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Closing the digital divide in education: an innovative review of demand and supply side policies in four ASEAN member states

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ABSTRACT

The rapid adoption of digital technologies in education highlights the importance of closing the digital divide in education. However, research on school connectivity policy regimes to bridge the digital divide in education in the Association of Southeast Asian Nations (ASEAN) region is lacking. The authors conducted a systematic review of policies in Cambodia, Malaysia, Thailand, and the Philippines following a framework synthesis approach. Through desk research, data was identified based on a supply and demand side framework and included policy documents from relevant ministries and departments, reports by international development organizations and non-governmental organizations, and academic literature. The analysis reveals an imbalance between supply and demand-side policies and regulatory approaches with governments in the analyzed countries favoring demand side policies.

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1. INTRODUCTION

Broadband connectivity and digital technology are powerful enablers accelerating progress towards all 17 United Nations Sustainable Development Goals (SDGs). Mobile and fixed-line broadband has been shown to positively impact economic growth [1], [2]. Broadband supports the reduction of poverty, promotes inclusive and equitable education, improves healthcare and health information systems, and contributes to the building of resilient infrastructure while fostering innovation [3]. In education, broadband and other digital technologies promise far-reaching benefits. They can support achieving SDG 4 through various pathways, including enabling access to education among students in remote areas, increasing the relevance and quality of education, building lifelong learning pathways, strengthening education and learning management systems and monitoring learning processes [4]. Research also demonstrates that students can carry the knowledge and experience gained at school to other internet access points, where they can guide family and community members [5]. School connectivity can serve as an entry point for extending connectivity to unconnected communities [6].

The COVID-19 pandemic highlighted the persisting digital divide in the education sector in Association of Southeast Asian Nations (ASEAN) member states and elsewhere, with many children being unable to access online distance learning during lockdowns [7]–[10]. Underpinning the SDGs 2030 agenda is the pledge to "leave no one behind." COVID-19 has demonstrated that now, more than ever, this means leaving no one offline. This article argues that policymakers in ASEAN member states should deploy an integrated whole-of-government approach that balances supply and demand side factors to close the digital divide in education. In this context, supply-side policy refers to policies that aim to increase school

connectivity directly or indirectly. Demand-side policies are geared towards internet connectivity and the uptake of information and communications technologies (ICTs) in schools and the education system in general.

Comprehensive data on school connectivity is crucial for identifying coverage gaps and adjusting policy, accordingly [6]. Importantly, connectivity data should include indicators beyond whether schools have internet access, and encompass factors such as connection quality, number of devices, affordability of connection and whether internet connectivity supports pedagogical needs [6]. However, there is a severe lack of comprehensive data on school connectivity among ASEAN states. The only comprehensive assessment of digital technology integration into education in ASEAN is the Southeast Asian Ministers of Education Organization (SEAMEO) report titled status of ICT integration in ASEAN [11]. The report categorized ASEAN countries into three groups based on their level of ICT integration into education. The first group includes the countries with the most advanced integration of digital technology into education: Brunei Darussalam, Malaysia, and Singapore. The second group consists of Indonesia, the Philippines, Thailand, and Vietnam. Countries in third group, include Cambodia, Lao PDR, and Myanmar, which were only at the beginning of integrating digital technology into education [11]. As the SEAMEO study is now outdated, it may not reflect the current state of digital technology in the education of ASEAN member states. However, more recent data presented in this study indicate that the digital divide in education persists in the region, and education connectivity policies need to be adjusted to ensure that no school is left behind.

The availability of school connectivity data varies significantly among countries in the ASEAN region. The only country observed with up-to-date school connectivity data is Thailand. According to an International Telecommunication Union report [12], a large share of Thailand's schools is connected to the internet, with 97.47% of schools reported to have an Internet connection and only 0.8% without internet access, while data is missing for the remaining 1.7% of schools. However, the report also states that many of the schools connected rely on a mobile internet connection, which may not be sufficient for educational purposes. Another survey supports this sentiment, finding that 52% of surveyed high school students described their school internet connection as weak [13]. Furthermore, the reliability of government-reported data is questionable due to self-reporting mechanisms and jurisdictional issues.

