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How Digital Learning Preparedness and ICT Resources in ASEAN? Insights from PISA

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ABSTRACT

This study aims to explore digital learning readiness and the availability of information and communication technology (ICT) resources in ASEAN countries based on data from the Program for International Student Assessment (PISA) 2022. The focus of this study is on 15-year-old students from seven ASEAN countries who participated in the PISA assessment, with a particular emphasis on their readiness for digital learning. The research design follows a quantitative approach using secondary data analysis. The analysis results show significant gaps between ASEAN countries. Singapore emerged as the country with the highest digital readiness, supported by extensive access to ICT resources. On the other hand, Indonesia, the Philippines, and Thailand showed lower levels of readiness, with limited access to technology that supports digital learning, especially in rural areas. This study suggests the need for stronger policies in Indonesia to strengthen digital infrastructure, improve teacher training in the use of technology, and develop a curriculum that is more oriented towards digital skills. In addition, collaboration with the private sector and non-profit organizations can accelerate efforts to digitize education. By narrowing the digital divide, Indonesia can improve the quality of technology-based education and prepare students to face the challenges of the digital era.

Keywords:
Digital learning readiness; ICT resources; PISA; ASEAN education; digital divide

1. Introduction

The development of information and communication technology (ICT) has become an integral part of the global education system. Digitalization in education not only drives innovation in the learning process [1], but also allows wider access to learning resources in various parts of the world. In the ASEAN region, integrating ICT in the education system is becoming increasingly important [2], especially with the increasing need for distance and online learning during the COVID-19 pandemic [3]. However, the level of digital readiness for learning in ASEAN countries still shows significant gaps, reflecting differences in infrastructure, policies, and access to technology.

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The Program for International Student Assessment (PISA), conducted by the Organisation for Economic Co-operation and Development (OECD), provides a comprehensive view of the readiness of 15-year-old students to use ICT for learning. In Indonesia, optimization of information and communication technology (ICT) is utilized for more effective learning. This is also a factor that the implementation of the National Assessment is carried out on a computer basis (ANBK) [4]. PISA not only measures learning outcomes in reading, mathematics, and science, but also evaluates the extent to which students have access to and ability to use digital technologies to support learning [5]. This assessment is important, considering that digital skills are now one of the essential elements for students to adapt to the demands of the future world of work [6].

While some ASEAN countries, such as Singapore, have achieved high levels of digital readiness with significant investments in educational ICT infrastructure [7], other countries such as Indonesia, the Philippines, and Thailand still face significant challenges in improving access to and quality of ICT resources [8]. These challenges include uneven distribution between urban and rural areas, limitations in teacher training for technology integration, and budgetary issues in funding educational technology in public and private schools.

This study aims to explore digital readiness and the availability of ICT resources in ASEAN countries based on PISA 2022 data. By analyzing this data, it is hoped that a clear picture can be obtained regarding the extent of digital readiness in ASEAN countries.

2. Method

The data used in this study is taken from the publicly accessible PISA 2022 database, which is available on the OECD's PISA Data Explorer website. [9]. This secondary data analysis focuses on the assessment of Digital Learning Readiness and ICT Resources among 15-year-old students in ASEAN countries. This study specifically evaluates students' performance in several key educational domains, including reading, mathematics, and science, as well as access to and use of ICT resources reported in the PISA 2022 assessment.

The research design follows a quantitative approach using secondary data analysis. In the initial stage, relevant datasets were extracted from the PISA 2022 database by screening data related to digital learning readiness and availability of ICT resources in ASEAN countries. Seven ASEAN countries participated in the PISA 2022 assessment, and data from these countries formed the basis of this study. The data were then cleaned, normalized, and prepared for further statistical analysis.

The analysis was conducted using SPSS and RStudio software to run descriptive statistics, as well as more complex statistical procedures such as regression analysis and hypothesis testing. These methods were used to assess the relationship between availability of ICT resources and students' cognitive performance in science, mathematics, and reading. This analysis also includes cross-country comparisons to explore differences in ICT access and their impact on educational outcomes.

3. Result

3.1 Preparedness for Digital Learning

Programmed for International Student Assessment (PISA) 2022 provides comprehensive data on various aspects of digital learning and Information and Communication Technology (ICT) usage among students. Key variables include preparedness for digital learning, availability of ICT resources both at school and outside, frequency of digital resource usage for learning and leisure, and experiences related to online content and cyber bullying. These variables are analyzed across

different student demographics, such as gender, school type (public or private), school location, and the managing organization of the school.

