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Abstract

This study aims to provide an overview of the diverse educational technology (ed-tech) programmes, policies and interventions (PPIs) in South Asia, Southeast Asia, and the Middle East and North Africa. It outlines key initiatives in nine countries to provide a description of the primary aims, applications and types of ed-tech in these three regions, and the ways that local governments have prioritised and implemented ed-tech at the national level. Whilst country-level initiatives aim to reach different target populations, what becomes clear is that many of the ed-tech PPIs studied here focus on improving the quality of and access to education.

A cross-country and cross-regional comparison highlights the shared facilitating factors that promote and encourage the uptake of ed-tech at a national level, such as adequate investment and political buy-in. This report also provides a descriptive analysis of factors hindering the uptake of ed-tech, mainly related to infrastructure, cultural factors, and physical access to technological devices. Since the COVID-19 pandemic, there has been a global increase in interest, investment and relevance in ed-tech from all stakeholders. It is this continued evolution of ed-tech that ensures its relevance and sustainability into the future across the regions.

Authors

Nisha Arunatilake heads the Labour, Employment and Human Resource Development unit at the Institute of Policy Studies of Sri Lanka (IPS). She has extensive post-doctoral experience in conducting policy related economic research in labour market analysis, education, public finance and health.

Lakshila Wanigasinghe is a research officer at the Institute of Policy Studies of Sri Lanka (IPS). She holds a MSc in Economics with a concentration in Development Economics and a BA in Economics with concentrations in International, Financial and Law and Economics from Southern Illinois University Carbondale (SIUC), US.

Himani Vithanage is a research assistant working on health, education, and labour policy at the Institute of Policy Studies of Sri Lanka (IPS). She holds a BA in Economics with First Class Honours from the University of Colombo.

Binura Seneviratne is currently working as an ODI Fellow (Senior Economist) at the Ministry of Finance, Tonga. He has previous work experience in economic policy research at the Institute of Policy Studies, Sri Lanka. He holds a masters in Economic Policy (MSc) from the Australian National University, Australia and a Bachelors in Economics and Finance (BSc Hons) from the University of York, United Kingdom.

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Acronyms and abbreviations

ADB	Asian Development Bank
GDP	Gross Domestic Product
GPI	Gender Parity Index
HIC	High-Income Country
LIC	Low-Income Country
LMIC	Lower Middle-Income Country
LMS	Learning Management System
MENA	Middle East and North Africa
NGO	Non-Governmental Organisation
SA	South Asia
SEA	Southeast Asia
SEAMEO	Southeast Asian Ministers of Education Organisation
SDG	Sustainable Development Goal
UMIC	Upper Middle-Income Country
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations Children's Fund
UNRWA	United Nations Relief and Works Agency

Key concepts

Key concepts	Definition
Ed-tech	Hardware, software, infrastructure, or digital content designed or appropriated for educational purposes (Hennessy et al., 2021). Hardware includes, for instance, feature phones, smartphones, radios, televisions, tablets, and laptops. Software may be used by students and teachers; as well as for school management, and monitoring and evaluation processes. Infrastructure typically involves electricity, local connectivity, and access to the internet. Oher digital contents involve, for example, open licensing, open innovation, or crowdsourcing (Haßler et al., 2020).
Ed-tech policies	For the purposes of this paper, we consider ed-tech policies as any government interventions aiming to promote access to Information and Communication Technologies (ICT) for use in the education sector; improve ICT infrastructure to support educational activities; or promote innovations in teaching-learning processes and access to educational services.
Ed-tech programmes	A program can be defined as an organised set of activities designed to produce concrete results and have a certain impact upon a problem (Shafritz, 2004). In this report, initiatives implemented by the private or civil society sector, or in collaboration with the government, are considered as programmes.

Ed-tech landscape and challenges in Asia and the Middle East and North Africa

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Introduction

The use of educational technology (ed-tech) has been accelerating, particularly since the COVID-19 pandemic, and is expected to introduce profound and long-lasting changes in access to quality education and equitable education outcomes (Kang, 2021; Zubairi et al., 2021). There is also growing momentum behind online self-led learning platforms (Buchanan, 2020; Major et al., 2021) and global investments in ed-tech products have been increasing in the past decade, with predictions for continued growth and global interest (Glasner, 2002). The use of technology in education is therefore becoming more critical to understand as it is prioritised by stakeholders, and as development and implementation varies across contexts.

The COVID-19 pandemic has sparked renewed interest in ed-tech worldwide (Munoz-Najar et al., 2022), leading to diverse impacts in the way it has been integrated into policies, programmes and interventions (PPIs). LMICs in South Asia (SA), Southeast Asia (SEA), and the Middle East and North Africa (MENA) included in this study have been impacted by the growth in ed-tech, as there has been a proliferation of online platforms to support online learning and promote improved learning outcomes (Major et al., 2021). Against this background, this report aims to provide a review of ed-tech PPIs in SA, SEA and the MENA region to explore how technology can advance quality and equitable education. The research questions that frame this report are:

1. How important have ed-tech PPIs been in SA, SEA and the MENA?
2. What are the priorities of ed-tech PPIs within each region and in what ways has ed-tech been used?
3. What factors have facilitated or acted as barriers to the development and implementation of ed-tech PPIs within each region?
4. How has the ed-tech landscape changed in these regions since the COVID-19 pandemic and what is the future of ed-tech in the light of those changes?

This paper is divided into five sections. The subsequent subsections introduce key insights about factors relevant for ed-tech uptake and implementation. Section 2 details

the methodological framework of this report including research methods, geographical selection, data collection, and scope. The third section discusses the relevance of ed-tech PPIs in each region. The fourth section is dedicated to the thematic analysis of priorities and uses of ed-tech in the regions, key factors facilitating and hindering development of ed-tech PPIs, and changes observed since the COVID-19 pandemic. The last section provides a conclusion and makes recommendations for shaping the future landscape of ed-tech in the regions and in LMICs more widely.

Primary and secondary school enrolment rates

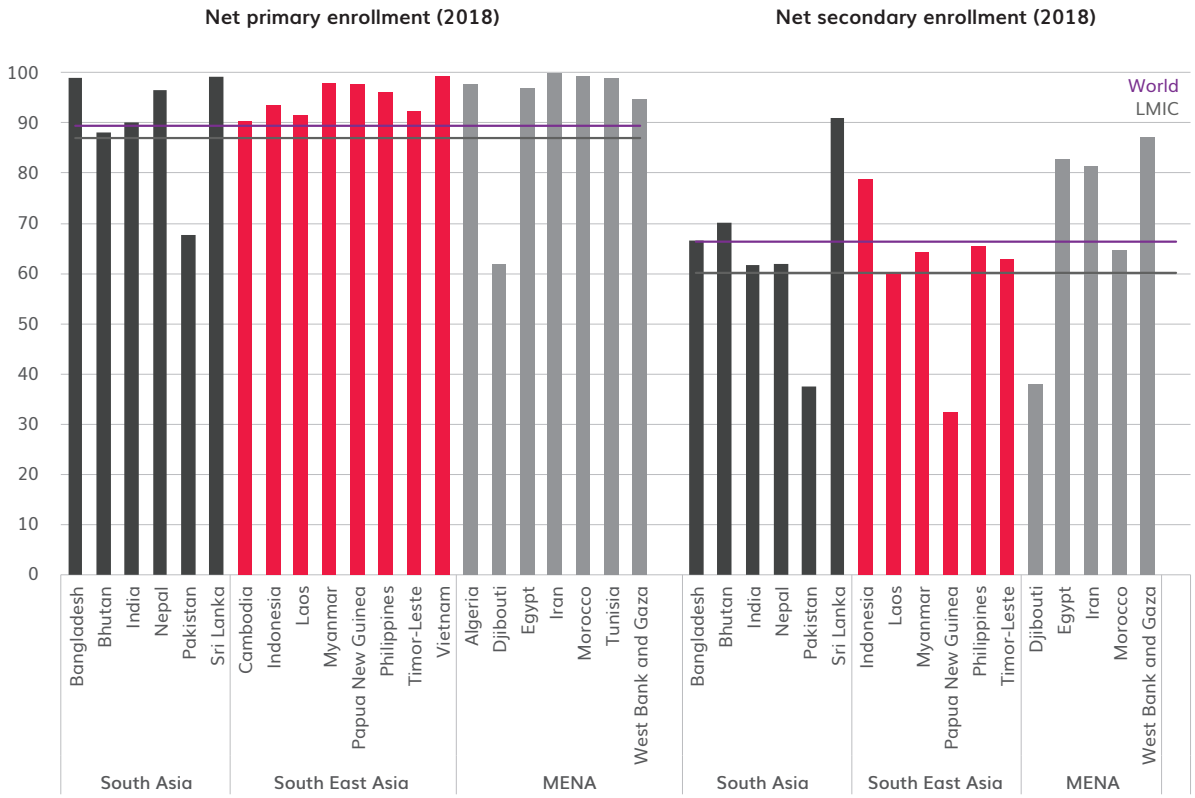
First, exploring the primary and secondary school enrolment rates in the regions becomes relevant, as this provides the context to which ed-tech PPIs are integrated and implemented. There is great variation in learning opportunities, out-of-school rates and GPI levels in relation to primary and secondary education enrolment both within and among regions.

Net primary school enrolment rates average between 90% to 95% in all three regions (The World Bank, 2023). Specifically in LMICs, average net primary enrolment rates are also higher than the world average (89%) and the overall LMICs average (87%), with rates of 90% in SA, 95% in SEA, and 93% in MENA (The World Bank, 2023). However, there are disparities within and across the regions. For example, Sri Lanka has reached a nearly complete (99%) primary school enrolment rate, while Pakistan reports a rate of 68% –the lowest rate in SA. Within SEA, all LMICs are performing above the world average and the LMIC average, with enrolment rates higher than 90%. In the MENA region, all countries have enrolment rates higher than the world average (89%) and the overall LMICs average (87%), except for Djibouti (62%) (Figure 1).

Net secondary school enrolment rates in the three regions are lower, averaging 65% in SA, 61% in SEA and 71% in MENA (World Bank Data, 2018). Except for Pakistan, secondary school enrolment rates in SA are better than the LMIC average (60%), but lower than the world average (66%) (Figure 1). As with primary enrolment rates, Sri Lanka has the highest secondary school enrolment rate (91%) whereas Pakistan has the lowest (37%). It is noteworthy that SEA has the highest average primary enrolment (95%) but the lowest average secondary enrolment rate (61%). Indonesia has reached around 79% in secondary school enrolment, while Papua New Guinea lags around 32%. MENA has the highest average secondary school enrolment rate (71%) among the three regions for the countries included in this study, but great variations are observed, with the highest rate at 87% in West Bank and Gaza, and the lowest at 38% in Djibouti.