Other countries in this study do not have up-to-date data or no data is available. The most recent publicly available data in Malaysia is from 2013 and does not include connectivity indicators. According to available data, 27% of schools lacked a computer lab, and 3% had no access to 24-hour electricity [14]. In contrast, Cambodia has more recent data but is limited to one indicator. The Ministry of Education, Youth and Sport [15] reports that 20.4% of schools at the pre-primary level, 36.5% of schools at the primary level, and 62.4% of schools at the secondary level had access to electricity, internet, and computers for pedagogical purposes in 2018. Given the broadness of this indicator, it does not give a clear picture of the state of school connectivity in Cambodia.

Meanwhile, there is no data publicly available in the Philippines. However, general connectivity data suggests there would be considerable gaps in school connectivity since only 47% of Filipinos actively used the internet in 2019, and only 80% of the population was covered by at least a 4G network in 2017 [16]. While the available data shows that ASEAN member states have made progress, it also suggests that some schools are left behind. Therefore, this study is concerned with how these schools can be enabled to harness the potential of digital technology.

Research shows that regulatory and policy frameworks are crucial for increasing general connectivity and bridging the digital divide [17]. For instance, developing a national broadband plan is linked to higher fixed and mobile broadband penetration [18]. Rural areas, in particular, pose challenges to extending connectivity that market forces alone cannot overcome [19]. Hence, government regulation and policy play a crucial role in fostering rural connectivity. To this end, the Alliance for Affordable Internet [19] and the GSM association [17] recommend that governments should implement policies that can incentivize or obligate private sector actors to extend connectivity to rural and remote areas through measures such as streamlining regulatory processes, effectively managing spectrum allocations, adopting appropriate tax and fee structures, and stimulating broadband demand.

Policy and regulations also play an essential role in improving school connectivity. Research conducted by the International Telecommunication Union (ITU) [6] indicates that governments can enhance school connectivity through regulatory regimes, such as pay-to-play licensing or universal service obligations. Such supply-side policies need to be complemented by demand-side interventions. According to Kozma [20], integrating digital technology into education policies is essential for the effective and efficient uptake of digital technology in educational institutions. A balanced school connectivity framework thus needs to integrate both supply and demand side policies for the successful integration of digital technology into the education sector.

Despite the importance of policies to advance school connectivity, little research examines policy regimes that support school connectivity in ASEAN. The only comprehensive study analyzing and comparing digital technology in education policy regimes in eight ASEAN countries, namely Cambodia, Myanmar, Thailand, Singapore, Vietnam, Lao PDR, Malaysia, and Indonesia, was conducted by UNESCO in 2013 [21]. The report found that each country has developed some form of ICT in education policy, although they were quite different, reflecting the varied national contexts. However, the report also notes that many countries struggle to implement policies, leading them to "stay on paper". Furthermore, few countries have dedicated institutions or agencies for digital technology in education, leaving the integration of ICT into education to the respective education or ICT ministries and departments. These findings are confirmed by Machmud *et al.* [22], in their review of policies for the integration of digital technology into education in Myanmar, Thailand, Singapore, and Indonesia, found that all four countries have made efforts to integrate digital technology in education policy but also report varying degrees of progress. Outside of these studies, little research is considering school connectivity policy regimes in the ASEAN region.

This article aims to fill this gap in the literature by applying a framework synthesis approach to analyzing school connectivity policy regimes in Cambodia, Malaysia, the Philippines, and Thailand. To this end, the authors posed the following research question: considering demand and supply policies, what is the state of school connectivity policy regimes in four ASEAN member states Cambodia, Malaysia, the Philippines, and Thailand? In addition, the authors describe the methodological approach taken for this study, which is followed by a discussion of the conceptual framework adopted for the analysis. In the subsequent sections of the paper, the authors present the findings and analysis. The authors conclude the article with a discussion of the limitations of the study and the implications of these findings for further research.

2. METHOD

The researchers conducted a systematic review of existing policies and evidence related to the digital divide in education in ASEAN in 2022. A systematic review can be used to evaluate and compare policies [23]. While many systematic review studies deploy quantitative methods, qualitative studies have increased in prevalence [24], [25]. There are different approaches to qualitative analysis within systematic reviews [25]. This study uses the framework synthesis approach, which builds on the framework analysis method [26]. Framework synthesis uses a literature-based framework to review and synthesize collected literature [27]. While this method is mainly used in public health research, it is also applied in education studies, such as to examine the impact of social media on education [28]–[30].