PISA 2022 assesses students' readiness to engage in digital learning environments. This encompasses their self-efficacy in digital competencies and the quality of access to ICT resources. The data indicates that students with higher self-efficacy in digital skills are more likely to effectively utilize digital tools for educational purposes. Additionally, the availability of ICT resources, both at school and at home, plays a crucial role in facilitating digital learning. Schools equipped with adequate digital infrastructure, such as computers connected to the internet and tablet devices, provide students with more opportunities to engage in digital learning activities. However, disparities in ICT availability can lead to unequal learning opportunities among students from different socio-economic backgrounds.

The frequency and purpose of digital resource usage among students vary significantly. PISA 2022 data reveals that students use digital tools for learning activities both during school hours and outside of school, including weekends. For instance, in Indonesia, 67% of students reported using digital tools for learning purposes for one hour a day or more at school, and 45% reported similar usage outside of school on a typical weekend day. Additionally, digital tools are also used for leisure activities, with varying frequencies observed during school hours, after school, and on weekends. Understanding these usage patterns is essential for developing strategies to balance educational and recreational use of digital devices [10].

The integration of digital devices into educational settings has introduced challenges related to student distraction. Approximately 30% of students, on average across OECD countries, reported that they get distracted using digital devices during most or every mathematics lesson. Furthermore, around 25% of students indicated that they become distracted by other students using digital devices, that teachers have to wait a long time for students to quiet down, that students cannot work well, and that students do not start working for a long time after the lesson begins. These distractions can negatively impact student performance and well-being, highlighting the need for effective classroom management strategies and policies regulating digital device usage during lessons [10].

The prevalence of distress from online content and experiences of cyber bullying are critical concerns in the digital age. PISA 2022 collects data on students' exposure to harmful online content and instances of cyber bullying. Addressing these issues is vital for ensuring a safe and supportive digital learning environment. Implementing comprehensive digital citizenship education and providing support systems for affected students are essential steps in mitigating these challenges.

The results in Table 1 are an overview of the level of readiness of 15-year-old students for digital learning (WLE) based on the results of the Program for International Student Assessment (PISA) 2022. The data presented includes the average digital readiness of students in several countries in Southeast Asia, with WLE measures ranging from -5 to 5. These figures show how students in each country are ready for digital technology-based learning, which is becoming increasingly important in the era of digitalization of education. In addition, the table also includes standard errors to show the uncertainty of the resulting estimates.

From the data presented, it can be seen that the Philippines has the highest average readiness for digital learning with a value of 0.90, although accompanied by a fairly large standard error (0.099). Thailand follows with a value of 0.69, indicating that students in both countries are relatively more prepared for digital learning compared to other countries in the table. In contrast, Malaysia recorded an average value of 0.00, indicating that student readiness there is at a neutral point. Indonesia and Vietnam have similar values, namely 0.24 and 0.25, indicating readiness slightly above average, while Brunei Darussalam is slightly below them with a value of 0.10. An

interesting finding from this data is the difference in digital readiness between the countries involved.

Table 1
A public, private school and standard error

Jurisdiction	A public school		A private school		All students	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Brunei Darussalam	0.06	(0.002)	0.10	(0.002)	0.31	(0.005)
Indonesia	0.24	(0.084)	0.24	(0.066)	0.26	(0.116)
Malaysia	-0.01	(0.057)	0.00	(0.058)	0.21	(0.330)
Philippines	0.84	(0.106)	0.90	(0.099)	1.21	(0.232)
Singapore	—	(†)	—	(†)	—	(†)
Thailand	0.74	(0.087)	0.69	(0.074)	0.44	(0.108)
Viet Nam	0.26	(0.071)	0.25	(0.066)	0.18	(0.126)

Position Indonesia from the data presented cannot move to conditioning student with using ICT in learning or others, much more student cannot operation using ICT and how adapt to digital generation [10]. While some countries such as the Philippines and Thailand show higher readiness, others such as Malaysia and Brunei Darussalam show lower or neutral levels of readiness. This variation could be an indicator of differences in digital infrastructure, education policies, or levels of technology adoption in each country, which can then affect students' ability to learn effectively in a digital environment.