Lower secondary school enrolment rates indicate higher levels of out-of-school children, specially in secondary education in the regions. Average out-of-school rates for upper secondary schools are 17 percentage points higher than for lower secondary schools in SA (29%) and MENA (25%), and 19 percentage points higher in SEA (31%) (UNICEF, 2022). Pakistan, Bhutan, and Bangladesh from SA, and Cambodia, Laos, and Myanmar from SEA have the highest out-of-schools rates for both upper and lower secondary education, exceeding the world average of 13% (UNICEF, 2022). The MENA region appears to have relatively lower out-of-school rates compared to SA and SEA, remaining below the world average (UNICEF, 2022).0

Figure 1. Net primary and secondary enrolment rates

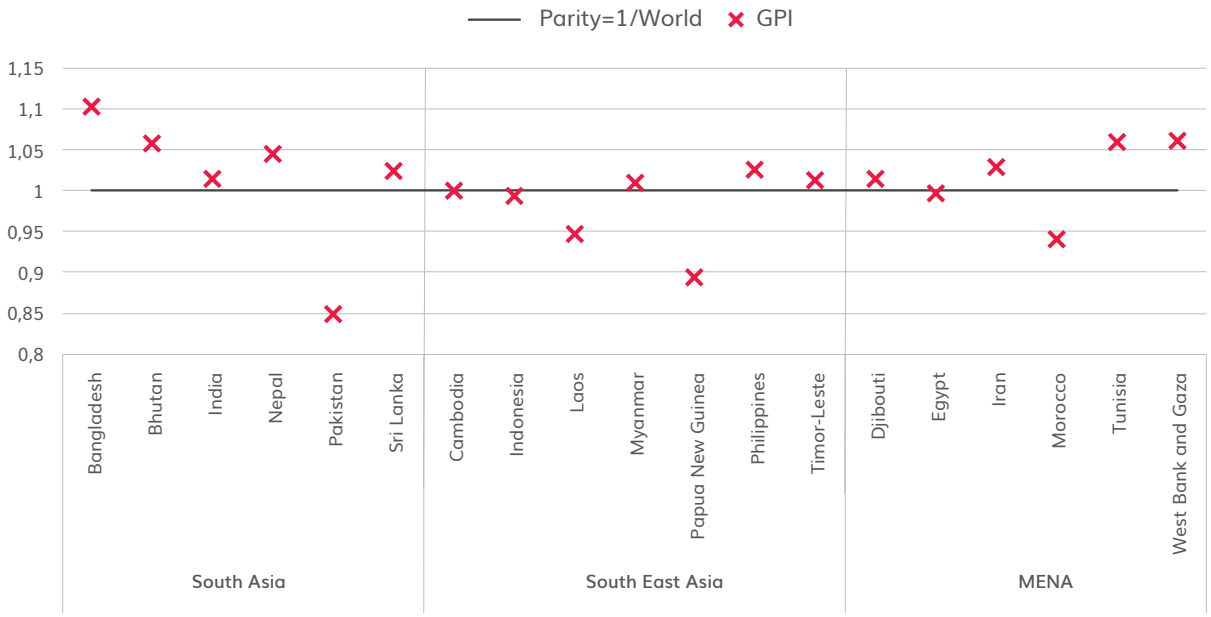


Note. Elaborated by the authors based on the The World Bank, World Development Indicators (2018, 2023). No data is available for primary enrolment rates for Lebanon in the MENA region. Cambodia and Vietnam in SEA and Lebanon and Tunisia in MENA are not considered in calculating the secondary enrolment rates due to the low availability of data. Net secondary enrolment rates for India, Papua New Guinea, Philippines, Djibouti, and Iran are prior to 2018 due to the lack of data for 2018.

Gender disparities in learning opportunities are also evident between and within the three regions through the Gender Parity Indexes (GPI) for primary and secondary

enrolment.[1] GPI in most countries is at parity, closer to parity, or more advantageous for girls, with a few exceptions, especially in SEA (Figure 2). Both in SA and MENA, girls are more advantaged than boys in most countries, except for Pakistan and Morocco, respectively. In SEA, girls are more disadvantaged in Indonesia, Papua New Guinea, and Laos, whereas boys are more disadvantaged in Myanmar, the Philippines, and Timor-Leste. Cambodia appears to have gender parity in primary and secondary enrolment.

Figure 2. Gender Parity Index (GPI) – Primary and secondary school enrolment



Note. Elaborated by the authors based on the World Bank Data (2018). A GPI of less than 1 suggests girls are more disadvantaged than boys in learning opportunities and a GPI of greater than 1 suggests the other way around. The world GPI is at parity (GPI of 1) and the LMIC GPI is at 0.99. No data is available for Vietnam in the Southeast Asian region and Algeria and Lebanon in the MENA region. 2018 data is not available for Nepal (2019), Cambodia (2020), Iran (2020), and Tunisia (2016). For these countries, data available for the closest year is used.

Internet and mobile phone penetration rates

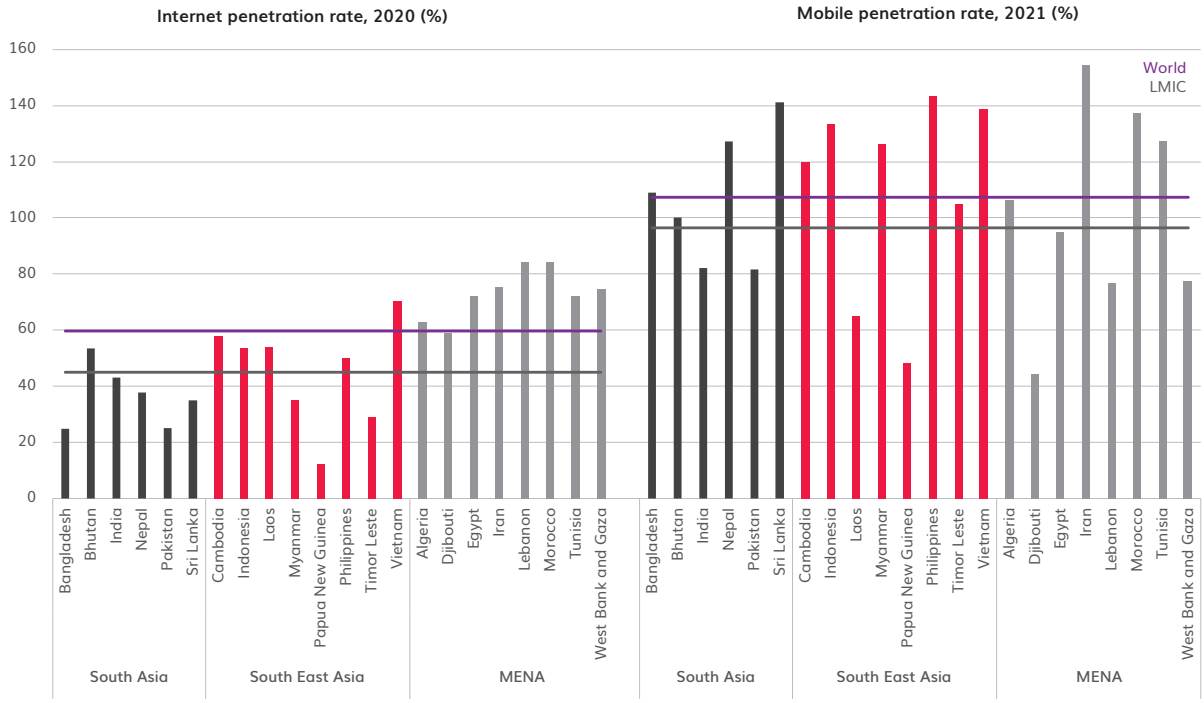
Internet penetration[2] is an enabler in the uptake and implementation of ed-tech as it provides a platform for key stakeholders to access and utilise PPIs. Data shows that

1 Gender Parity Index (GPI) for gross enrolment in primary and secondary education measures the ratio of female to male gross enrollment in primary and secondary education.

2 Internet penetration captures the percentage of the population using the internet.

average internet penetration rates vary between 36% in SA, 45% in SEA and 73% in MENA (The World Bank Data, 2020a). The lowest average internet penetration rate is seen in South Asia (37%), where only Bhutan has a higher internet penetration rate than the LMIC average of 45% (Figure 3). SEA's average internet penetration is on par with the LMIC average (45%) but lower than the world average (60%). Within SEA, all countries but Vietnam (70%) have rates below the world average of 60%. In MENA, Djibouti nearly reaches the world's average of 60%, with a 59% internet penetration rate, whilst all remaining countries have higher rates.

Figure 3. Internet and mobile penetration rates



Note. Elaborated by the authors based on The World Bank Data (2020, 2021a).

Mobile phone penetration rates[3] are significantly higher than internet penetration rates (higher than 100 per cent) (Figure 3). All regions have average mobile penetration rates that are higher than the overall average for LMICs (97%), and nearly half of the countries included in this study (10 out of 22) have rates above the world's average (107%). SEA has the highest average mobile penetration rate at 110%, SA has a rate of 106%, while the MENA region has the lowest rate at 102% despite its very high

3 Mobile penetration rates capture mobile phone subscriptions per 100 people.

internet penetration. All the LMICs in SEA, except for Papua New Guinea and Laos, have mobile penetration rates higher than (or closer to) the world average. Similarly, in SA, all countries except for India (82%) and Pakistan (82%) have mobile penetration rates higher than (or closer to) the world average at 107%. In MENA, mobile penetration rates widely vary, with Iran having the highest rate among all countries studied (155%), while Djibouti lags with 44%.

COVID-19 pandemic

With the COVID-19 pandemic and the consequent school closures, there was a need for distance learning using ed-tech. As evidenced later in this study, this gave rise to new ed-tech PPIs in the three regions in addition to an expansion of the coverage of existing PPIs in terms of beneficiaries and content. During school closures, ed-tech played a vital role in facilitating the continuation of students' education especially through programmes that promoted self-led learning among students through online platforms, learning management systems, educational apps and tv channels.

An evident impact of the COVID-19 pandemic, as identified through this study, is the accelerated use of ed-tech in the three regions. Many of the stakeholders surveyed have observed a rise in the number of ed-tech users. Moreover, the pandemic contributed to a shift in perceptions regarding educational technology. Both the public and stakeholders are now increasingly recognizing the role of ed-tech in enhancing the resilience of education systems. Additionally, there is a growing awareness of the advantages associated with integrating technology into both the learning and teaching processes.

Methodology

Research design and methods

This paper was undertaken using a mixed-methods research design. First, a list of countries was created based on geographical scope, income classification and indicators related to ed-tech enablers and barriers. Second, a desk review was conducted to identify a preliminary list of ed-tech PPIs in the regions since 2010. Out of this list, eighteen PPIs were selected for an in-depth analysis, additionally informed by key stakeholder interviews from across the regions. The research questions were addressed through a deductive reasoning approach and analysed thematically.

Region and country selection

The study focuses on LMICs due to the lack of literature on ed-tech in these countries, the high potential for improvement in educational outcomes using ed-tech, and the relatively higher access to technology in LMICs compared to LICs. Nine LMICs were selected to conduct the study, with a specific focus on eighteen case studies, as detailed below.

The first criterion for country selection was geographical representation. Within the three regions, focus was directed towards GDP Per Capita in identifying LMICs as defined by the World Bank's income classification (See Table 1). Next, secondary school enrolment rates were considered to capture the diversity of education performance across the region. Primary education was not included as a criterion since primary enrolment rates are relatively similar across the three subregions and have better performance compared to secondary enrolment. Thirdly, levels of internet and mobile penetration rates were assessed to capture the potential of incorporating technology in education. Lastly, the Government Effectiveness Percentile Rank[4] was considered in the context of each country.

Through investing in infrastructure and teacher training, ed-tech has the potential to grow in the Asian and MENA region and enhance learning outcomes.

These indicators play a vital role in facilitating or hindering ed-tech. Correspondingly, depending on the performance of these indicators, they may be ed-tech enablers or barriers. For instance, countries having high internet penetration and high government effectiveness may have a higher potential to implement ed-tech policies and incorporate ed-tech in their education system, while countries having low internet penetration and government effectiveness are likely to have a lower potential.

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4 The World Bank's measurement of Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Percentile rank indicates the country's rank among all countries covered by the aggregate indicator, with 0 corresponding to lowest rank, and 100 to highest rank. Percentile ranks have been adjusted to correct for changes over time in the composition of the countries covered by the World Bank Worldwide Governance Indicators (WGI).

These criteria were considered to demonstrate the depth and variation in ed-tech PPIs that exist in the three subregions, as well as to examine the influencing factors that have resulted in prioritising certain PPIs. Based on these criteria, India, Pakistan and Sri Lanka were selected in SA; Cambodia, Indonesia and Vietnam in SEA; and Egypt, Palestine and Tunisia in the MENA region, as highlighted in blue in Table 1.

Table 1. Indicators for country selection

Region / Country	GDP Per Capita (2021)	World Bank Income Classification	Gross Secondary School Enrolment (%)	Internet Penetration Rate (%) (2021)	Mobile Penetration Rate (%) (2021)	Government Effectiveness Percentile Rank (2021)
South Asia						
Bangladesh	$2,458	LMIC	70	39	109	28
Bhutan	$3,266	LMIC	91	86	100	74
India	$2,238	LMIC	78	46	82	61
Nepal	$1,229	LMIC	84	52	127	16
Pakistan	$1,505	LMIC	42	21	82	36
Sri Lanka	$3,994	LMIC	91	44	141	49
Southeast Asia						
Cambodia	$1,625	LMIC	58	60	120	34
Indonesia	$4,334	LMIC	99	62	134	65
Laos	$2,536	LMIC	60	62	65	31
Myanmar	$1,211	LMIC	76	44	126	8
Papua New Guinea	$2,645	LMIC	44	32	48	17
Philippines	$3,461	LMIC	87	53	143	56
Timor Leste	$2,741	LMIC	85	39	105	25
Vietnam	$3,756	LMIC	96	74	139	60
MENA						
Algeria	$3,700	LMIC	103	71	106	29
Djibouti	$3,050	LMIC	43	69	44	19
Egypt	$3,887	LMIC	86	72	95	35
Iran	$4,084	LMIC	87	79	155	17

Lebanon	$4,136	LMIC	N/A	87	77	10
Morocco	$3,795	LMIC	82	88	138	45
Tunisia	$3,807	LMIC	91	79	128	44
Palestine (West Bank and Gaza)	$3,679	LMIC	90	82	78	21

Note. The countries of specific focus in each region are highlighted in blue. Elaborated by the authors based on the latest available data on the World Development Indicators (WDI) by The World Bank (2021b).