Framework synthesis typically involves five stages of research: familiarization, identifying a thematic framework, indexing, charting, mapping and interpretation [25], [31]. The researcher first becomes familiar with the literature on the relevant topic and selects a framework based on the literature in the familiarization and identification stages. For this study, the authors adopted a supply-demand side framework based on the literature on broadband policy frameworks. The selection process of the framework is discussed in detail in the next section.

In the indexing stage, framework synthesis requires searching, screening, and analyzing existing evidence based on the initial framework [23]. While systematic reviews often focus on academic studies, policy documents can also form the basis of a framework synthesis study [25]. Evidence included in this study includes policy documents from relevant ministries and departments, reports by international development organizations and NGOs, and academic literature. The authors limited the countries of analysis to Cambodia, Malaysia, the Philippines, and Thailand due to the availability of policy documents and to represent the region's socio-economic and cultural diversity.

Following the indexing stage, the authors charted the main characteristics of the policy documents collected by categorizing them and identifying themes [23]. During this process, the authors identified five subthemes under demand-side policies and three subthemes under supply-side policies. These themes are presented in the findings section of this article utilizing a narrative approach [25]. The findings are analyzed and interpreted within the context of the literature on the digital divide in education.

2.1. Conceptual framework: demand and supply-side policies

There are various school connectivity policy analytical frameworks mainly developed by international development actors. One framework from the internet society stipulates five priority areas for developing education connectivity policies covering infrastructure and access, vision and policy, capacity building, content and devices, and inclusion [32]. Another analytical framework is the systems approach for better education results (SABER) digital technology policy framework developed by the World Bank. It identifies eight key themes in education policy, including vision and planning, digital technology infrastructure, skills and competencies, learning resources, educational management information system (EMIS), monitoring and evaluation, and equity, inclusion and safety [33]. Similarly, the SEAMEO

Secretariat has developed a framework that contains guiding questions around the following ten digital technology-in-education dimensions: i) national digital technology-in-education vision; ii) national digital technology-in-education plans and policies; iii) complementary national digital technology and education policies; iv) digital technology infrastructure and resources in schools; v) professional development for teachers and school leaders; vi) community/partnerships; vii) digital technology in the national curriculum; vii) teaching and learning pedagogies; ix) assessment; and x) evaluation and research [11].

These frameworks focus on the demand side of school connectivity and the integration of ICT in the classroom. However, this emphasis on the demand side potentially risks understating the importance of supply-side policies. Given the considerable variation in school connectivity and the difficulties of some countries in connecting remote and rural schools, it is essential to examine the influence of supply-side policies on education connectivity. In more recent initiatives towards fostering school connectivity, there has been a recognition of the importance of measures that enable school connectivity. For instance, the ITU and UNICEF Giga initiative to connect every school to the Internet has adopted a framework based on four pillars: map, finance, connect and empower. In this framework, a clear focus is put on enabling connectivity first to integrate digital technology into education and communities later [6]. However, the Giga framework is unsuitable for analysis as it is intended as a guideline for implementing initiatives. Thus, developing a framework for analyzing school connectivity policy for this study is necessary.

This study builds on a large body of literature examining government policies' influence on general broadband connectivity. Within this literature, various approaches exist for the analysis of government broadband connectivity policy. For instance, Cava-Ferreruela and Alabau-Muñoz [34] adopted a framework for analyzing government broadband policy that categorizes policy regimes based on the level of government intervention in the market. Falch and Henten [35] developed a framework based on the three main policy dimensions concerning competition, state aid, and the relationships between content and networks. Under each dimension, they identified tensions between two poles: infrastructure vs service competition, regulatory vs developmental policies, and network vs content prioritization [35]. While these are suitable frameworks for analyzing overall connectivity policy, they are unsuitable for the education sector. Given that strong government involvement in education can be assumed, categorizing policy regimes based on the degree of government involvement would not be helpful for the analysis of school connectivity.

Another popular approach is a framework based on differentiating supply and demand-side policies. Research shows that because both supply and demand side factors determine broadband extension by private sector actors, government policies need to address both the supply and demand side to stimulate the extension of broadband Internet connectivity [36]. Based on an analysis of factors for broadband adoption in the European Union, Trkman *et al.* [37] developed a framework that adopts the separation of policies on the supply and demand side. The framework considers three dimensions on each side, including means and enablers, services, and the digital technology environment. Belloc *et al.* [38] have also adopted a framework that differentiates between supply-side and demand-side policy in a study analyzing broadband policies in 30 OECD countries. They found that both supply and demand-side policies are essential in stimulating broadband penetration.