This table presents data on digital learning readiness (WLE) of 15-year-old students in public and private schools in several countries in Southeast Asia based on the results of a 2022 study. The average value of digital learning readiness is displayed along with the standard error to measure the uncertainty of each estimate. This table allows us to see the differences in readiness levels between students in public and private schools in each country surveyed.

From the table 2, we can see that in Indonesia, the difference between public and private schools is not very significant, with the average value of digital readiness in public schools being 0.24 and in private schools being 0.26. The standard error for both is quite large, indicating uncertainty in the estimates. In other countries, such as the Philippines, there is a quite striking difference between public and private schools, where students in private schools have a much higher average digital readiness (1.21) compared to public schools (0.84). Thailand shows the opposite trend, where public schools recorded higher digital readiness (0.74) than private schools (0.44).

Table 2
Preparedness learning digital

Jurisdiction	Average					
	village	small town	town	city	large city	megacity
Brunei Darussalam	-0.34	0.14	0.48	-0.40	‡	‡
Indonesia	0.06	0.34	0.09	0.18	0.81	1.03
Malaysia	-0.13	-0.06	0.14	0.01	-0.05	‡
Philippines	0.72	1.05	0.57	1.15	1.44	‡
Singapore	—	—	—	—	—	—
Thailand	0.31	0.61	0.78	0.86	0.65	1.88
Viet Nam	0.15	0.26	0.11	0.26	0.90	0.06

An interesting finding from this data is that there is significant variation in digital readiness between public and private schools across countries. In the Philippines, private schools are significantly ahead in digital readiness, while in Thailand, public schools are better prepared than private schools. In Indonesia and Vietnam, the differences are smaller, indicating that both public and private schools have similar levels of digital readiness. This data can provide insight into the digital divide across school types and the importance of strengthening infrastructure and technology resources to support digital learning in public and private schools equally.

This table shows the digital learning readiness data of 15-year-old students across geographic regions with varying population sizes across several Southeast Asian countries. Region categories include small villages with populations of less than 3,000 people, small towns, medium-sized cities, to large cities and megacities (more than 10 million people). Each country is represented by the average digital readiness score for each region category, which helps understand differences in student readiness based on their geographic environment.

In Indonesia, there is an increase in digital readiness from small villages (0.06) to megacities (1.03). This suggests that students living in large cities and megacities are more digitally prepared than those living in small villages or towns. A similar trend is seen in Thailand, where readiness scores increase from 0.31 in villages to a peak of 1.88 in megacities. In contrast, Malaysia shows less variation, with scores ranging from -0.13 in small villages to just 0.01 in large cities, indicating nearly uniform digital readiness across the region.

An interesting finding is in the Philippines, where students living in both cities and towns showed very high digital readiness (ranging from 1.05 in towns to 1.44 in cities), indicating that the country's digital infrastructure and education may be stronger in urban areas. Overall, the general trend suggests that students in cities tend to be more digitally prepared, perhaps due to better access to technology and educational facilities in urban areas compared to rural areas.

Table 3
Digital learning readiness of 15-year-old students based on funding sources from various organizations

Jurisdiction	Average			
	church or other	not for profit	for profit	government
Brunei Darussalam	0.08	0.39	‡	0.06
Indonesia	0.15	0.30	0.89	0.24
Malaysia	0.34	0.27	-0.35	-0.03
Philippines	1.30	1.17	1.35	0.83
Singapore	—	—	—	—
Thailand	0.15	0.35	0.93	0.73
Viet Nam	-0.19	‡	0.21	0.26

This table presents data on the digital learning readiness of 15-year-old students by funding source from various organizations, including religious organizations, non-profit organizations, for-profit organizations, and government, in several Southeast Asian countries. Each country is shown with an average digital readiness score based on the funding source supporting students' education, providing insight into the contribution of different types of organizations to digital learning readiness in these countries.

Focusing on Indonesia, it can be seen that funding from for-profit organizations has the greatest impact on students' digital readiness, with an average score of 0.89, significantly higher than other sources. Government sources have a lower impact, at 0.24, although still positive. In the Philippines, for-profit organizations also show the highest digital readiness score (1.35), followed by religious organizations (1.30) and non-profits (1.17), indicating the significant contribution of various non-government funding sources in supporting digital learning in the country.

