Exploring the Construct Validity of Information and Communication Technologies Questionnaire in Indonesia based on PISA 2022 Dataset

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ABSTRACT

This study investigates the construct validity of Information and Communication Technologies (ICT) questionnaire in Indonesia based on Programme for International Students Assessments (PISA) 2022 (N=13,439). There are nine items that are selected from ICT resources based on the same items from prior dataset in 2018. A confirmatory factor analysis (CFA) was employed to analyze the reliability and validity of ICT resources questionnaire by generating four model-data fit in AMOS. The results showed that 3-factor correlated model provides good model-data fit among other models, in which laptop or notebooks become the most significant devices that are used by Indonesian students. However, three items may be considered invalid to form ICT resources as their factor loadings were less than 0.3. This infers that the implementation of technology at Indonesian school still limited by using laptop in science and mathematics learning. Further study is recommended to analyze the correlation between ICT resources towards science performance in Indonesia context.

***Keywords**: ICT, PISA, Science, Indonesia*

INTRODUCTION

Many countries, including Indonesia, has participated in PISA since 2000 which allowing the government to evaluate and compare the quality education based on the PISA test outcomes. Basically, there are three subjects that are tested in PISA namely: science, mathematics, and readings. Therefore, the notion of integrating ICT for learning activities at school is associated to those subjects, particularly science. The Organization for Economic Co-operation and Development (OECD) allows each country to select questionnaire that are applicable in their region and Indonesia only focuses on ICT resources in education sectors. According to Indonesia PISA data 2022, most students already have their own ICT devices such as smartphones or laptop to support their learning activities both at school and home. Therefore, it is notable that ICT integration in all levels of education is inevitable. Even teachers in kindergartens level require ICT to teach students (Yang, 2022) because they are already familiar with ICT at home. However, every country has their own way to investigate ICT that is related to students' performance. There are many studies that explore the integration of ICT at school in developed countries such as in Australia and Korea (Bhang &

Huh, 2023) compared to Indonesia as developing country. It seems because those countries have different challenges as well as support to integrate ICT in education facilities from government and students' families. As a developing country, Indonesia has a lot of homework because there are also many areas in rural area that have minimum ICT facilities both at school and home. Therefore, this report aims to explore the construct validity of ICT Resources in Indonesia based on PISA data 2022. This context can be considered related to pandemic which related to the utilization of ICT resources as it changed the way of learning within a short time.

Regarding studies related to ICT as part of learning activities, many articles have explored the effect of technology which are associated with students' performance. Many researchers have been conducting studies that explored deeper ICT resources and their impact on teaching and learning activities such as Guo et al., (2022), S. C. Li & Petersen, (2022), Martínez-Gautier et al., (2021), and Ukut & Krairit (2019) who revealed that ICT resources are positively correlated to students' performance. Martínez-Gautier et al. (2021) carried out a study on Spanish performance based on PISA data 2015 and found that there is positive association on using ICT for students both at school and home. The accessibility of ICT at school and home should be equal, so that students have the same access to the learning material. However, study carried out by Wang & Wang (2023) found that ICT resources have negative association towards students' academic performance. It is possible that other factors may also influence the correlation of ICT towards students' performance. For example, a mixed method study by Liong et al. (2023) revealed that female students have more interest in ICT compared male students in Hongkong. This indicates that there are other indirect factors that influence students' performance with the assist of ICT. Also, male and female students may also have different attitudes towards ICT.

In terms of ICT devices, both hardware and software are correlated to each other. Petko et al., (2017) mentioned that the quality of hardware and software should be meet the minimum standards for learning. It is vital because decent ICT for both teachers and students will assist them in the learning processes. Moreover, internet connection also required for devices to make it work (Baydas & Goktas, 2016) because students from both urban and rural area should be able to access the learning material. Likewise, it is also valuable to note that ICT resources at home should meet the minimum requirement to conduct remote learning (Erdogdu, 2022) because when ICT can be accessed at home, it allows students to explore more learning materials in a fun way such as watching tutorial videos on YouTube that motivate them to learn. In other words, students are able to develop their self-efficacy in learning. Ultimately, the ICT required internet connections which allowed school communities to connect and interact with each other both at home and school.