This study applies the general framework of supply and demand-side policies to the education sector. In this context, supply-side policy refers to policies that aim to increase school connectivity directly or indirectly. Direct measures refer to government infrastructure projects for school connectivity, whereas indirect measures include policies that incentivize or obligate private sector actors to connect schools to the Internet. In contrast, demand-side policies are geared towards the use of Internet connectivity and the uptake of ICTs in schools and the education system in general. These include a variety of measures that enable students, teachers, and administrators to utilize and benefit from connectivity, such as the provision of devices, the development of relevant content, and skills development.

3. RESULTS AND DISCUSSION

This study is mainly concerned with country-level approaches to bridging the digital divide in education. However, ASEAN has included ICT in education in their high-level, regional ICT policies. Under the ASEAN ICT Masterplan 2020, ASEAN [39] commits to increasing access to broadband and integrating digital technology into education systems. The plan stipulates that it will "address new and emerging digital and information divides through a sustained agenda of digital education in schools, re-skilling in next-generation telecentres, and life-long learning" [39]. This commitment requires various policy interventions on education connectivity's supply and demand sides. On the supply side, the plan emphasizes the need to ensure every child has broadband internet access. The demand-side policies stated in the plan include providing training to educators for the use of ICTs in the classroom, encouraging youth to pursue a career in

the ICT sector, promoting the collaboration between education and ICT sectors, and generally promoting awareness of the benefits of ICTs in education [39].

ASEAN's regional policy commitment is mirrored by member states observed in this systematic review. All the countries analyzed aimed to increase school connectivity through ICT or education policies. However, they vary in terms of their commitment and integration of school connectivity into overall broadband policy. Some countries include school connectivity in high-level national development and digital technology policies. For instance, the Philippines' National Broadband Plan states that the government "shall take necessary steps to ensure that primarily all public schools, health institutions, government sites, and public places will be connected to the internet" [40]. Additionally, most countries had a specific digital technology in education policy master plan under the relevant education ministries [41]–[43]. However, not all countries explicitly include education as a priority in their high-level ICT policies as the Philippines do.

3.1. Demand side policies

Through the analysis of the policies within the countries observed, five themes emerged on the demand side of school connectivity. These five areas include provisions for increasing access to devices, integrating digital technology into national school curricula, content development, teacher training, and application of digital technology for administrative services and data management. While not all countries implemented policies in all areas, the five themes provide useful insights into the scope of demand-side policy interventions.

3.1.1. Access to devices

One main policy area across most countries was the supply of devices to schools. Under the Philippine education technology master plan, several measures to increase access to devices in public schools are listed, including electronic library systems, computer laboratory rooms, and appropriate educational technology packages [44]. The Department of Education Computerization program aims to provide devices, including computers, routers, and printers, to primary and secondary schools and to provide laptop units to mobile teachers [45]. In Malaysia, the Ministry of Education has implemented various programs to bring devices to schools. The smart school project aims to equip more than 10,000 schools with various devices [14], [46]. The Malaysia Netbook program supplied one million students from low-income families with a netbook [46]. In the master plan for information and communication technology in education, the Cambodian government stipulated that all computers deployed in schools and in teacher training centers must fulfil specific requirements and a minimum number of computers per student [41]. Furthermore, the Cambodian government aims to adopt integrated digital technology systems and network architecture to increase productivity; equip schools, teacher training centers, and Ministry of Education offices with standardized equipment; and consolidate network bandwidth [47]. Thailand has also invested in digital technology devices in schools, reaching a relatively high ratio of devices per student [48]. One notable project has been the one tablet per child program, which distributed approximately 1.2 million tablets before it was scraped in 2014 [48].

3.1.2. Integration of digital technology into school curricula

Another central area of policy is integrating digital technology into national curricula. Most countries have implemented digital technology-specific subjects and made provisions to integrate digital technology into teaching and learning. In 2001, Thailand began expanding its efforts to integrate digital technologies into the education system through digital technology-focused subjects, digital technology for teaching and learning, and expanding general digital technology infrastructure in the education sector [48]. In the revision of Thailand's primary education curriculum in 2008, digital technology was included as a topic of study in all grades, and integration has been deepened over subsequent master plans [48].