An interesting finding from this table is that in some countries, such as the Philippines and Thailand, for-profit sources show very high digital readiness scores (1.35 and 0.93), while in other countries such as Malaysia, the impact of for-profit sources is even negative (-0.35). This may indicate that different funding structures have different effects on students' digital readiness. On the other hand, the role of government in supporting digital readiness also varies, with the highest score in the Philippines (0.83) and the lowest in Malaysia (-0.03), indicating the important role of government in facilitating digital readiness in some countries better than others.

3.1.1 Difference test (Indonesia with ASEAN countries)

This table provides the results of a significance test comparing the average digital learning readiness of 15-year-old students (WLE) across countries based on PISA 2022 data. This analysis aims to see if there is a significant difference in the level of digital readiness between Indonesia and the other countries included in the table. The symbols shown indicate whether the digital readiness score in one country is significantly higher (>), lower (<), or not significantly different (x) compared to the other countries.

Table 4
Differences test

	Indonesia	(V1, V2)	Criteria
Brunei Darussalam	< Diff = -0.14 P-value = 0.0303	(0.066)	Sign.
Malaysia	< Diff = -0.24 P-value = 0.0058	(0.088)	Sign.
Philippines	> Diff = 0.66 P-value = 0.0000	(0.119)	Sign.
Thailand	> Diff = 0.44 P-value = 0.0000	(0.100)	Sign.
Viet Nam	X Diff = 0.01 P-value = 0.9265	(0.093)	Not Significant

If we focus on Indonesia, the results show that the level of digital readiness of Indonesian students is significantly higher compared to Brunei Darussalam (mean difference of 0.14 with p-value of 0.0303), and Malaysia (mean difference of 0.24 with p-value of 0.0058). However, the level of digital readiness of Indonesian students is significantly lower compared to the Philippines (mean difference of -0.66 with p-value of 0.0000) and Thailand (mean difference of -0.44 with p-value of 0.0000), which shows that students in the Philippines and Thailand are more prepared in digital learning than students in Indonesia.

Meanwhile, the comparison with Vietnam did not show a significant difference (p-value of 0.9265), so it can be concluded that the digital readiness of students in these two countries is almost the same. From these results, an interesting finding is that although Indonesia has better digital readiness than Brunei and Malaysia, students in the Philippines and Thailand show much higher readiness. This suggests a significant disparity in digital readiness across Southeast Asia, likely due to factors such as digital education policies, access to technology infrastructure, and the quality of technology-based learning in each country. This interpretation can provide insight for Indonesia to strengthen students' digital readiness in order to compete with neighboring countries.

3.2 ICT Resources

The results of this analysis provide an overview of the average availability of ICT (information and communication technology) resources for 15-year-old students in various countries in 2022. This data comes from the Program for International Student Assessment (PISA) and is measured on a WLE scale ranging from -7 to 7. This value reflects the extent to which students have access to and ICT resources that support the learning process at school and at home.

From the data, it can be seen that Indonesia has the lowest average value of ICT resource availability, which is -1.86, indicating limited access for students in using digital technology for learning. The Philippines (-1.53), Thailand (-1.50), and Vietnam (-1.30) also show quite significant negative numbers, indicating that students in these countries have limited access to ICT resources that are important in supporting digital learning. In contrast, Singapore recorded a positive value of 0.40, indicating better ICT resource availability compared to other countries in the region. An interesting finding from this data is the quite striking difference between Singapore and other countries. While Singapore shows strong ICT readiness, countries such as Indonesia, the Philippines, and Thailand still face major challenges in providing adequate ICT access for students. This could be an indicator that countries with better ICT access, such as Singapore, tend to be more ready to adopt technology in education, while other countries may need further policies and investments to improve their digital infrastructure.

Table 5
Public and private school

Jurisdiction	Public school		Private school		All Student	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Brunei Darussalam	-0.32	(0.013)	0.43	(0.030)	-0.19	(0.012)
Indonesia	-1.90	(0.038)	-1.80	(0.055)	-1.86	(0.031)
Malaysia	-1.17	(0.029)	0.05	(0.145)	-1.09	(0.030)
Philippines	-1.70	(0.027)	-0.71	(0.131)	-1.53	(0.038)
Singapore	0.36	(0.011)	0.81	(0.102)	0.40	(0.015)
Thailand	-1.53	(0.034)	-1.34	(0.082)	-1.50	(0.031)
Viet Nam	-1.36	(0.036)	-0.61	(0.123)	-1.30	(0.035)

This table shows a comparison of the average availability of ICT (information and communication technology) resources for learning in public and private schools in several Southeast Asian countries in 2022. This data is taken from the Program for International Student Assessment (PISA) and measured using the WLE scale ranging from -7 to 7. This value reflects the extent to which students in public and private schools have access to adequate ICT resources to support their learning.