The studies found are align with PISA 2022 framework on ICT resources questionnaire (OECD, 2023) where there are many items such as the availability of smartphones, computers, educational software, and decent internet connection.

Unfortunately, many studies do not explore detailed components that form ICT resources. Therefore, this study employed confirmatory factor analysis of ICT resources which allows researchers to conduct further research on ICT, particularly which items that seems effective in any learning activities.

METHODOLOGY

This quantitative study 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, 2023). According to OECD (2016), surveys and tests were conducted by using two methods namely paper-based and computer-based. Indonesia data were chosen in PISA test 2022 which participated by 13,439 students from 410 schools. This report only selected items that form ICT resources in Indonesia which also compared to previous PISA data 2018. From both years, there are nine items that are selected because those are similar data from both years. Some items were trimmed because they are considered as home possession items in PISA data and some were invalid. The data for ICT resources were focused on the availability of ICT at home which can be seen from the PISA technical report. The data of ICT resources construct in PISA 2022 is shown in Table 1 below. Then, the selected items can be seen in the Table 2.

Table 1. ICT Resources Questionnaire in PISA 2022

Name	Type	Width	Decimals	Label
ST250Q01JA	Numeric	2	0	Which of the following are in your [home]: A room of your own
ST250Q02JA	Numeric	2	0	Which of the following are in your [home]: A computer (laptop, desktop, or tablet) that you can use for school work
ST250Q03JA	Numeric	2	0	Which of the following are in your [home]: Educational Software or Apps
ST250Q04JA	Numeric	2	0	Which of the following are in your [home]: Your own [cell phone] with Internet access (e.g. smartphone)
ST250Q05JA	Numeric	2	0	Which of the following are in your [home]: Internet access (e.g. Wi-fi) (excluding through smartphones)
ST250D06JA	String	21	0	Which of the following are in your home? <Country-specific item 1>
ST250D07JA	String	21	0	Which of the following are in your home? <Country-specific item 2>
ST253Q01JA	Numeric	2	0	How many [digital devices] with screens are there in your [home]?
ST254Q01JA	Numeric	2	0	How many of the following [digital devices] are in your [home]: Televisions
ST254Q02JA	Numeric	2	0	How many of the following [digital devices] are in your [home]: Desktop computers
ST254Q03JA	Numeric	2	0	How many of the following [digital devices] are in your [home]: Laptop computers or notebooks
ST254Q04JA	Numeric	2	0	How many of the following [digital devices] are in your [home]: Tablets (e.g. [iPad®], [BlackBerry® Playbook™])
ST254Q05JA	Numeric	2	0	How many of the following [digital devices] are in your [home]: E-book readers (e.g. [Kindle™], [Kobo], [Bookeen])
ST254Q06JA	Numeric	2	0	How many of the following [digital devices] are in your [home]: [Cell phones] with Internet access (i.e. smartphones)

Table 2. Selected items ICT resources questionnaire PISA 2022 that are similar to previous PISA data 2018.

Name	Label
ST250Q01JA	Which of the following are in your home: a room of your own
ST250Q02JA	Which of the following are in your home: A computer you can use for schoolwork
ST250Q03JA	Which of the following are in your home: educational software
ST250Q05JA	Which of the following are in your home: Internet access
ST254Q01JA	How many of the following (digital devices) are in your home: Televisions
ST254Q03JA	How many of the following (digital devices) are in your home: Laptop computers or notebooks
ST254Q04JA	How many of the following (digital devices) are in your home: [Cell phones] with Internet access (i.e., smartphones)
ST254Q05JA	How many of the following (digital devices) are in your home: Tablets (e.g. [iPad®], [BlackBerry® Playbook™])
ST254Q06JA	How many of the following (digital devices) are in your home: E-book readers (e.g. [Kindle™], [Kobo], [Bookeen])