The Philippines' policies also call for integrating digital technology into curricula, including the inclusion of digital technology in home economics and livelihood education subjects at the primary education level and the subject technology and home economics at the secondary level [44]. The policies also call for the integration of digital technologies across all subjects for teaching and learning through the introduction of appropriate devices and content [44]. By integrating ICTs in both specific subjects that teach digital skills as well as across all subjects, the policies seek to ensure that students can gain digital skills that apply to a wide range of activities and outside of school.

3.1.3. Content development

The observed policies also include provisions to support digital content development within and beyond the formal education system. The Malaysia Education Blueprint 2015-2025 highlights the importance of providing the relevant tools to use digital technologies for successful learning, such as educational games, multimedia, and other digital content [14]. This approach is taken further under the basic e-learning country

(*dasar e-pembelajaran negara* or DePAN) 2.0 policy, which aims for 40% of courses to have original e-content by 2025 and for most of this content to be developed and available openly [42]. To increase access to digital content, the ministry of education developed a virtual learning environment (VLE) for all schools based on Malaysia's education internal network 1BestariNet, which hosts the content. However, in 2019, this VLE was replaced by the introduction of Google Classroom [49].

Cambodia has developed digital materials and online tools for tertiary, primary, and secondary education. For easy access to materials, the education ministry, in partnership with the Korea Software HRD Centre and Khmer Academy, has created an online portal which includes interactive multimedia, posters, digital lessons, and other content [50]. The government has also implemented the Cambodian research and education network, which connects five higher education institutions and offers online learning materials [51].

Thailand has implemented various programs to develop digital content accompanying their device policies [48]. There has also been an effort to develop open education resources, evident in the open education resources project set up by the ministry of education and the Ministry of Science and Technology. Various higher education institutions have established massive open online courses through the Thai massive open online course's website, which recorded 422,930 registrations on 406 courses run by 95 institutions. Additionally, several universities have repositories of online academic resources [52].

3.1.4. Teacher training

Another prominent policy area is teacher capacity building to allow teachers to utilize digital technologies in the classroom effectively. In Cambodia, a large part of digital technology in education policy concerns teachers' capacity building. The curriculum for teacher training centers has included training on digital technology for all teachers since 2003. Furthermore, the master plan for Information and Communication Technology in Education and the subsequent policy and strategy on Information and Communication Technology in Education have extensive provisions for integrating digital technology skills training into teacher training curriculums [41], [47]. These policies stipulate training for the use of digital technology in the classroom [41], [53]. Further initiatives focus on digital literacy training for the general public [50]. The education sector strategic plan further aims to strengthen and expand science, technology, engineering, and mathematics (STEM) subjects by training teachers in computer-based competencies [15].

In Malaysia, the ministry of education has sought to increase teachers' use of digital technology in the classroom since 2000 through training programs in most rural schools [54]. Under the Malaysia Education Blueprint 2015-2025, these efforts were continued to ensure that all teachers meet a minimum level of digital technology literacy supported by a professional development platform run on 1BestariNet's VLE [14]. This platform also supports teachers and school administrators to plan and produce educational resources and implement novel education practices and distance learning [49]. Under the DePAD 2.0 policy, Malaysia set goals of 100% of all teachers having basic digital skills and knowledge of technical and pedagogical tools and 25% of educational staff having advanced digital skills [42].

The Philippines also introduced programs to increase educators' digital literacy to stimulate the uptake of digital technology in the classrooms. The Department of Education's Computerization program aims to raise students' and educators' overall digital technology literacy [45]. Additionally, the Philippine Education Technology Master Plan aims to train most public secondary teachers in basic computer skills [44]. Together, these policies aim to ensure that students can benefit from the introduction of ICT in the education system.

3.1.5. Administrative services and data management

Some countries also have policies aiming to develop education services that utilize broadband connectivity. An example of this is Malaysia's use of the 1BestariNet. As it is specifically developed for the education system, it offers to host additional services. To integrate digital technology into administrative processes, the ministry of education aimed to utilize the network as its central education data management platform [14]. These efforts are supported through measures such as the standardization and integration of e-learning policies at all levels, training of ministry officials to enhance digital skills, standardized certification of human resources, and annual allocation of budget to implement e-learning [54]. Cambodia aims to integrate digital technology into administrative processes within the Cambodian education system, such as building digital information management systems, establishing intranets, standardizing services, and upgrading software [41], [50], [53]. Likewise, the Philippines aims to integrate digital technology into the education system by increasing digital technology use for financing, monitoring, and evaluation [55].