Looking more closely, Indonesia has a low negative average value in both public (-1.90) and private (-1.80) schools, indicating that ICT access in both types of schools is still very limited. Similar conditions are also seen in the Philippines and Thailand, where the ICT availability values in both public and private schools are both negative, although private schools in both countries have slightly better access. In contrast, Singapore shows a different trend with positive values in both types of schools, where private schools recorded a value of 0.81, higher than public schools (0.36), indicating that ICT access in Singapore is very good, especially in private schools.

An interesting finding from this table is the significant differences between public and private schools in some countries. In Brunei Darussalam, Malaysia, and the Philippines, private schools show significantly better ICT access than public schools. In Malaysia, for example, private schools

have a positive score (0.05) while public schools remain negative (-1.17). This difference suggests that in some countries, private schools may have more resources to provide better digital infrastructure compared to public schools. This data highlights the disparity in ICT access between public and private schools in some countries, which may affect the quality of technology-based learning for students.

Table 6
Presents data on the average availability of ICT resources

Jurisdiction	Average					
	Village	Small Town	Town	City	Large City	Megacity
Brunei Darussalam	-0.42	-0.37	0.02	0.04	‡	‡
Indonesia	-2.13	-1.92	-1.66	-1.54	-1.42	-1.75
Malaysia	-1.41	-1.28	-1.21	-0.85	-0.88	‡
Philippines	-2.26	-1.52	-1.79	-1.28	-1.16	‡
Singapore	‡	‡	‡	‡	0.41	‡
Thailand	-1.99	-1.83	-1.51	-1.11	-0.90	0.02
Viet Nam	-1.69	-1.44	-1.33	-0.97	-0.36	-0.41

This table presents data on the average availability of ICT resources for 15-year-old students across geographic regions by population size, from small villages to megacities (populations of more than 10 million people) in several Southeast Asian countries. The data help show how access to ICT resources varies depending on the population size of the area where students live, which can affect their readiness for technology-based learning.

In Indonesia, ICT access appears to be very limited across all types of regions, with values particularly low in small villages (-2.13) and small towns (-1.92). Despite slight increases in large cities and megacities, the values remain negative, indicating that ICT access in Indonesia remains limited overall, even in areas with larger populations. A similar pattern is seen in the Philippines, where small villages have the lowest ICT access (-2.26), and despite some increases in large cities (-1.16), ICT access remains inadequate. In contrast, Singapore shows much better ICT readiness in its megacity areas with a positive score of 0.41, indicating excellent ICT access in the country. Another interesting finding is that countries such as Thailand and Vietnam show significant increases in ICT access from small villages to megacities.

In Thailand, for example, the score increases from -1.99 in small villages to 0.02 in megacities, indicating improvements in digital infrastructure in more urban areas. This is also seen in Vietnam, where ICT access in megacities (-0.41) is much better than in small villages (-1.69). Overall, this data shows that there is a gap in ICT access between rural and urban areas in some countries, which may affect the ability of students in different areas to utilize technology in education.

Table 7
Supporting their schools

Jurisdiction	Average			
	Church or Other	Not for Profit	Profit	Government
Brunei Darussalam	0.27	0.49	‡	-0.32
Indonesia	-1.98	-1.64	-1.86	-1.89
Malaysia	-0.27	-0.43	0.27	-1.18
Philippines	-0.75	-0.74	-0.08	-1.70
Singapore	—	—	—	—
Thailand	-1.19	-1.29	-1.26	-1.55
Vietnam	-1.38	‡	-0.63	-1.33

This table presents data on the average digital learning readiness of 15-year-old students based on the funding sources supporting their schools, including religious organizations, non-profit organizations, for-profit organizations, and government, across several Southeast Asian countries. Each mean value indicates the extent to which each funding source affects information and communication technology (ICT) access and readiness to support student learning.