These countries were selected in an attempt to capture diversity cross-regionally and inter-regionally in analysis. They include low performing, average performing and high performing countries in relation to the specified criterion. Sri Lanka is the most developed LMIC in SA, with close to universal secondary school enrolment, the highest mobile penetration rate (141%), and a relatively average internet penetration rate (44%). Contrastingly, Pakistan is one of the least developed countries in the region in terms of GDP per capita. It also has the lowest rates in the region for secondary enrolment (42%), internet penetration (21%), and mobile phone penetration (82%). India is more developed than Pakistan but less developed than Sri Lanka in terms of GDP per capita income. India's rate for secondary enrolment is 78%, internet penetration is 46%, and mobile penetration 82%. In terms of perceived government effectiveness, India has a relatively high rank, followed by Sri Lanka, while Pakistan has a relatively lower rank.

SEA is an emerging growth hotspot particularly in the realm of technology industries. The region is witnessing a surge in technological innovation, attracting significant investments (Wright, 2021). Indonesia is the largest economy in the region, and the most developed LMIC, while Cambodia is one of the least developed LMICs with lower levels of internet penetration (60%), mobile penetration (120%), and secondary school enrolment rates (58%). Vietnam is a well-developed LMIC with a very high level of internet penetration (74%) and mobile penetration (139%). Indonesia and Vietnam have a relatively high rank in government effectiveness, while Cambodia has a very low rank.

Since LMICs in MENA had similar internet penetration and secondary school enrolment rates, a different selection criterion was employed to support the selection. One Francophone nation, Tunisia, was selected with the aim of accounting for the French colonial legacies in the region. On its part, Palestine was selected given its complex socio-political history and the lack of literature on the state of ed-tech in Palestine. Egypt was included as the third country for close analysis in this report.

Desk review

A desk review of national and regional ed-tech PPIs in the selected nine countries was conducted through searching policy documents, unpublished research papers, programme evaluations, and websites. This resulted in a preliminary list of 123 ed-tech PPIs carried out from 2010 onwards. The list included a brief description, scope, country, main stakeholders, target population, and beneficiaries for each PPI. These were categorised according to their overall aims, applications, and types, as shown in Table 2.

Table 2. Aims, applications, and types of ed-tech

Aims	Applications	Types
a. Improving learning outcomes (SDG4) b. Responding to groups with different educational needs and improving access for more vulnerable groups (i.e., girls, children with disabilities, children from rural areas etc.) c. Enhancing the resilience and responsiveness of education systems d. Contributing to other sustainability goals (other than SDG 4) including SDG 10 on reducing inequalities.	a. Supporting education in schools b. Providing non-formal education c. Supporting teacher pre-service and in-service education enhancement d. Supporting school management systems e. Technology-enabled behavioural interventions f. Facilitating self-led learning programmes.	a. Improving access to hardware b. Improving the development of software c. Investments in the environment for Ed-tech to be utilised.

Note. Elaborated by the authors based on Colás-Bravo (2019), Haßler et al. (2020), Khan et al. (2012), Rodriguez-Segura (2022), Sanyal (2001) and Global Education Monitoring Report Team (2021)

Out of the initial list, a total of eighteen programmes, two per country, were selected for in-depth analysis. The chosen PPIs were restricted to those that were concretely implemented, as the initial list included regulations and project proposals on ed-tech that were not initiated. Selected PPIs were also limited to those that targeted children aged 6-18 in primary and secondary education.

Case studies

Two programmes from each of the nine countries were chosen for deeper analysis through key informant interviews. One initiative with wide coverage, usually implemented in collaboration with the relevant Ministry of Education; and one considered innovative for its differences with mainstream programmes in the country. The table below outlines the selected programmes for analysis.

Table 3. Case studies for analysis

Region	Country	Programmes/ Case Studies	Target group	Lead implementer (public/private/collaboration)
South Asia	India	Class Saathi	Primary and secondary schools. Focus on rural areas.	Private ed-tech company
		OLabs	Upper-secondary school (Grades 9 to 12).	Public-private partnership
	Pakistan	Teletaleem	Primary, secondary, tertiary, and technical education.	Private tech organisation, in collaboration with others from the private and public sectors
		WonderTree	Special needs children (Autism, Down Syndrome, Global Development Delay).	Private tech startup, in collaboration with international organisations, NGOs, private sector, and public sector
	Sri Lanka	Akura	Public, private, and international schools, including school administration staff	Private software company
		Nenasa	Primary and secondary schools. Focus on rural areas.	Public-private partnership
Southeast Asia	Cambodia	Basic Education Equivalency Programme (BEEP)	Youth aged 14 and above, particularly school dropouts	Public sector and international organisations
		Tesdopi	Secondary	Private startup
	Indonesia	SEAMOLEC Regional Open Learning Centre	Teachers in ASEAN countries, primarily Indonesia.	Regional organisation governed by the Southeast Asian Ministers of Education Organization - SEAMEO
		Ruangguru	Primary, secondary, college, vocational, corporates	Private ed-tech company
	Vietnam	FPT Education	Primary, secondary, university	Private tech company
		Marathon Education	Primary, secondary	Private ed-tech startup
MENA	Egypt	Egyptian Knowledge Bank Study Portal	Elementary, primary, secondary, tertiary, researchers	Public-private partnership
		Madrasty	Primary, secondary	Private venture
	Palestine	The UNRWA E-learning Platform	Palestine refugee students	International Organisation
		The E-learning Curriculum in Palestinian Primary and Secondary Education	Primary and secondary schools	Public-private partnership
	Tunisia	EDUNET 10	Primary and secondary schools	Public-private partnership
		Sghartoon	Children with dyslexia (aged 5-8)	Private ed-tech startup with collaborators from the public sector

Note. Elaborated by the authors.

Interviews

Once case studies were selected, key informant interviews were conducted with stakeholders using a semi-structured format, enabling flexibility to delve deeper into certain areas depending on the responses given by the interviewees. These stakeholders were identified through the selected 18 ed-tech programmes (case studies). A combination of in person and online interviews were conducted. Overall, twenty-five stakeholders were interviewed, including key government and private sector personnel, co-founders of ed-tech startups, as well as organisations who partner with the government for ed-tech projects (Table 4).

Table 4. Number of interviews per country

Region	Country	Number of interviews		
		Public sector	Private sector	NGO/International organisation/ Regional organisation
South Asia	Sri Lanka	2	4	0
MENA	Tunisia	3	1	1
	Egypt	1	2	1
	Palestine	1	0	1
Southeast Asia	Indonesia	0	1	4
	Vietnam	0	1	0
	Cambodia	0	1	1

Note. No interviews were conducted for Pakistan and India due to limited professional connections in said countries. Information for the case studies in these two countries were collected through available information in their official websites. Elaborated by the authors.

Thematic analysis

The information collected from the case studies was coded and analysed using the NVivo qualitative data analysis software. For each research question, common themes were identified using a deductive reasoning approach. These sets of codes were expanded based on information arising from the case studies and interviews (See Annex 1).

The importance of ed-tech was assessed based on the PPIs' contribution towards the achievement of Sustainable Development Goal 4 (SDG 4), reducing gaps in access to education for vulnerable groups, reducing the digital divide, solving limited infrastructure

issues, improving the efficiency of education systems, and connecting key stakeholders (students, teachers, parents, administrators).

The facilitating factors of ed-tech PPIs were assessed by looking at key stakeholders and institutions that support the development and implementation of ed-tech in the regions. These included the roles of governments, the private sector, donors, and cross-sectoral collaborations. The factors that hamper the development and implementation of ed-tech were assessed both in terms of supply-side barriers faced by ed-tech implementers and demand-side barriers faced by ed-tech users.

Changes to the ed-tech landscape since the COVID-19 pandemic were assessed by looking at the coverage and offerings of ed-tech for beneficiaries; changes to support mechanisms such as the role of government, policy priorities and funding; changes in attitudes; and challenges and opportunities faced by ed-tech providers in expanding the use of ed-tech since the pandemic.

Limitations

To account for changes in the ed-tech environment influenced by the pandemic, there is a stronger focus on more recent studies on use of ed-tech. Furthermore, some documents, especially local government reports, were available in local languages only. Therefore, there is a bias in this report as the PPIs analysed are restricted to available literature in English. Every effort was taken to locate literature focusing on the countries listed in the sample. No key informant interviews were undertaken for the selected four programs in India and Pakistan due to restricted professional networking in these two countries.

The relevance of ed-tech in Asia and MENA

Ed-tech PPIs have been important in the three subregions under study. Asia's rapid population and economic growth is creating an increasing demand for quality education, and ed-tech plays a vital role in meeting this demand. In the MENA region, ed-tech has been particularly important to bridge the gap in education for conflict affected children, as highlighted later in this report. The following subsections show that interest in the use of ed-tech to improve learning has been present in countries of the three regions prior to the COVID-19 pandemic. National governments have either on their own, or in collaboration with other countries, launched PPIs to promote the uptake of, and opportunities for, integrating ed-tech into mainstream education.

South Asia

The desk review showed that SA has a long history of national-level ed-tech policies, which were intensified during the COVID-19 pandemic. The government of Sri Lanka, for instance, has introduced several initiatives to incorporate ed-tech into the education system. Under the "Government Digitalizations Initiative 2016-2019", the Information and Communication Technology Agency (ICTA), in collaboration with the Ministry of Education, implemented several projects aimed at developing digital classrooms in government schools, training teachers, establishing digital libraries, developing accreditation frameworks, and establishing interactive networks among stakeholders (Information and Communication Technology Agency, n.d.). These initiatives show that importance is being placed upon the integration of ed-tech within mainstream schooling, showing promising prospects for the future of ed-tech in the country.

> **Facilitating the achievement of SDG 4 and reducing gaps in access to education for vulnerable groups are important goals related to ed-tech in South Asia.**

The Sri Lankan government is also undertaking concerted measures to intensify ed-tech initiatives by improving infrastructure and supporting student learning and teacher capacities. The "National Education Policy Framework (2020-2030)", formulated by the National Education Commission (NEC), recognises that all schools, irrespective of geographical location and number of students, must be provided with technological facilities. It recommends that authorities be equipped to handle all ICT related matters and facilitate its use in the General Education system (National Education Commission, 2022).

An ongoing plan of the Ministry of Education is the "General Education Sector Development Plan (2020-2025)". One of its priorities is to improve and promote digital-based teaching and learning to create a culture that encourages self-learning and innovation through digital technology (Ministry of Education, 2020). This project comprises the establishment of e-libraries, e-textbooks, and smart classrooms; the development of ICT facilities and WI-FI zones in schools; introducing ICT as a subject from grade six onwards; conducting e-learning and digital learning training programmes for education officers, teachers, and principals; providing educators with areas to develop

and upload online materials; and, introducing national-wide virtual classroom programmes (Ministry of Education, 2020).

In addition, the Ministry of Education initiated in 2020 the "E-Thaksalawa" programme, which is the official Learning Management System (LMS) of the General Education system in the country. This platform provides content in five key areas: learning, activities and tasks, means and resources, interactivity, and assessment; and is the largest Massive Open Online Course (MOOC) platform for education in Sri Lanka (E-thaksalawa, n.d.). During the same year, the Ministry of Education also formulated a "Contingency Emergency Response Plan (CERP)" for the Education sector to minimise disruptions resulting from the COVID-19 pandemic (Ministry of Education, 2020). This plan incorporated components to respond to disruptions during and post- COVID-19 for the entire state school education system.