3.2. Supply side policies

The relevant education ministries in the four countries analyzed in this study have comprehensively addressed the demand side of education connectivity. However, the supply side presents a different picture.

Most countries observed have implemented initiatives connecting schools to the internet. However, depending on the national context, governments have applied different approaches to extending school connectivity. Through the authors' analysis, three approaches emerged. The first approach integrates school connectivity into general connectivity policies, evident in Thailand and the Philippines. The second approach consists of specific programs for extending school connectivity, which is evident in Malaysia. The third approach, which is evident in Cambodia, is characterized by a strong reliance on private sector actors and corporate social responsibility (CSR) activities.

3.2.1. General connectivity approach

Schools are integrated into larger connectivity projects in Thailand and the Philippines. In the Philippines, the Free Public Internet Access Program, also known as "Pipol Konek", aims to create free public Internet access points in all public spaces. The program explicitly includes public education institutions in the definition of public places, thus aiming to connect all public schools to the Internet [40]. The National Broadband Plan reaffirms this commitment, stating that the government will take the necessary action to connect all public schools to the Internet [40].

The main digital infrastructure development project in Thailand is the village broadband internet project or Net Pracharat, which intends to connect all villages to the broadband network [56]. According to a report by Adipat *et al.* [56], the program had connected 24,700 villages and installed as many free public Wi-Fi hotspots by 2019. The Wi-Fi hotspots were installed in public places, including but not exclusively in public schools. The report further notes that the project also included implementing a training program for basic digital skills, reaching more than 1.2 million people by 2018. The next stage of the initiative is to expand fiber connectivity to unconnected community hospitals and schools, aiming to connect about 1,200 schools and 700 hospitals. The Ministry of Digital Economy and Society plans to open the NetPracharat network for use by private telecom operators under an open access regime to expand network coverage [56]. In contrast to the program in the Philippines, where the government explicitly includes public schools in their connectivity targets, NetPracharat includes no goals to achieve universal school connectivity in all the villages covered by the initiative.

3.2.2. Education specific approach

In Malaysia, the government is expanding school connectivity by developing the 1BestariNet network, specifically aimed at the education system. Implemented in 2011, the program aimed to connect all 10,000 public schools in Malaysia to 4G mobile broadband [14]. Under the newer DePAN 2.0 policy, additional goals are specified for connecting schools to the internet, aiming to reach 100% coverage with a minimum of 2.5 Mbps per student [54]. Contrasting with school connectivity programs in the Philippines and Thailand that are driven by the respective digital technology ministries, school connectivity efforts in Malaysia are driven by the relevant education ministry.

3.2.3. Private sector-centric approach

In Cambodia, various policy instruments stipulate that teacher training centers and schools should be connected to the Internet in urban and rural areas, but they lack more specific measures for implementation [41], [53]. Moreover, Cambodia has relied mainly on CSR activities of telecommunications operators to connect its schools to the Internet. For instance, Viettel's brand Metfone is committed to permanently connecting all administrative offices of the education ministry and all public schools, universities, and teacher training centers to the internet [41]. It invested US$ 10 million into school connectivity over two phases. However, the agreement with Metfone only covered schools with electricity access [51], [57].

3.3. Discussion

School internet connectivity with sufficient bandwidth is foundational for successfully integrating digital technology into education [4], [6]. However, not all schools in the countries studied have access to a sufficient internet connection. The study's analysis utilizing a supply and demand framework shows that there are no holistic approaches to addressing this challenge to date. While this study found comprehensive measures on the demand side, there is a lack of comprehensive supply-side policy to connect all schools to the Internet.

On the demand side, we identified five main areas of policy intervention, including devices, teacher capacity building, curricula, content development, and services and data management as shown in Table 1. All countries have made extensive efforts in at least some of these areas to integrate digital technology into education. These findings confirm earlier studies in the region, which have also found comprehensive demand-side interventions [11], [21], [22]. In some cases, these efforts are supported by supply-side interventions. For instance, in Malaysia, the 1BestariNet developed to increase school connectivity was also used to host content and support other demand-side efforts such as education services and data management. However, a lack of supply-side interventions potentially undermines demand-side interventions.