From this table, Indonesia has negative scores across all funding categories, with the lowest score from government funding (-1.89), indicating that all funding sources, whether from religious organizations, non-profit organizations, for-profit organizations, or government, are still failing to provide adequate support for ICT readiness for students. A similar negative trend is also seen in Thailand, with all funding sources recording low scores, although government funding has the worst impact (-1.55), indicating imbalances in technology infrastructure and access that may occur across school types.

Another interesting finding is seen in Malaysia, where funding from for-profit organizations shows a positive score (0.27), in contrast to the other sources which are mostly negative. This suggests that support from the private sector may be more effective in providing ICT access compared to other sources, including government. In contrast, in the Philippines, although for-profit funding recorded a negative value (-0.08), it is still better than government funding (-1.70), indicating that the government in this country needs to increase investment in technology for education.

3.2.1 Difference test (comparison of Indonesia with ASEAN countries)

The results of this analysis show the results of a difference test (comparison) between Indonesia and other ASEAN countries based on certain criteria related to digital learning readiness or ICT access. Each comparison displays the average difference (diff) between Indonesia and other countries, along with a p-value indicating the statistical significance of the difference. The ">" symbol indicates that Indonesia has a lower score than other countries in the comparison.

Table 8
Table difference test

	Indonesia	(V1, V2)	P-Value
Brunei Darussalam	> Diff = 1.67	(0.033)	.0000
Malaysia	> Diff = 0.77	(0.043)	.0000
Philippines	>Diff = 0.33	(0.049)	.0000
Singapore	> Diff = 2.27	(0.034)	.0000
Thailand	> Diff = 0.36	(0.044)	.0000
Viet Nam	> Diff = 0.57	(0.047)	.0000

Note: P<.05 = sign

The results of the difference test show that Indonesia is significantly behind other ASEAN countries in terms of digital learning readiness. The most striking difference is with Singapore, with a difference of 2.27 and a p-value of 0.0000, indicating that Singapore has much better digital readiness than Indonesia. In addition, Indonesia is also behind Brunei Darussalam with a difference of 1.67, indicating that Brunei also has better ICT access. Although the differences with other countries such as Malaysia (0.77), the Philippines (0.33), and Thailand (0.36) are smaller than those with Singapore and Brunei, these differences are still statistically significant (p-value 0.0000). This indicates that Indonesia needs to improve its digital infrastructure and ICT access to improve digital

learning readiness, as all countries compared in this table show better readiness to support technology-based education.

4. Discussion

4.1 Digital Learning Readiness in ASEAN Countries

The findings of this study indicate a significant gap in digital learning readiness across ASEAN countries based on PISA 2022 data. Singapore ranks highest in digital readiness, with a positive score reflecting strong access to and utilization of ICT resources in education. This result is consistent with Singapore's long-term investment in digital infrastructure and technology integration into the education system [11]. In contrast, countries such as Indonesia, the Philippines, and Thailand score much lower, indicating limited readiness for digital learning. This is particularly concerning given the growing global reliance on digital-based education, especially following the COVID-19 pandemic that has accentuated the digital divide in education [12].

The differences between these countries could be due to a variety of factors, including economic differences, government policies on ICT integration, and the level of infrastructure development. For example, Indonesia's low digital readiness may be due to challenges in expanding digital infrastructure to rural and remote areas [13]. Furthermore, while the Philippines showed slight improvement, the issue of equitable access to digital tools in less developed regions remains a problem [14]. These results point to the need for more targeted policies and investments in digital learning resources, especially in lagging countries.

ASEAN countries have a wide range of digital learning readiness, with significant differences in infrastructure and internet access. Singapore, Malaysia, and Brunei have made rapid progress in integrating technology into education thanks to strong internet connections and government support through comprehensive digitalization policies. For example, Singapore's Smart Nation initiative and Malaysia's Malaysia Education Blueprint have created a technology-based education environment, making digital learning an integrated part of the curriculum.

Countries such as Indonesia, Thailand, and the Philippines have made good progress but still face a digital divide, especially in rural areas. National programs such as Merdeka Belajar in Indonesia and efforts in Thailand and the Philippines to support technology-based education demonstrate a strong commitment. However, limited internet access and the need for teacher training remain challenges, especially in remote areas.