Similarly, the Pakistani government has taken steps to enhance the implementation of ed-tech PPIs across the national school system. The Ministry of Information Technology and Telecommunication (MoITT) has attempted to create an enabling environment for the use of ed-tech in the country (Baloch & Taddese, 2020). Two resulting policies are the "National Information and Communication Technology (NICT) Strategy for Education in Pakistan (2004–05)", and the "Digital Pakistan Policy (2018)". The latter and more recent promote ed-tech through initiating projects to provide network accessibility at educational institutes across Pakistan, therefore improving national internet penetration rates (MoITT, 2018). These also support the development of e-portals to use academic texts, research materials, and other supplementary resources for schools, colleges, and universities across the country (MoITT, 2018).

In addition to the national-level policies in Pakistan, there are also ed-tech policies targeting specific provinces. For instance, the "School Education Sector Plan and Roadmap for Sindh province (2019-2024)", formulated by the School Education and Literacy Department of the Government of Sindh, focuses on several aspects of ed-tech (Government of Sindh, n.d.). This includes the digitalisation of educational materials and assessment methods in public schools which can enable both students and teachers to use technology to enhance e-learning results, support setting up an e-assessment system, and a way to collaborate with organisations that specialise in ed-tech. This collaboration system aims to make content more age-appropriate and accessible for students, particularly for those in rural areas (Government of Sindh, n.d.).

Similarly, the "Punjab IT Policy (2018)", implemented by the local government, targets the introduction of ICT into the school curriculum, the provision of interactive education to school students through computers and e-learning programmes, intensive computer

training for teachers in all government schools, and the establishment of distance education programmes, including participation in global learning and education networks (Government of Punjab, n.d.). The proliferation of provincial as well as national ed-tech initiatives in Pakistan demonstrates a strong recognition of the importance of digital learning to improve student outcomes.

There are also government initiatives targeting specific student groups, such as the "ICT for Girls Programme" initiated in 2015 by the MoITT (EQUALS Global Partnership, n.d.). The programme aims to provide annual training to 10,000 girls from disadvantaged backgrounds on foundational ICT knowledge and coding skills, based on 'the four Cs': Critical thinking, Communication, Collaboration, and Creativity. Under the second phase of this programme, 226 schools in Islamabad were equipped with ICT labs, accompanied by the training of 202 teachers through Microsoft's Train the Trainer programme in 21st Century Super Skills.css. The initiative's primary goal is to ensure that more than 110,000 girls in Islamabad attain computer literacy skills that are on par with global standards. Partners of this programme are the Federal Directorate of Education, Pakistan Bait ul Mal (PBM), the Universal Service Company (USF Co) and Microsoft.

The government of Pakistan also initiated additional ed-tech programmes as a response to the COVID-19 pandemic, such as Radio School, TaleemGhar in Punjab, and the e-taleem portal. These programmes utilise online websites and radio broadcasts to provide educational content to students. The latest undertaking in Pakistan's ed-tech portfolio at the national level is the Ministry of Federal Education and Professional Training (MoFEPT)'s TeleSchool mobile app (Sheikh & Nadeem, 2023). This TeleSchool mobile app targets kindergarten up to grade 12 and aims to revolutionise formal education in Pakistan through digital technologies, reflecting the government's commitment to foster innovation in the education sector. The above programmes demonstrate that the Pakistani government is prioritising mainstreaming ed-tech throughout the country in order to meet educational objectives, and the efforts were intensified due to the COVID-19 pandemic.

In India, as with Sri Lanka and Pakistan, research shows a history of promotion of ed-tech use and integration into education systems. India's "National Policy on Education 1986", modified in 1992, emphasises the importance of using ed-tech to improve access to, quality, and the governance of education (Rao & Prasad, n.d.). Two central government schemes known as the "CLASS (Computer Literacy and Studies in Classrooms)" and the "Educational Technology (ET)" emerged through this policy (Bhattacharya et al., 2023). By combining these two in 2004, the government of India introduced the "ICT in Schools" programme, which offers secondary school students an opportunity to improve their technology skills and engage in computer-assisted learning (Rao & Prasad, n.d.).

The programme aims at narrowing the digital divide among students from diverse socio-economic backgrounds and geographical locations (Ministry of education of India, n.d.). It focuses on providing computer-aided education, the establishment of smart schools, teacher capacity enhancement, and development of e-content (Ministry of education of India, n.d.).

In parallel, "The National Curriculum Framework (NCF) 2005" of India recognises the importance of ed-tech while underlining the teacher's role in the classroom. It emphasises the student's active involvement in their own learning and recommends that educational technology interventions should encourage two-way interaction instead of one-way reception (Bhattacharya et al., 2023). This shows that ed-tech initiatives in India have sought to build on positive rapport between teacher and student, and encourage students to actively participate in their own learning experience.

Additionally, the National Policy on "ICT in School Education", formulated in 2012, aims to improve ed-tech activities and processes that would contribute to the access, quality, and efficiency in the school system (Ministry of Human Resource Development, 2012). Some components under this policy are ICT for literacy and competency enhancement, teaching–learning processes, supporting educational opportunities for children with disabilities, open and distance learning, school management and ICT infrastructure (Ministry of Human Resource Development, 2012). This shows that the Indian government is prioritising the improvement of ed-tech infrastructure and considering diverse forms of technology in order to support students with different abilities and to increase opportunities available to them.

Moreover, under the new "National Education Policy (NEP), 2020" of the Ministry of Human Resource Development, the integration of technology into education is planned to occur through enhanced digital textbooks, high-quality electronic educational resources for capacity building of teachers and students, and educational software made available for students and teachers of all levels (Ministry of Human Resource Development, 2020). Importantly, the NEP explores the different uses of educational apps and gamification for language acquisition, adaptive assessments for monitoring student progress, personalised learning software, and technology for enhancing teacher skills (Ministry of Human Resource Development, 2020). Additionally, the NEP aims to create a National Educational Technology Forum to offer educational leaders, governments, and other stakeholders access to the latest knowledge and research, along with the opportunity to seek advice and exchange best practices (Bhattacharya et al., 2023). This shows the wide scope of the NEP and how ed-tech is planned to be used as all-encompassing and for different purposes in India.

Lastly, some of the NEP's priorities have reached fruition through government-sanctioned private endeavours, such as the BYJU's online learning programme. BYJU's offers a variety of educational videos on mathematics, science, social studies, and English with the purpose of improving teaching-learning processes (BYJU's, n.d.; Jha & Jha, 2022). The videos also feature a variety of teaching methods including animations, simulations, and interactive exercises (BYJU's, n.d.). For teachers, there are a range of educational videos designed to help them improve their teaching skills and create more effective learning experiences, covering lesson planning, classroom management, and assessment (BYJU's, n.d.). The main purpose of the BYJU initiative is to provide critical support to traditional education institutions to transition to online teaching-learning modes (BYJU's, n.d.). The initiative has enabled any learner with a smartphone and stable internet connection to gain and strengthen knowledge and skills in a different environment.

In addition to these policies, there are also technology-based education platforms initiated by the government of India, such as the Digital Infrastructure for Knowledge Sharing (DIKSHA) portal and mobile app, and the Study Webs of Active Learning for Young Aspiring Minds (SWAYAM). The NEP and other recent policies illustrate the ongoing importance placed on ed-tech by the Indian government to facilitate improved learning outcomes for students across the country.

Selected countries in SA have placed a growing importance both on improving ed-tech opportunities and initiatives available for students and teachers nationally, and on developing country-wide policies to facilitate the uptake and implementation of technology to improve learning outcomes.

Southeast Asia

There is evidence of ed-tech PPIs at the regional and national levels in SEA. Stakeholders in the selected countries have shown a keen interest in supporting and improving their educational systems through ed-tech.

At the regional level, the strategic plan of the Southeast Asian Ministers of Education Organizations (SEAMEO)[5] for 2021-2030, targets improving regional cooperation, sharing best practices, and contributing toward educational and human resource development in the region. The Smart School Programme SEAMEO 4.0 (2021- 2030) aims to improve

5 The SEAMEO is a regional intergovernmental organisation established in 1965, with the aim of promoting regional cooperation in education, science, and culture (SEAMEO, n.d.). SEAMEO includes eleven member countries from SEA, nine associate member countries from the region and several affiliated organisations.

access to education by introducing technology into the classroom (SEAMEO, n.d.). This initiative emphasises the use of digital technologies and artificial intelligence to create a more innovative, inclusive, and future-ready education system in the region. The "4.0" in its name refers to developing skills for the 4th Industrial Revolution (SEAMEO, n.d.). It is notable that this collaboration focuses on the integration of ed-tech in the classroom and how it is attempting to systematise the use of ed-tech regionally, as it shows the possibility to be scaled-up and mainstreamed in the future.

In addition, the selected countries in the region have developed and implemented national ed-tech policies. The Ministry of Education and Culture in Indonesia has developed a strategic plan and roadmap for 2021-2025 to incorporate technology into education that includes the allocation of 2.5 trillion IDR (approximately 173 million USD) for the development of ed-tech and digital literacy programmes (Ministry of Finance Republic of Indonesia, 2021). The ed-tech roadmap (2021-2025) lays out a strategic plan for integrating technology into Indonesian education, with goals to enhance digital infrastructure, content, and literacy while promoting various ed-tech platforms (Desouza, 2023).

Moreover, the Ministry of Religious Affairs (MORA) ed-tech partnership (2020) seeks to enhance religious education quality by collaborating with ed-tech companies to provide resources and support to religious institutions through the MORA Ed-tech Partnership 2020 (Suriastini et al., 2020). This shows that the Indonesian government is investing substantial funds and resources into the infrastructure and development of PPIs, which will, in the long term, contribute to the sustainability and increased uptake of ed-tech in the country.

Cambodia has also taken steps to implement ed-tech PPIs to improve educational outcomes in recent years. The government has spent nearly 1.8 million USD through the "Education Management Information System" (EMIS) Master Plan 2014-2018, aimed at improving access to quality education for children at all levels of schooling (Ministry of Education, Youth and Sports, 2014). This strategy includes training and tools to improve the availability of information for better planning and administration of education services (Ministry of Education, Youth and Sports, 2014). The EMIS Master Plan also aims to strengthen data-driven decision-making in education. It has been designed to gather, process, and analyse information on schools, teachers, and students to help decision-makers identify gaps, allocate resources effectively, and track progress (Ministry of Education, Youth and Sports, 2014). By enhancing data collection and application, the government aimed to address education challenges and improve the overall quality of education.

In addition, the "Policy Guidelines for New Generation Schools (For Basic Education in Cambodia)" aims to transform selected schools through the use of modern technology in the classrooms, called New Generation Schools (NGS) (Ministry of Education, Youth and Sports, 2016). The NGS model strives to deliver high-quality education by adopting innovation and technology, fostering student-centred learning, and nurturing a culture of continuous improvement (Ministry of Education, Youth and Sports, 2016). By implementing these guidelines, the Cambodian government hopes to establish schools that can serve as examples of best practices and stimulate widespread reforms across the education sector (Ministry of Education, Youth and Sports, 2016).

Furthemore, the government of Cambodia launched in 2018 the "Policy and Strategy on Information and Communication Technology in Education" to improve teaching, learning and administrative processes (Ministry of Education, Youth and Sports, 2018). It promotes the use of technology to facilitate student-centred learning, encourages digital literacy, and prepares students to be part of a technologically advanced workforce. The policy also highlights the necessity of offering teacher training and support to guarantee the successful implementation of ed-tech Ministry of Education, Youth and Sports, 2018). The different policies initiated in Cambodia illustrate a similar situation as in Indonesia, as prioritisation is being given to increasing the use of ed-tech in nationwide policies and mainstreamed into formal education.

> **"The region recognises the importance of digital literacy and are working to provide training and resources for students and teachers to become proficient technology users.**

In the case of Vietnam, the Ministry of Education and Training (MoET) focused on improving quality education and training from 2016-2020, by strengthening the use of ICT in order to manage and support teaching and learning activities and scientific research (Ministry of Education and Training, 2017). In this context, the government implemented several policies and initiatives to promote the integration of ed-tech in teaching and learning, including the "Decision No. 117/QD-TTg" (Jan 2017), aimed at enhancing the use of technology in managing and supporting teaching-learning activities and scientific research; and the "Circular No. 21/2017/TT-BGDĐT" (Sep 2017) concerning ICT in training activities for teachers, staff, and managers working in educational institutions (Ministry of Education and Training, 2017).

