ISCED level 6]	0.68
38		Does your father have any of the following qualifications: [ISCED level 5]	0.73
39		Does your father have any of the following qualifications: [ISCED level 4]	0.73
40	Science Performance	Plausible value 1 in science	0.93
41		Plausible value 2 in science	0.93
42		Plausible value 3 in science	0.92
43		Plausible value 4 in science	0.93
44		Plausible value 5 in science	0.92
45		Plausible value 6 in science	0.93
46		Plausible value 7 in science	0.93
47		Plausible value 8 in science	0.93
48		Plausible value 9 in science	0.93
49		Plausible value 10 in science	0.92