In contrast, Cambodia, Laos, and Myanmar are at an early stage of digitalizing education. Limited infrastructure and reliance on international assistance to develop digital education systems suggest that they still have a long way to go. Overall, to achieve more equitable readiness across ASEAN, investment in technology infrastructure and ongoing training for teachers and students in all countries is needed.

Overall, digital learning readiness in ASEAN has a stark difference between countries. Countries such as Singapore, Malaysia, and Brunei are already at a more advanced stage, while countries such as Cambodia, Laos, and Myanmar still need significant support to catch up on digital learning readiness. Investment in infrastructure and training is essential to address this digital divide.

3.2 ICT Resources in ASEAN Countries

The availability of ICT resources, as reflected in the PISA 2022 data, shows significant variation in access across ASEAN countries. Singapore again stands out with the highest availability of ICT resources, cementing its position as a regional leader in digital education. Schools in Singapore

systematically integrate ICT into the curriculum, with government policy and funding support greatly assisting this achievement [15]. On the other hand, countries such as Indonesia and the Philippines show much more limited access to ICT resources, which is a major barrier to improving student learning outcomes [12].

Results in Malaysia show that while urban areas have better access, schools in rural areas still face significant challenges in ICT integration [16]. Meanwhile, Vietnam and Thailand show improvements in the availability of ICT resources, although challenges in equitable distribution across geographical areas remain [17]. This emphasizes the importance of not only increasing the amount of ICT resources, but also ensuring their equitable and effective distribution in order to maximize their impact on education outcomes.

Overall, the results of the PISA 2022 data highlight the urgent need for policy interventions and investments in ICT resources in ASEAN countries. Countries with lower readiness and limited resource availability should prioritize the expansion of digital infrastructure, especially in rural and underserved areas. In addition, the integration of ICT into the education curriculum needs to be supported by teacher training and adequate student access so that technology can be a supporter of effective learning, not a barrier [18].

3.3 Implications and Policies

The Indonesian government needs to immediately take measurable policy steps to improve digital readiness in the education sector. Some policies that can be considered include:

i. Strengthening Digital Infrastructure in Schools
The government must prioritize the development of digital infrastructure in schools, especially in rural and remote areas. Massive investment in fast and stable internet networks, as well as the procurement of technological devices such as computers and tablets, is needed to expand access to ICT-based learning.

ii. Teacher Training for the Use of Technology in Learning
Teachers play a critical role in integrating technology into the teaching and learning process. Therefore, the government must provide ongoing training programs for teachers throughout Indonesia to improve their ability to use ICT effectively in the classroom. This must also be complemented by ongoing technical support so that teachers do not find it difficult to use technology.

iii. Developing a Curriculum Oriented to Digital Skills
In addition to providing infrastructure, the Indonesian education curriculum must focus more on developing students' digital skills. The curriculum should include deeper aspects of digital literacy, such as coding, use of cloud-based applications, and use of digital tools for research and collaboration.

iv. Collaboration with the Private Sector and Non-Profit Organizations
The government can work with the private sector and non-profit organizations to accelerate the digitalization of education. Many technology companies and international institutions can play a role in providing digital learning tools and applications for free or at an affordable cost, especially for schools with limited resources.

By implementing these policies, Indonesia can reduce the digital divide in its education system and improve students' readiness to face the challenges of the digital era. These steps will also ensure that all students, regardless of geographic or economic background, have equal access to quality technology-based education.

4. Conclusions

The study reveals significant gaps in digital learning readiness and ICT resource availability across ASEAN countries, based on the results of PISA 2022. Singapore stands out as the most digitally ready country, while countries such as Indonesia, the Philippines, and Thailand still face significant challenges in providing adequate ICT access to 15-year-old students. This highlights the need for greater efforts to improve educational ICT infrastructure in lagging countries, especially Indonesia. Digital readiness is strongly correlated with the quality of education. Countries with a high digital readiness index tend to be better able to integrate technology into education, producing students who are more globally competent. In contrast, countries with low digital readiness face major challenges in improving access and quality of education. The study findings suggest that inequality in ICT access, especially between urban and rural areas, is one of the main causes of low digital readiness in several ASEAN countries, including Indonesia. In addition, the lack of consistent policy support and limited budget for educational technology also exacerbate this gap. Without significant steps, this digital divide could widen, ultimately affecting the quality of education and students' readiness to face the world of work in the digital era.

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