Moreover, the government has been steadily increasing its investment in ed-tech, with plans to further boost funding in the future. According to the World Bank, Vietnam plans to increase its research and development investment to 1.5-2% of GDP by 2030, with a focus on innovation in digital technology and education (Cameron et al., 2019). As with Indonesia and Cambodia, Vietnam is prioritising the investment in ed-tech in order to contribute to long-term initiatives that will improve the quality of education and training.

MENA

The ed-tech PPIs in most countries in the MENA region date back to 2010, the earliest year for which data was gathered for this study. The selected countries have integrated ed-tech as a solution for improving access to quality education in their strategic programmes for the education sector. The use of ed-tech for improving access and quality of education is seen even in the conflict affected Palestine, mainly due to bilateral and multilateral donor assistance to bridge gaps in education.

Since 2006, the Tunisian Ministry of Education has integrated ed-tech as part of a national e-administration project designed to make the administration of education more open, more efficient, and accessible to citizens. This orientation was supported by the 2010-2014 e-strategy for developing e-government, which sought to transform administrative procedures and operating modes in relation to key factors such as IT infrastructure, the legal framework and IT security.

Additionally, "The National Strategy for ICT Integration in Education, 2010-2015" was initiated for the development of infrastructure, human resources and educational content, as well as to provide technological equipment and to promote the use of ICT in educational management (Association for the Development of Education in Africa, 2014). The programme was spearheaded by the Ministry of Education (MoE) and Centre National des Technologies en Education (CNTE) and ran in parallel the "Digital Schools Program", which was first started in 2014, and then reviewed in 2022. This programme focused on improving educational content for primary and secondary school children in the form of a digital toolkit (Orange Foundation, n.d.). As part of this programme, children are provided with tablets and access to servers, which enables students to obtain educational content without internet access. This is an initiative by the telecommunication company Orange in collaboration with the MoE and allows children who do not have internet access to continue to have access to educational materials (Orange Foundation, n.d.).

This was followed by the "Digital Solution for All" initiative, which is a component of the "Education Sector Strategic Plan 2016-2020" for Tunisia to improve the use of

ed-tech (European Training Foundation, 2020). The initiative aims to develop strategies to improve the use of ICT in the teaching-learning process in the country, as well as in the management and administration of education services (European Training Foundation, 2020). In parallel, Tunisia's EDUNET 10 (2021-2024) programme seeks to expand the connectivity of education institutions by providing them with access to the internet (CommsUpdate, 2023). This is a joint initiative by the MoE and the Ministry of Communication and Technologies and implemented with funding from the International Bank for Reconstruction and Development (IBRD), the Asian Development Bank (ADB), and the Tunisian government (CommsUpdate, 2023). These high-level stakeholders investing in ed-tech in Tunisia demonstrates the prioritisation being given to technology in order to better facilitate learning in the country for students.

In the case of Palestine, the Ministry of Telecommunications and Information Technology and the Ministry of Education & Higher Education oversee technology integration in education nationally. Digital education is a part of the education sector's strategic plan for 2017-2022 (Ministry of Education and Higher Education, 2017) and, in previous years, the Ministry of Education and Higher Education has received support from Belgium for e-learning from 2011-2015 to improve the use of technology in the teaching-learning processes in schools, expand modern equipment and the digitisation of education, as well as to strengthen teacher training (Medium, 2016; Belgian Development Agency, n.d.). This highlights the importance of technology in nationwide policies on education and the emphasis being increasingly placed on teacher training in the uptake of ed-tech.

Additionally, as part of the response plan to the COVID-19 pandemic, Palestine initiated the "Education Cluster Strategy" 2020-2021 implemented by the Partners for Sustainable Development (PSD) and UNICEF, with support from a consortium of donors including UN-agencies such as the UNRWA, UNICEF and United Nations Educational, Scientific and Cultural Organization [UNESCO] (Education Cluster & UNICEF, 2020). This initiative incorporated distance learning as a main objective under its COVID-19 response plan, aiming to provide children and parents with access to free online platforms, worksheets and lessons to ensure the continuation of learning (Education Cluster & UNICEF, 2020).

Egypt has also integrated the use of ed-tech within the "Education Strategic Plan, 2014-2030", which includes the use of technology and capacity building for innovation as one strategic component (Ministry of Education, n.d.). In line with the Education Strategic Plan, the "Education 2.0 Reforms" 2018-2030 aims for a full transformation of the education system, to promote skill-based and digital learning for primary and secondary school children (Moustafa et al., 2022). This policy targets the improvement of

digital learning for children from marginalised backgrounds and those with disabilities. Further, the Ministry of Education introduced ICT as a subject in schools with the objective of enhancing technological culture and fostering digital literacy skills among students through the "Ministerial Resolution No. 194 of 2020" (Global Education Monitoring Group, 2023). As with Tunisia and Palestine, Egypt has also placed importance on the use of ed-tech to improve learning opportunities for children, and it is through the systematisation of ed-tech PPIs that opportunities for the growth of ed-tech can be nurtured.

To conclude, the review of policies in the nine selected countries demonstrates early interest in employing ed-tech to enhance learning, even before the onset of the COVID-19 pandemic. National governments have initiated multiple PPIs to encourage the adoption and integration of ed-tech into education systems.

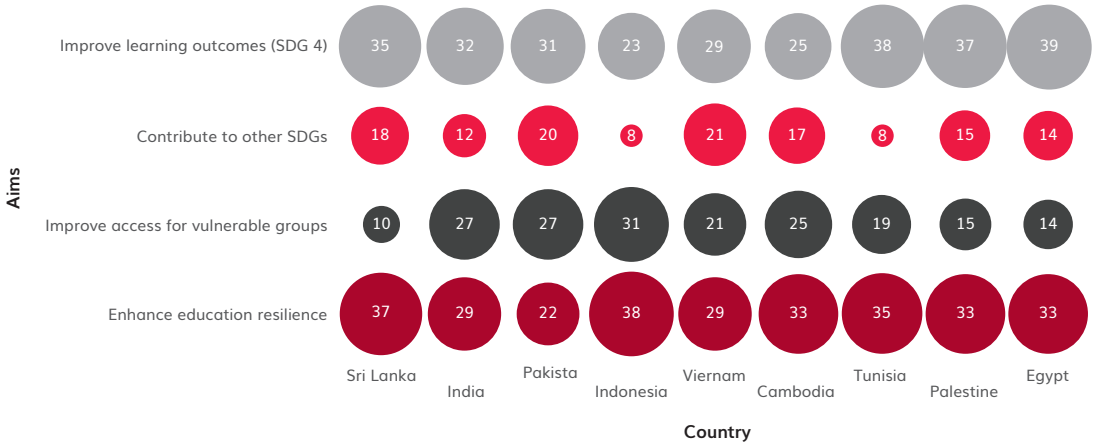
Analysis of the ed-tech landscape

Ed-tech aims, applications and types

An analysis of the 123 ed-tech PPIs found in the regions reveals that the most prevalent aims of ed-tech in the selected countries have been to improve learning outcomes, as related to SDG4, and to enhance the resilience and responsiveness of education systems in relation to disruptions (Figure 4). This is particularly relevant in relation to the COVID-19 pandemic, which gave rise to new ed-tech PPIs that were implemented or initiated to cope with the disruption in education. Improving access to education for vulnerable populations and responding to different educational needs is also a focus of ed-tech PPIs in these countries.

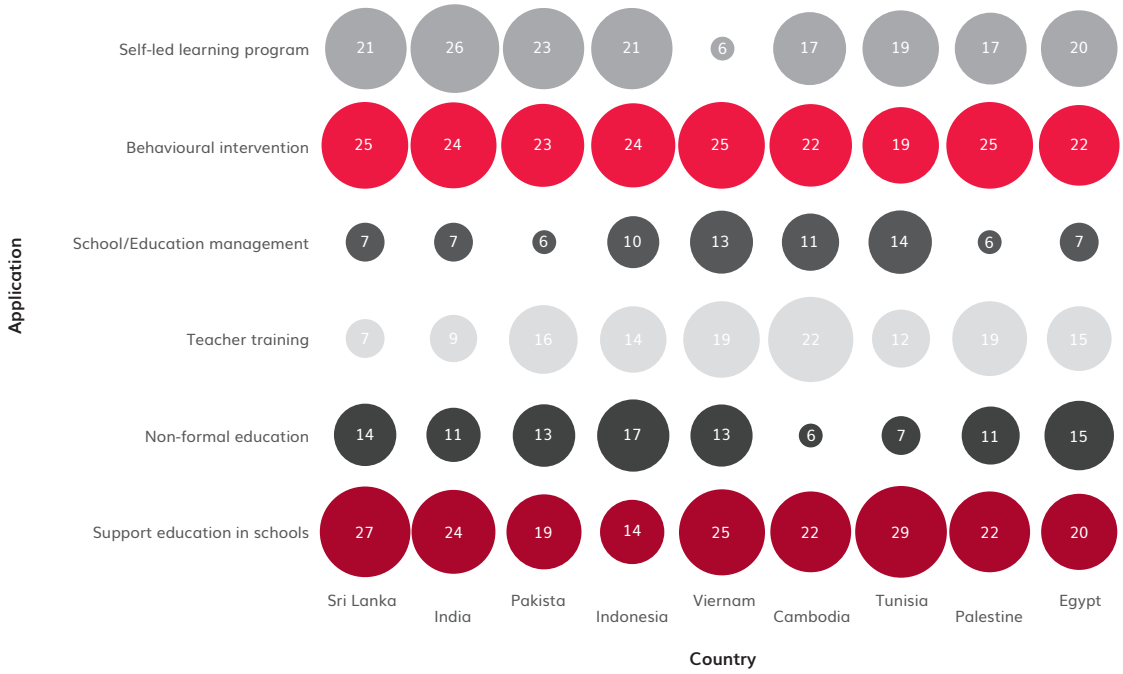
The reviewed PPIs were found to be most commonly used to support education in schools, offer self-led learning programmes and implement technology-enabled behavioural interventions (Figure 5). The former facilitate the learning process in school, while self-led learning programmes enable self-paced learning for students at home or outside of the school environment. Most self-led learning programmes also support education in schools as they generally include Learning Management Systems (LMS), e-learning platforms, educational apps, and television or radio channels that are dedicated to students. Technology-enabled behavioural interventions refer to those that affect or stimulate the mental state of students and/or seek to cause behavioural changes.

Figure 4. Aims of ed-tech



Note. This figure is based on the identified 123 ed-tech PPIs. The number of PPIs per country are normalised to 100 and indicated within bubbles. The size of bubbles reflects the number of PPIs (normalised to 100), such that the larger the bubble, the larger the number of ed-tech PPIs having a particular aim. Elaborated by the authors using the preliminary list of 123 ed-tech (primarily 2010 onwards).

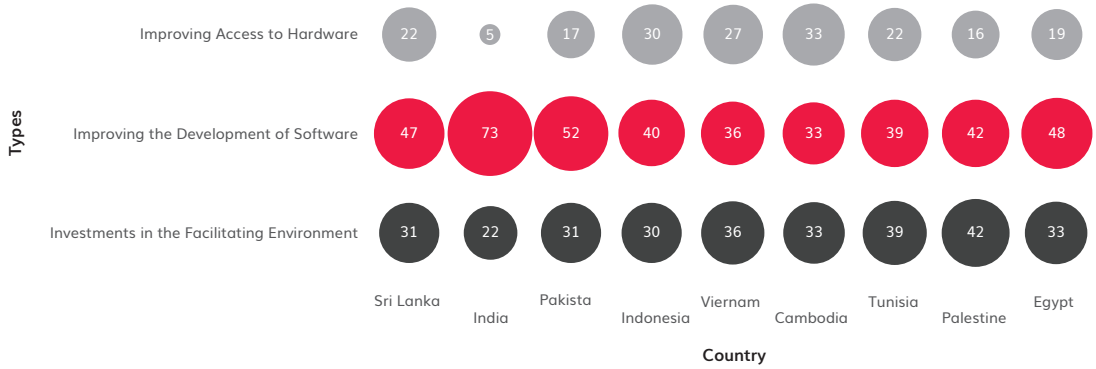
Figure 5. Applications of ed-tech



Note. This figure is based on the identified 123 ed-tech PPIs. The number of PPIs per country are normalised to 100 and indicated within bubbles. The size of bubbles reflect the number of PPIs (normalised to 100), such that the larger the bubble, the larger the number of Ed-tech PPIs of a particular application. Elaborated by the authors using the preliminary list of 123 Ed-tech PPIs (primarily 2010 onwards).