Data were analyzed by using SPSS (Statistical Package for the Social Sciences) version 27 to validate the data and explore the component of questionnaire. Moreover, this software is also used to conduct Exploratory Factor Analysis (EFA) and to recode the value of ST250 to provide the same order with other questions in which the author put additional alphabet "R" in order to differentiate with the original data. Ultimately, AMOS software version 29 was employed to conduct confirmatory factor analysis (CFA) which aims to assess the validity and reliability of questionnaire items on ICT resources in four alternative models. CFA also 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 which study by Hair et al. (2018) mentioned that factor loadings should at least 0.70 to be considered significant.

RESULTS

This section provides the findings after data analysis. The result of EFA, particularly on rotated component matrix, is shown in Table 3 below.

Table. 3 EFA (Exploratory Factor Analysis) of ICT Questionnaire 2022

Rotated Component Matrix[a]

	Component		
	1	2	3
Which of the following are in your [home]: A room of your own			.846
Which of the following are in your [home]: A computer (laptop, desktop, or tablet) that you can use for school work	.699		
Which of the following are in your [home]: Educational Software or Apps	.343		
Which of the following are in your [home]: Internet access (e.g. Wi-fi) (excluding through smartphones)	.649		
How many of the following [digital devices] are in your [home]: Televisions			.517
How many of the following [digital devices] are in your [home]: Laptop computers or notebooks	.673	.341	
How many of the following [digital devices] are in your [home]: Tablets (e.g. [iPad®], [BlackBerry® Playbook™])		.761	
How many of the following [digital devices] are in your [home]: E-book readers (e.g. [Kindle™], [Kobo], [Bookeen])		.828	
How many of the following [digital devices] are in your [home]: [Cell phones] with Internet access (i.e. smartphones)	.595		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 4 iterations.

Based on the EFA results on rotated component matrix, there are three categories that shape ICT resources. From table 3, the author can conclude that the first group, with five items, is considered as integrated technologies (IT), the second group with two items is considered as eBook readers (ER), and the third group with two items is considered as supporting facilities (SF). The item that is shown in two groups is selected as one that has higher value. Therefore, ST254Q03JA is included in the first group. The data was then used to create one factor, n-factor orthogonal, n-factor correlated and hierarchical model of CFA using AMOS. The results of the CFA model are shown in Figure 1-4 below.