Furthermore, while demand-side interventions in all countries observed are comprehensive, they largely address students as a homogenous group. However, research highlights that some groups are less likely to access ICTs or benefit from increased school connectivity. For instance, female students often face more barriers than male students in benefiting from ICTs in education [8]. Additionally, students from lower socio-economic backgrounds are less likely to benefit from digital technology, creating additional inequality [9], [58]–[60]. Governments should thus include policies that aim at supporting specific groups that are at higher risk of being left behind.

On the supply side, we identified three main approaches to connecting schools. They include a general connectivity approach, an education-specific connectivity approach, and a private sector-centric approach as shown in Table 1. These approaches reflect the stakeholders involved in extending school connectivity [6]. As evident in Thailand and the Philippines, the first approach includes school connectivity in general connectivity projects and is led by the relevant digital technology ministries. In contrast, the second approach, as seen in Malaysia, focuses on education-specific connectivity extension and is led by the relevant education ministry. In the third approach, as observed in Cambodia, school connectivity extension is led by the private sector through CSR activities. This approach of incorporating the private sector has also been successfully applied in other countries such as China during the COVID-19 pandemic [9]. However, none of the countries analyzed made efforts to develop an integrated approach for extending school connectivity that leverages the different capacities of all three sectors.

Furthermore, the analysis shows that only Malaysia and the Philippines have adopted universal coverage goals for schools. While they adopt different approaches (general connectivity approach vs education-specific approach), both countries have set targets and specific steps towards universal school coverage. In contrast, Thailand has adopted policies that treat school connectivity as an appendage to wider connectivity extension projects without specific school coverage targets. Such an approach will likely lead to problems in extending school connectivity and sustainability issues since school connectivity is not a priority of these connectivity projects.

The review of school connectivity policy regimes in four ASEAN member states shows that all countries observed aim to leverage digital technology in the education sector. Therefore, both supply and demand side factors must be addressed for schools to benefit from digital technology in the education sector [4], [61]. However, the debate on digital technology in education focuses mainly on what happens inside schools, such as digital technology integration into curriculums, distribution of devices, and teacher training, while neglecting how to connect schools to the Internet.

Our findings suggest an imbalance between supply and demand side policies for expanding school connectivity, with most policies focusing on the demand side. Governments in the countries studied have implemented a wide range of policies on the demand side. However, on the supply side, only Malaysia and the Philippines have adopted universal coverage goals for schools. None of the countries studied have adopted a holistic school connectivity policy regime that integrates the relevant ICT and education government bodies and the private sector. However, research in other contexts has shown the importance of integrating multiple stakeholders in bridging the digital divide in education [10], [61], [62]. The authors thus argue that to bridge the digital divide in education, countries in the region need to increase efforts to build integrated whole-of-government policy regimes for school connectivity that comprehensively address supply and demand side aspects.

Table 1. Approaches to increase school connectivity

	Demand side policy	Supply side policy
School connectivity approaches	Access to devices	General connectivity approach
	Integration of digital technology into school curricula	Education specific approach
	Content development	Private sector-centric approach
	Teacher training	
	Administrative services and data management	

4. CONCLUSION

This study has analyzed the policy framework to extend school connectivity in four ASEAN member states, addressing a gap in the literature on school connectivity in the region, which overwhelmingly focuses on the integration of digital technology into schools without considering wider school connectivity policy regimes. The study demonstrates the usefulness of a demand and supply side framework for evaluating policy interventions for increasing school connectivity. The study's findings further contribute to the literature on school connectivity, underlining the importance of holistic policy frameworks for school connectivity that leverage all relevant stakeholders and balance demand and supply-side interventions.

There are some limitations to this study. The nature of this research is exploratory and, as such, limited in its scope and data collection. Further research should thus seek to validate these findings through research that includes other data sources and a broader geographical scope. It would also be of interest to study the interactions of supply and demand side policies in depth in specific schools or regions rather than on a national level. For instance, we suggest case studies on a local level that consider the impact of national demand and supply-side policies on the experience of school staff, students, local government, local non-governmental organizations, and private sector actors. Furthermore, studying the interactions between the different stakeholders in school connectivity efforts reflected in the three supply-side connectivity approaches identified in this study could provide insights into how to develop more integrated policy approaches. In this context, research attention should be given to the potential barriers to increased integration of ICT and education ministries as well as private sector actors.

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