Furthermore, improving the development of software programmes were the most common type of ed-tech PPIs (Figure 6). Investments in the facilitating ed-tech environment, such as training teachers to use technology is also prevalent, and is an important priority area for the future of ed-tech. The least prevalent type of intervention is improving access to hardware, which mainly includes the distribution of devices such as laptops and tablets, as well as providing electricity and internet accessibility to students and schools mostly from rural and underprivileged areas.

Figure 6. Types of ed-tech PPIs



Note. This figure is based on the identified 123 ed-tech PPIs. The number of PPIs per country are normalised to 100 and indicated within bubbles. The size of bubbles reflects the number of PPIs (normalised to 100), such that the larger the bubble, the larger the number of ed-tech PPIs of a particular type. Elaborated by the authors using the preliminary list of123 ed-tech (primarily 2010 onwards).

The in-depth review of 18 case studies and key informant interviews provides further insights into, and examples of, the aims, applications and types of ed-tech PPIs observed in the regions. Overall, the 18 initiatives analysed have sought to contribute towards at least two SDG 4 targets, as summarised in the table below.

Specific initiatives like Indonesia's Ruangguru are tailored to improve learning using techniques such as gamification to motivate students and keep them engaged with their studies. This platform offers customised, high-quality educational content and services, designed to meet individual student needs and foster self-learning practices (Ruangguru, 2022). By utilising data analytics and machine learning algorithms, this platform creates personalised learning paths for each student, tracking their progress and identifying areas where they need extra help, then recommending appropriate learning materials and tutors (Ruangguru, 2022).

Similarly in Vietnam, the Marathon Education initiative seeks to meet all students' learning and personal development needs across the country (Venturra, 2022). Marathon

Education employs a test-bank that allows students to create assessments and do mock tests independently (Venturra, 2022). In utilising digital learning technologies to personalise the learning experiences of students, these ed-tech initiatives in Indonesia and Vietnam help to improve engagement with learning, creating a facilitating environment in which better educational outcomes are possible.

Table 5. Contribution towards SDG 4

Country	Ed-tech Programme	SDG 4 Targets[6]									
		4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.a	4.b	4.c
India	Class Saathi	x			x	x			x		
	OLabs	x				x			x		
Pakistan	WonderTree		x			x			x		
	TeleTaleem	x	x		x	x	x		x		x
Sri Lanka	Nenasa	x				x	x	x	x		x
	Akura	x			x				x		
Cambodia	BEEP	x		x	x	x		x	x		
	Tesdopi	x			x	x	x		x		
Indonesia	SEAMOLEC				x	x			x		x
	Ruangguru		x		x				x	x	
Vietnam	FPT Education	x		x		x		x	x	x	x
	Marathon Education	x			x		x		x		
Egypt	Egyptian Knowledge Bank (EKB)	x	x			x			x		
	Madrasty	x				x					
Palestine	The UNRWA Elearning Platform	x			x	x	x				
	E-learning Curriculum in Palestinian Primary and Secondary Education	x			x		x		x		x

6 SDG 4 Targets: 4.1 Universal primary and secondary education; 4.2 Early childhood development and universal pre-primary education; 4.3 Equal access to technical/vocational and higher education; 4.4 Relevant skills for decent work; 4.5 Gender equality and inclusion; 4.6 Universal youth literacy; 4.7 Education for sustainable development and global citizenship; 4.a Effective learning environments; 4.b Scholarships; 4.c Teachers and educators.

Tunisia	EDUNET10	x				x			x		
	Sghartoon		x			x					

Note. Elaborated by the authors.

Other initiatives have sought to complement formal education where traditional infrastructure has not been adequate. For instance, OLabs in India has particularly focused on making lab resources available remotely for students from rural schools (Amrita, n.d.). "Nenasa" in Sri Lanka has similarly made educational content available to rural students by connecting schools to the Nenasa TV channels (Dialog Foundation, n.d.). The e-Library Nenasala Programme has further encouraged people in rural areas to visit public libraries and religious community centres that provide them with free access to computers and the internet (Komasaru, 2011).

Edunet10 in Tunisia has also focused on developing infrastructure to better support the implementation and integration of ed-tech through improved connectivity and access to digital resources. The initiative has aimed at establishing a robust digital infrastructure to support the development of high-quality digital educational services and content (CommsUpdate, 2023). Its main objective is to make high-speed broadband network access available in all schools and to provide reliable and fast broadband connectivity for teachers and students (CommsUpdate, 2023).

Nafham ("We Understand"), a free online K-12 educational video platform, was launched in Egypt in 2012, as the government was unable to build new schools fast enough in order to accommodate the surge in enrolments because of high birth rates (Jalbout & Farah, 2016). The platform allows teachers, parents and students to post educational videos on the topics of the school curriculum. The videos are accessible through their website and mobile application, and students who participate in teaching have been found to perform the best (Jalbout & Farah, 2016). By 2015, Nafham had 600,000 monthly active users with over 23,000 videos - 9,000 of which are original content (Jalbout & Farah, 2016).

On its part, Class Saathi in India has sought to reduce educational gaps resulting from the lack of adequate infrastructure by developing offline technology. It uses Bluetooth clickers to provide students and teachers without internet and electricity with access to online content using offline technology (Taghive, n. d.). In conceptualising and implementing ed-tech as a supplement to traditional modes of learning, these two initiatives strengthen existing teaching and learning modalities where traditional infrastructure has not been adequate with the use of digital learning technologies.

Four of the initiatives studied have sought to improve access to education by targeting vulnerable or marginalised student groups that have not been supported adequately by mainstream education. This is the case of the Basic Education Equivalence Programme (BEEP) in Cambodia, that specifically caters to the needs of lower secondary school dropouts (UNESCO, 2023). The programme aims at supporting young Cambodians aged 14 and older to complete their basic education through online courses without disrupting their employment. The BEEP initiative also targets indigenous women and youth with disabilities (UNESCO, 2023).

Similarly, the WonderTree programme in Pakistan aims at filling gaps in existing educational programmes by supporting children with disabilities. This is a technology-enabled behavioural intervention that uses ed-tech to enhance the mental state of students, demonstrating the important role that ed-tech can play in education outside of traditional classroom environments (WonderTree, 2023). The initiative caters to the educational needs of children from various spectrums of motor and cognitive difficulties including Autism, Down Syndrome, and Global Development Delay through Augmented Reality (AR) based games, seeking to support the development of coordination skills, motor skills (such as agility, balance, speed and reaction time), cognitive skills (sustained attention, speed of information processing, multiple simultaneous attention, working memory and pattern recognition) and functional skills (therapeutic exercises) (WonderTree, 2023).

The Sghartoon platform in Tunisia was also developed to provide parents and therapists with tools and educational games to help children improve their reading, writing, and spelling skills while providing a constructive and interactive experience. The digital teletherapy platform, targeted at children with dyslexia, is used by 2,000 children and 50 therapists[7].

Finally, the Madrasty programme in Egypt targets students living with chronic health conditions and disabilities, to provide access to pre-recorded and live educational programmes prepared by teachers. Its assessment tool also provides personalised feedback and AI tutoring and is offered free of charge (Care Egypt Foundation, 2021). The project is implemented as a component of CARE International in Egypt's Education Program, and has 14,4000 registered and 19,000 subscribers (Care Egypt Foundation, 2021).

By ensuring social inclusion and tailored support, such ed-tech programmes contribute to reducing educational and socio-economic disparities. Due to the fact that

7 See more about Sghartoon: https://sghartoon.com/

these initiatives focus on specific target groups, their coverage is not large-scale nor nationwide, but the user statistics emphasise how ed-tech programmes can play a vital role in improving access to education for vulnerable or marginalised populations.

Other distance learning initiatives, not included in the case studies, have similarly focused on improving access to education by specifically targeting out-of-school children. A noteworthy example is the GIRLS Inspire project in Bangladesh, India, and Pakistan, that uses open and distance learning to reach girls who have been prevented from attending school due to early marriage, cultural norms, and distance (Commonwealth of Learning, 2019). The project was found to have a positive impact on girls' access to economic opportunities and the ability to make health decisions, understand social rights, and access resources, thus benefiting them to become more active citizens, to advocate for themselves and making wider opportunities available to them (Commonwealth of Learning, 2019).

Enhancing the efficiency and productivity of the education system and reducing costs are also important objectives to the use of ed-tech in the region, which is mainly achieved through Education Management Information Systems (EMIS). For example, the Akura initiative in Sri Lanka enables schools to connect with parents, individually and collectively, to communicate school activities, send invoices, and provide feedback on student learning outcomes (Akura, 2019). By facilitating clearer and easier communication between schools and parents, the Akura initiative represents a successful ed-tech PPI which has improved the confidence of parents in the education system by enhancing transparency and accountability of schools.

Some of the initiatives previously mentioned, such as the Nenasa TV and Nenasa App in Sri Lanka, OLabs in India, Marathon in Vietnam, and BEEP in Cambodia also exemplify ed-tech initiatives envisioned to enhance the resilience of education systems, particularly in response to crises. These initiatives implemented or initiated self-led learning programmes through e-learning platforms, educational apps and television channels during the COVID-19 pandemic, to cope with the disruption in education by enabling students to carry out their studies from home.

In addition, the Digital Learning Platform (DLP) in Palestine provides insights on how ed-tech can enhance the education systems' resilience and responsiveness particularly in contexts of conflict. The DLP is an online educational platform developed by the UNRWA (United Nations Relief and Works Agency for Palestine Refugees in the Near East [UNRWA], 2021). It serves as a digital learning hub, providing uninterrupted access to remote learning materials and resources for students to improve digital literacy skills, enhance their own learning, and promote equitable access to quality education

(UNRWA, 2021). The platform aims to ensure continuity of learning for Palestine refugee students, who are often unable to physically attend schools (UNRWA, 2021).

Similar ed-tech solutions have been implemented in other conflict-affected areas outside this report's scope. Afghanistan's Community-Based Education (CBE), for instance, has enabled children in remote or conflict-affected areas to continue their education from the safety of their homes while providing an alternative to formal education (Nagesh et al., 2021). This has been the case particularly for girls and groups of students who are unable to attend schools due to insecurity, distance, or other constraints (Nagesh et al., 2021).

This section has outlined the aims, applications and types of ed-tech PPIs found in SA, SEA and MENA. The examination has revealed a multifaceted landscape for diverse learners. The prevailing aims of these initiatives are centred on improving learning outcomes and enhancing education resilience. While gamification, personalised learning, and self-learning strategies have been implemented to improve learning, other initiatives primarily focus on complementing formal education by making resources available in under-served areas, improving infrastructure, or developing offline technology. Some programmes particularly target vulnerable student groups that have not been supported adequately by mainstream education, including school dropouts, children with disabilities and out-of-school children.

Ed-tech in the three regions has been mainly used to support education in schools, foster self-led learning programs and promote behavioural interventions. This includes efforts to enhance the education system generally, but also by developing distance learning systems to respond to crises or support children in conflict-affected areas. Software development and investment in the creation of facilitating environments for ed-tech underscore the technological foundation of these initiatives. As the ed-tech landscape continues to evolve, this report emphasises the dynamic and adaptive nature of these initiatives, providing insights into the potential future directions and priorities for ed-tech development.

Factors facilitating the development and implementation of ed-tech

The following subsection outlines two main factors that have facilitated the development and implementation of ed-tech PPIs in SA, SEA and MENA. The first is political and public backing that can help drive the use of ed-tech regionally and nationally, as adequate infrastructure and funding can provide a catalyst for growth. Second, the success of ed-tech initiatives is strongly influenced by the presence of multi-stakeholder

partnerships and a strong private ed-tech sector, both of which can foster innovation in developing products suitable for a variety of audiences.