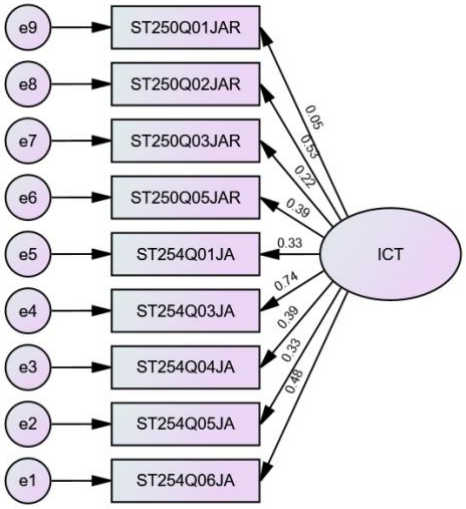

Figure 1. One Factor Model

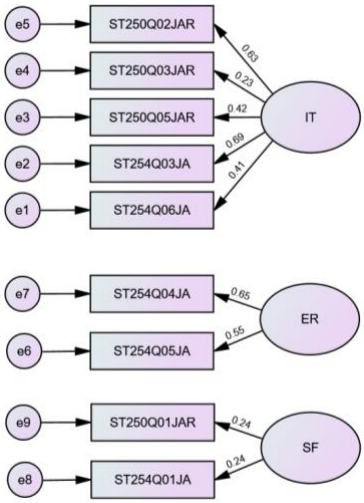

Figure 2. 3-Factor Orthogonal Model

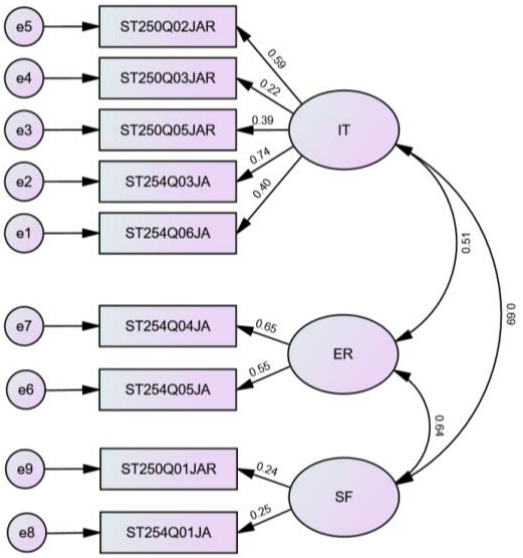

Figure 3. 3-Factor Correlated Model

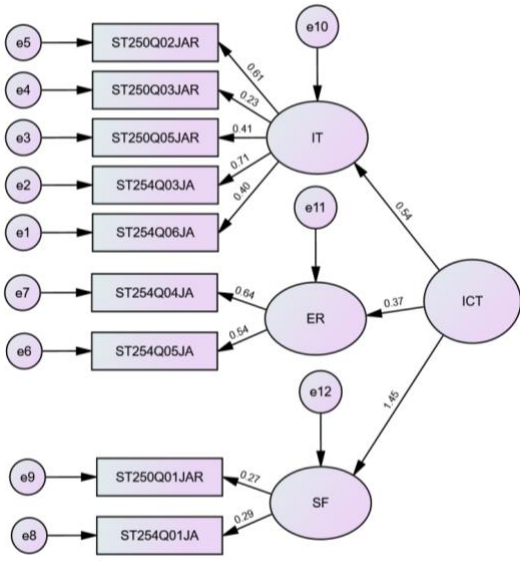

Figure 4. Hierarchical Model

After creating all model of CFA, summary data for each model is collected which can be seen in Table 4 below.

Table 4. Summary of Goodness-of-fit indexes for alternative models of ICT Resources PISA 2022 in Indonesia

No.	Model	CMIN	CMIN/df	NFI	TLI	CFI	RMSEA
1	1-Factor Model	2017.998	74.741	.841	.693	.816	.074
2	3-Factor Model	3234.037	107.801	.702	.555	.704	.089
3	3-Factor Correlated Model	1419.479	52.573	.869	.785	.871	.062
4	Hierarchical Model	1997.889	68.893	.816	.717	.818	.071

The validity of all items that form ICT is shown in the standardized estimates from each model. Furthermore, in order to decide the best model, it is important to look at the value of CMIN (chi-square), NFI (Normative fit index), TLI (Tucker-Lewis index), CFI (Comparative fit index) and RMSEA (Root mean square error of approximation).

The standardized estimates of model 1 depicted in figure 1 show the factor loadings for each item of ICR resources. All factor loadings except ST250Q01JAR and ST250Q03JAR are higher than 0.30 which means valid for this model. Furthermore, item ST254Q03JA is significant for ICT resources at 0.74. This model also found the value of all indexes (NFI, TLI, CFI, and RMSEA) at 0.814, 0.693, 0.816 and 0.074.

The estimates of the second model, 3-factors orthogonal model in figure 2 depicts that six items are valid while three items namely ST250Q03JAR, ST250Q01JAR, and ST254Q01JA are invalid as the value of those items are below 0.30 at 0.23, 0.24, and 0.24 respectively. The score for CMIN is higher while NFI, TLI, CFI are lower than the first model and RMSEA score is higher at 0.89.