Political and public backing

Political and public backing helps to drive the use of ed-tech, as adequate infrastructure and funding can provide a catalyst for growth (Regan & Khwaja, 2019; Rowell, 2010). In Sri Lanka, for instance, the vision and plan to invest in the future of education, along with the support and interest from the Ministry of Education have been major facilitators for the implementation of the Nenasa programme. Interviewees attributed this to the knowledge and experience of certain government officials who recognised the importance of investing in technology for education (anonymous, personal communication, 2023).

In SEA, institutional cooperation within the region has effectively facilitated the growth of ed-tech. As explained above, the Ministries of Education operate through SEAMEO to promote ed-tech uptake at an overarching institutional level. The SEAMEO Regional Open Learning Centre (SEAMEOLEC) supports the development of e-learning and blended learning programmes, teacher capacity building, and the use of technology in education within the subregion (SEAMEO, n.d.). Various ed-tech start-ups and Massive Open Online Courses (MOOCs) have emerged, such as Topica (Vietnam), Ruangguru (Indonesia) and Thai-MOOC (Thailand) (Curtis et al., 2022). This indicates that state-sanctioned backing to online courses can provide a bedrock for scaling up the use of ed-tech.

Some SEA countries are also actively enhancing digital literacy by providing comprehensive training and resources for both students and teachers to become adept in technology use. In addition to introducing versatile online learning platforms that cater to diverse users and can be accessed from various locations, these nations are investing significantly in developing necessary infrastructural support (Mallet, 2019). This includes establishing robust broadband internet connections, Wi-Fi networks, and equipped computer labs in educational institutions (Mallet, 2019).

Similarly, prioritising ed-tech within national policies and providing adequate infrastructure as the foundation for ed-tech have been facilitating factors in its development and implementation in MENA (Weber, 2019). For example, one core facilitator for ed-tech highlighted in Tunisia is the national telecommunication network, which covers the entire geography and integrates high-speed multifunctional switches that support telephone, internet, and multimedia traffic (anonymous, personal communication, 2023). Different technologies are employed for data transmission, thus ensuring the use of reliable and modern infrastructure networks, equipment, and services (International

Telecommunication Union, n.d.). With strong infrastructure in internet access and connectivity, there is a higher probability that target groups are able to access ed-tech reliably and consistently.

There has also been a significant development in digital infrastructure in Palestine, where wired and wireless communications have been enhanced and internet connectivity has improved (Awam et al., 2015). This has contributed to providing the necessary infrastructure for effectively implementing e-learning and accessing educational resources online (anonymous, personal communication, 2023). The government of Egypt has similarly made efforts to bridge the digital divide by improving access to technology and digital resources to students from all backgrounds, including those in under-served areas (Elgohary, 2022). Efforts to improve infrastructure have been coupled with initiatives to provide laptops and tablets to students and to expand internet connectivity (Elgohary, 2022). These two measures have facilitated ed-tech uptake.

Multi-stakeholder partnerships

The presence of productive partnerships between multiple ed-tech stakeholders, as well as the contributions of donors and other funding institutions is a factor that appears to strongly influence the success of ed-tech PPIs (Fabre & Straub, 2021; Pillay & Hearn, 2009). Both public sector and private sector stakeholders, individually and collaboratively, contribute to this space, and the types of collaborations are varied. They include public-private partnerships, donor-private partnerships and private-private partnerships (e.g. telecommunication companies and electricity companies).

The case of Class Saathi in SA is exemplary. Seed funding was provided by Samsung Ventures in 2017 and two years later, Class Saathi was successfully piloted in India. With multiple stakeholders taking part in this initiative, including Samsung C-Labs, Google, KAIVALYA Education Foundation, Progressive Foundation, FORD Foundation, Forest Partners, i-Scream Media, HCL, Madhya Pradesh government, and Uttar Pradesh government, the company raised $2.5million to expand its operations (Business Standard, 2022). In cases such as the 'Akura' school management system in Sri Lanka, which was developed as a Corporate Social Responsibility (CSR) program with no government involvement, support from other private companies facilitated its implementation. For example, the Mobitel company has supported this system by providing telecommunication services through Amazon Web Services (AWS) as the server provider (anonymous, personal communication, 2023).

In SEA, the presence of around 342 private ed-tech companies operating across the region is a key facilitator of ed-tech (Skills Nation, 2022). Collaborative initiatives between

the public and private sector, as well as the involvement of international development agencies, also help to continue and improve the uptake and implementation of technology (ADB, 2020). The BEEP programme in Cambodia, for instance, entails the participation of numerous stakeholders, including the Ministry of Labor and Vocational Training and the Ministry of Education, Youth, and Sport, Decent Employment for Youth in Cambodia (DEY), UNESCO, UNIDO, UNICEF, and ILO. In addition, the Skills Development Fund offers financial support and skills training, while Smart Axiata supplies the internet infrastructure, enabling students to learn with free internet access (Smart, n.d.).

Countries in MENA have also sought alternate financing models through private sector partnerships with tech giants, Microsoft, Apple and Intel, as well as through collaborations with World Bank and UNESCO. These relationships have facilitated the financing of infrastructure development to improve connectivity and access, material assistance, and the development of high-quality educational content for students and teachers (anonymous, personal communication, 2023). The K-12 Egyptian Knowledge Bank (EKB) Study Portal in particular has had a remarkable impact. Among other factors, the programmes' success has been attributed to its horizontal management structure, facilitated through a private-public partnership model that involves over 150 partners (Reimers & Opertti, 2021; anonymous, personal communication, 2023). The continued leadership and support from government officials, including the Minister of Education, Dr. Tarek Shawki, have played a crucial role in the EKB's development and integration into the formal education system (Mogheith et al., 2019; anonymous, personal communication, 2023).

> **Lack of infrastructure, unequal access to technological resources, and the high costs associated with accessing ed-tech were the main constraint for the use and implementation of ed-tech in the three regions.**

Barriers to the development and implementation of ed-tech

Various factors were found to pose barriers to the development and implementation of ed-tech in the three regions. These include a lack of financial resources and ICT infrastructure, low-levels of teachers' capacity in the use of ed-tech, and resistance to change associated with social and contextual factors. This section details specific challenges for the development and implementation of ed-tech in the three regions.

Uneven access to ICT infrastructure and high operational costs

Lack of infrastructure, unequal access to technological resources, and the high costs associated with accessing ed-tech were cited by interviewees as a main constraint for the use and implementation of ed-tech in the three regions (anonymous, personal communication, 2023).

In SA, there is a large digital divide within countries. For instance, only about 24% of people in India have access to the internet, and the percentage for rural households is 15% (Jha & Jha, 2022). Access to electricity is also uneven, with 16% of India's households receiving 1 to 8 hours of electricity daily, 33% receiving 9-12 hours, and 47% receiving more than 12 hours a day (Jha & Jha, 2022). Furthermore, many students do not have access to adequate tools to benefit from ed-tech. While 24% of Indians own a smartphone, only 11% of households own desktop computers, laptops, notebooks, or tablets (Jha & Jha, 2022). A survey conducted by the National Council of Educational Research and Training further reveals that about 27% of students did not have access to smartphones or laptops to attend online classes in 2020 (Nagari, 2020).

Reported barriers to the Class Sahti initiative in India include the cost of ed-tech programmes limit ed-tech uptake in some schools, specially depending on the number of students, local funding, and allocation protocols (anonymous, personal communication, 2023). Despite Class Saathi circumvents the need for the internet, access to electricity and hardware such as mobile phones is still required to make use of the programme, which limits access for students in under-served areas. Similar remarks were made by interviewees from the Nenasa programme in Sri Lanka, highlighting that even when infrastructure and connectivity are provided, the access to and affordability of hardware for users remains a challenge, especially considering the country's high inflation (anonymous, personal communication, 2023). High operational costs have also been barriers for the uptake of the Akura programme, including among others, the cost of hiring software engineers (anonymous, personal communication, 2023).

The digital divide in SEA similarly limits access to equal ed-tech opportunities because of the prevalence of limited infrastructure access, resources issues, and skills shortages. In Indonesia, approximately 72% of primary school students had access to mobile phones in 2022, but in contrast, only around 5% of students had access to computers (Statista Research Department, 2023). Regions with higher incomes, large cities, and greater educational facility capacity tend to yield students with better learning outcomes compared to areas with lower income and capacity (The World Bank, 2020b). In addition, building the necessary technological infrastructure for implementing ed-tech PPIs is a significant challenge. Despite the Ministry of Informatics' efforts to provide

internet access through the BAKTI Kominfo project, financial disputes have led to slow progress and an uncertain timeline for implementation (Global Education Monitoring Report Team & SEAMEO Regional Open Learning Center, 2023). Further contributing to this situation are the high educational costs and digital divide in Indonesia, exacerbated by the COVID-19 pandemic (Afkar & Yarrow, 2021).

In Vietnam, the lack of facilities for online teaching and learning was cited as a key challenge for the development of e-learning, as not all teachers and students own computers or smartphones. This factor is further exacerbated given the price-sensitive education market in Vietnam, where higher-income parents in urban areas tend to spend more on private tutoring for their children compared to those in rural areas (Nguyen et al., 2021). Recently, more and more city-living parents register for online and offline supplementary pre-school classes for their children, which is not as popular in rural areas (Nguyen et al., 2021). The disadvantage experienced by families with lower levels of income in Vietnam means that they are unable to purchase the necessary resources or support to effectively engage with ed-tech PPIs, thus widening the digital divide and equal access to ed-tech.

Obstacles pertaining to the lack of connectivity and network coverage are also two of the most stated barriers across the countries of study in the MENA region. Insufficient network coverage and the lack of high-speed internet impedes the successful adoption of ed-tech, particularly in rural areas, as communities do not have access to adequate infrastructure (anonymous, personal communication, 2023). Infrastructural availability, impacts the ability of ed-tech policies to be rolled out, and even if they are rolled out, affects the usability of such platforms (anonymous, personal communication, 2023).

Low-levels of teacher capacity

Research has shown that teachers who are well-trained in using ed-tech are more likely to select the right ed-tech tools for their students, to use them in a way that is aligned with their teaching goals, and to provide students with the support they need to use ed-tech effectively (Mandal & Srinivas, 2022). Being well-trained involves pre-service and in-service teacher training and therefore cannot be integrated as a standalone, one-off training (Mandal & Srinivas, 2022). Evidence also shows that teachers who are enthusiastic about using ed-tech are more likely to create a positive learning environment for students (Trust et al., 2016).

Low-levels of teacher capacity remain a major barrier towards successfully implementing ed-tech. Interviewees in Sri Lanka reported that finding expert teachers

with relevant knowledge and available time has caused important delays in the Nenasa's programme implementation (anonymous, personal communication, 2023). The imbalances created between infrastructure shortages, systematic workload, and teacher awareness and training, act as a barrier that can prevent the adoption of ed-tech PPIs. In disadvantaged areas with a lack of teachers, the adoption of ed-tech initiatives requiring skilled teachers would be harder, and it is difficult to predict how ed-tech could compensate for the loss of learning and instruction in underprivileged regions without skilled teachers.

Lack of teachers' digital skills and appropriate training were also mentioned as important barriers for the implementation of ed-tech in SEA. For example, interviewees explained that teachers in Cambodia are often unprepared to navigate online platforms, understand digital content, and effectively use digital devices for learning (anonymous, personal communication, 2023). There is also a lack of support for teachers on using digital tools and platforms, which may hinder their ability to deliver online education effectively (anonymous, personal communication, 2023). It is therefore important that when reviewing the barriers to the implementation and uptake of ed-tech PPIs in the region, consideration is given toward providing adequate teacher training and support for parents and families.

Social and contextual factors

Social and contextual factors can also play a significant role in the integration of technology into education. Resistance and negative attitudes and mindsets towards the incorporating technology within the education system by key stakeholders, including parents, teachers, principals, and government officials, was cited by interviewees as an important barrier to the development of ed-tech in countries of the three regions (anonymous, personal communication, 2023). In Sri Lanka, however, some mentioned that this is changing after the COVID-19 pandemic, since school closures highlighted some of the benefits and value of ed-tech (anonymous, personal communication, 2023).

Resistance to adopt new technological tools for education was more apparent in certain contexts. For instance, the Akura program has encountered more reluctance from public school administrators to adopt ed-tech programs like the Akura school management system, as compared to private schools, despite it has been designed for ease of use both in rural and urban areas (anonymous, personal communication, 2023). Similarly, interviewees in Indonesia reported that the use of smartphones is not permitted in religious boarding schools *(pesantren)*, as they are considered to distract students from learning (anonymous, personal communication, 2023).