Moving to the third model, the 3-factors correlated model that depicted on figure 3 shows similar to the second model where the same three items are also invalid because the factor loadings are below 0.30. In addition, the correlation values among three order factors are more than 0.5. However, there is a significant decrease in CMIN scores from 3234.037 to 1419.497. The value of NFI, TLI and CFI are also higher than the first and second model at 0.869, 0.785, and 0.871, while RMSEA value is also lower than other models at 0.62.

The estimates of hierarchical model in Figure 4 portray those three similar items namely ST250Q03JAR, ST250Q01JAR, and ST254Q01JA in second and third models. Those items have factor loadings below 0.30 which implies that those items are invalid or not reliable for this model. CMIN score is increasing in this model to 1997.889 while NFI,

TLI, and CFI are decreasing to 0.816, 0.717, and 0.818 respectively. Nevertheless, RMSEA score is increasing to 0.071.

Comprehensively, the results among all models of CFA indicates that the third model is the best of all models because this model has the lowest CMIN, the highest NFI, TLI, and CFI, and RMSEA has lowest score. The analysis also shows three items that are considered invalid related to ICT resources. In detail, those items are educational software, a room of your own, and televisions.

DISCUSSION

The selected items that form ICT resources were examined through CFA analysis to see whether the questionnaires are valid. From the results can be seen that although three items are considered invalid in the analysis, it seems those invalid items are still correlated to ICT resources at home as there are many questionnaires that missing or invalid. It is possible that because there is easier access for students to the learning material through other devices such as smartphone and computer or laptop, making students tend to not include television, software, and private room as their supporting facilities on ICT resources. The results are aligned with study by Agasisti et al., (2023) that they did not mention television and private room as primary items that construct ICT resources. Furthermore, the 3-factor correlated model provides the best model-fit among all models. Most items are also found to be valid and reliable for this model in which item ST254Q03JA becomes the item that is significant for ICT resources. The item of ST254Q03JA is the availability of computers, laptops, or notebooks to support learning activities. It can be assumed that both teachers and students mostly used computers or laptops during pandemic situations. For example, online learning activities using zoom platform became popular (van Leuven et al., 2023) as it enables communicative interactions between teachers and students. However, the results indicate that the utilization of educational software was insignificant, meaning that there are limited educational software that benefit for students to learn science or mathematic. In this case, this can be evaluation for the implementation of ICT, because Petko et al. (2017) asserted that software and hardware should be integrated.

In recent years, some schools also provide flipped classroom model (Kardipah & Wibawa, 2020) where students need to access the materials before face-to-face meetings. Accessing the materials using a computer or laptop is highly significant as it provides a wide range of functions. In this case, it is related to studies by Guo et al. (2022), Li & Petersen (2022) which mentioned that most ICT resources align with the positive results in learning. In relation to science learning, having integrated devices which combines with resourceful educational software will assist both teachers and students in learning science. Moreover, having virtual access on any scientific laboratory may become solution in improving students' understanding as some Indonesian schools may not have reliable science laboratory for learning. Hence, the results may benefit for education sector to evaluate the

implementation of technology at school, particularly in science subjects such as biology, physics, and chemistry.

CONCLUSION

To sum up, there are some items questionnaire of ICT resources in Indonesia PISA data 2022 that considered invalid based on CFA analysis. However, the construct validity of ICT resources questionnaire in Indonesia PISA data 2022 can be considered valid although not all items have significant value. Interestingly, the PISA 2022 data that used in this study provides only ICT resources at home as there is pandemic which caused massive changes in learning activities from face-to-face to online learning. Ultimately, this report will be useful for researchers to dig deeper how far this variable affects students' performance, such as in science or mathematics. This report may also support the evaluation of Indonesian survey in ICT resources variables on the next PISA test, meaning that there should be evaluation from education stakeholders to enhance students' performance in science which is part of PISA test. It is recommended to explore further the correlation between ICT resources towards science performance in Indonesia that combine between PISA data and data in the field such as teachers' ICT skills and students' interest on ICT.

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