Social factors were highlighted as a hindering factor in Cambodia and Vietnam as well, however this was attributed to the traditional educational culture that is still predominant in these countries. In Vietnam particularly, senior teachers were said to display a higher level of resistance to adopting online platforms and digital tools (anonymous, personal communication, 2023). Exposure to the digital world can thus be limited and the integration of ed-tech in educational practices hindered due to contextual and social factors. As a result, some students may not adopt technology to complement traditional learning or build online self-learning practices.

In MENA, stakeholders' resistance to change was also cited as a main barrier to ed-tech uptake, coupled with the lack of a vision and strategy with respect to its adoption and use. For instance, one of the first challenges encountered by the Sghartoon program was the initial reluctance of therapists to adopt technology in their practices (anonymous, personal communication, 2023). This hesitation stemmed from concerns that the technological tool might replace or undermine their role in therapy. Similarly, a main barrier encountered by the Madrasty program has been scepticism from some parents and educators regarding the effectiveness of e-learning (anonymous, personal communication, 2023).

It is apparent that social attitudes toward technology and contextual factors continue to be a considerable barrier to the adoption of ed-tech PPIs across the regions studied. Resistance to upskilling and learning new technological skills is common among senior teachers and public school administrators, who may perceive it as burdensome or unnecessary. This reluctance to embrace technology in the classroom prevents the full realisation of ed-tech's potential in enhancing the learning experience. A negative conception of technology's impact in education from other key stakeholders, such as parents and government officials can further limit the implementation of ed-tech strategies.

Changes to the ed-tech landscape due to COVID-19

Increased interest in ed-tech

The COVID-19 pandemic precipitated an intensification of ed-tech PPIs across the three regions. For instance, the number of users of OLabs in India was reported to have doubled from 1,600,000 pre-pandemic to 3,200,000 after the pandemic, with over 12,000 schools in the country using them in 2021 (Bhubaneswar, 2021). The Class Saathi programme, also in India, expanded from 10 schools to more than 1,800 schools, and is expected to record a 300% year-on-year growth ahead (Times of India, 2022). Similarly, in Sri Lanka, according to interviewees, the Akura school management system

has experienced a 20% increase in its coverage of schools post-pandemic, despite it being a considerably small-scale ed-tech programme in the country (anonymous, personal communication, 2023).

This expansion of the number of beneficiaries and users of ed-tech during the pandemic has also resulted in the expansion of coverage. For example, the Nenasa programme in Sri Lanka launched two new ed-tech initiatives, namely, the "Nenasa educational app", which catered to more than 33,000 users, and the "Nenasa 1916" toll-free distance learning helpline (anonymous, personal communication, 2023). Prior to the pandemic, the content provided by the Nenasa initiatives was to be delivered in the Tamil language, with the intention of catering to the minority community of Sri Lanka. In Bangladesh, the Parliament Television started broadcasting thousands of lessons for primary, secondary, madrassa, and vocational education reaching students in the tens of millions during COVID-19. It is therefore apparent from the success of these programmes that the pandemic has encouraged the expansion of ed-tech PPIs.

The demand for distance learning owing to lockdowns and the consequent school closures also fostered government support for ed-tech programmes within the region during the pandemic (anonymous, personal communication, 2023). Similar steps were undertaken by the other governments in the region outside of this study's scope, such as Nepal (Lisa et al., 2021) and the Maldives (Sosale et al., 2020), which collaborated with the private and non-profit sectors to make free and open access educational content available for all learners amid school closures. This support has continued post-pandemic with the general public and stakeholders now expressing being more aware of the important role played by ed-tech in improving the resilience of education systems and the benefits of incorporating ed-tech into mainstream education and learning processes (anonymous, personal communication, 2023). Movement restrictions during COVID 19 created high demand for distance education, and new opportunities for the expansion of the ed-tech sector.

Some ed-tech providers also have plans to incorporate offline tech modes as a part of their existing ed-tech programmes as a response to the challenges faced during the COVID-19 pandemic by students from underprivileged areas, who do not have access to internet connection (anonymous, personal communication, 2023). There are some examples that already exist, such as television channels for students as provided by Nenasa in Sri Lanka, and Bluetooth clickers as provided by Class Saathi in India, among others. Such ed-tech initiatives incorporating offline tech solutions would improve access to ed-tech in the future, since the digital divide is another main barrier to the adoption of ed-tech in the region. Similarly, some other ed-tech PPIs aim to expand geographical coverage as well as to include minority languages (including sign language)

in their programmes, which would further contribute toward reducing inequalities in education (anonymous, personal communication, 2023).

In Indonesia, the education technology company Ruangguru, which offers a range of educational content and access to online tutors, saw an increase in demand for its online learning services during COVID-19. As students and parents sought alternative educational solutions, Ruangguru expanded its offers by introducing new features such as live streaming classes and making downloadable content so that materials were accessible without an internet connection (anonymous, personal communication, 2023). Ruangguru also increased collaborations with educational institutions throughout the country and experienced a significant increase in funding. This funding was mainly through venture capital and equity companies during the pandemic, making it one of the largest ever funded start-ups in the history of the Indonesian start-up ecosystem (Pratama, 2019). According to Pratama (2021), Ruangguru experienced over 50% growth in its user base to reach over 20 million students and 400,000 teachers in 2020. The success of Ruangguru during the pandemic demonstrates that the changes to the ed-tech landscape caused by COVID-19 have helped private ed-tech companies drastically expand their footprint and profitability, whilst simultaneously providing more opportunities for students.

Funding for ed-tech also increased in Vietnam. For instance, Marathon Education for students across Vietnam was established in 2021, immediately post-COVID-19, in the midst of a boom in ed-tech businesses. It raised more than 7 million USD within twelve months of its launch (Abudheen, 2022). It is apparent from the success of Marathon Education during and since the pandemic that the demand for digital learning technologies has seen private ed-tech companies expand and improve what they offer and become more profitable, therefore accelerating digital transformation in Vietnam. The Vietnam ed-tech market was estimated to exceed 3 billion USD by 2023 with around 260 ed-tech businesses in the country, most of which are startups and business-to-customer companies which attract the interest of both local and foreign venture capital funds (Nguyen, 2022).

The MENA region also saw significant changes in the ed-tech landscape as a result of COVID-19. In Egypt, the government distributed tablets to students, provided free access to online learning materials and digital platforms, and awarded ICT certifications to teachers through the International Computer Driving License (ICDL) programme (Ministry of Communications and Information Technoloy, 2020; 2021). The Ministry of Communications and Information Technology increased home internet download quotas by 20% for free (anonymous, personal communication, 2023). In much the same vein, the National Center for Education Technologies (CNTE) in Tunisia established a digital workspace for primary schools and developed a digital content platform to provide

access to educational resources online anonymous, personal communication, 2023). This demonstrates the important role that COVID-19 played in increasing access to online learning materials and resources, as well as infrastructure for higher levels of internet penetration.

Exposed gaps and vulnerabilities associated with ed-tech implementation

Despite the positive gains offered by ed-tech, there are still many students who do not benefit from it. A case study conducted by Vegas et al., (2021) focusing on Chennai in India, found that 1 in 5 of children were in schools that offered no remote instruction during COVID-19. This study was based on a phone survey of 201 households and 271 primary school aged children conducted in February 2021. It further found that only slightly above half of the children enrolled in schools that did provide remote instruction attended all classes; and ed-tech was more accessible for children from private schools and high socio-economic backgrounds.

The pandemic also exposed several challenges to conducting standardised classroom teaching in schools. In Vietnam, for instance, online teaching and studying were challenging for both teachers and students as this was a relatively new form of learning in the country (anonymous, personal communication, 2023). Additionally, newly established online learning platforms faced technical issues like system overloads, mismatches between the number of student registrations and online classrooms, unstable transmission signals, and host errors (anonymous, personal communication, 2023). In Cambodia, ed-tech was mainly used after the pandemic in education as a form of communication and information sharing, rather than improving quality of or access to education (anonymous, personal communication, 2023). The incorporation of ed-tech into schools is still at a micro-level and has not been systematically integrated into mainstream education.

The lack of infrastructure such as having limited electricity, makes it more challenging for students and teachers to access the internet and resources.

The COVID-19 pandemic also highlighted barriers to equal access to technology, especially in rural areas and among disadvantaged communities. For example, students

that had to attend online learning in Tunisia encountered challenges due to limited internet connectivity barring access to online learning resources (Smaali Bouhlila et al., 2022). Pellini et al. (2021) recommend that in the short term, a multimodal approach, which is a combination of high-, low-, and no-technology, increases opportunities for children from marginalised backgrounds to continue learning, particularly during emergencies. In the longer term, ed-tech combined with evidence-based approaches known to work well in education can help close learning gaps by providing diverse opportunities to students in hard-to-reach areas. This emphasises the importance of implementing inclusive PPIs that reduce the digital divide and ensure equitable access, as opposed to exacerbating the issue.

Conclusion

Though diverse in nature, SA, SEA, and MENA provide an important platform on which to explore ed-tech. Within the countries selected for this study, a multitude of ed-tech PPIs have been developed, utilised and implemented since 2010. The importance given to ed-tech varies across the countries and regions, but all demonstrate interest in the investment in and development of ed-tech PPIs. Though still a new phenomena, many ed-tech PPIs date back a decade or more. Additionally, ed-tech uptake has in fact grown as a result of COVID-19.

Within the countries selected for this study, ed-tech has contributed to improving specific educational goals and infrastructure, and to reducing gaps in access to education (United Nations, 2023). The initiatives examined in this paper were implemented throughout 2010 to 2022 to reach populations that were otherwise considered hard to reach. Some of these PPIs aimed to increase digital literacy and enhance access to quality education, particularly for vulnerable groups such as refugees and children with disabilities. Other programmes were designed to facilitate self-paced learning among children, provide teacher training, and facilitate school management.

Some research exists that casts a shadow over the positive role of technology in reducing the disparities in education and questions whether ed-tech addresses the issues faced by marginalised groups in LMICs (Hennessy et al., 2021). However, ed-tech platforms within SA, SEA and MENA appear to have facilitated the achievement of Sustainable Development Goal (SDG) 4, which aims to ensure inclusive, equitable, quality education and promote lifelong learning opportunities for all. With this in mind, programmes that were able to support the uptake and improvement of quality education, particularly throughout COVID-19, could be considered as exemplary in the future landscape of ed-tech.

All ed-tech initiatives reviewed in this paper were found to target the achievement of quality education (SDG 4) and many of the PPIs examined addressed the educational needs of students from vulnerable contexts or children with disabilities. Emphasis was also given, especially since COVID-19, to improving the resilience and responsiveness of education systems to disruption. Some initiatives also supported SDG 10 to reduce inequalities. Initiatives that contributed towards the achievement of SDG 10 specifically focused on reducing the urban-rural divide in access to education and technology, and other programmes primarily focused on supporting marginalised groups.

One of the most common aims of the selected PPIs was to contribute towards improving learning outcomes. Ed-tech itself provides programmes with supplementary resources by providing access to additional knowledge, aiding teachers to prepare tests, and functioning as an electronic tutors for students. Self-learning initiatives in SEA are particularly sophisticated as these provide high-quality educational content and services tailored to student needs and learning preferences. These initiatives are also a means for creating their own assessments by using data analytics and machine learning algorithms. Ed-tech applications that provide technology-based behavioural interventions and aim to influence behavioural changes were noted, as they use student-friendly approaches, such as games.

The most common types of ed-tech in SA, SEA and MENA focus on supporting education in schools, providing self-led learning programmes, and implementing technology-enabled behavioural interventions. Capacity building for teachers has also been important for the integration of ed-tech within classroom settings, and in-service and pre-service training has been defined as critical in the utilisation of ed-tech at school (Mandal & Srinivas, 2022). Similarly, by improving the investment in ed-tech start-ups and open online courses, there has been an increase in the amount of resources available online for teachers and students, which has facilitated learning, teaching and preparation for examinations. Ed-tech therefore brings potential to the regions in meeting SDG 4, as it can increase teacher capacities, provide free access to education for all, and support the facilitation of adequate learning opportunities.

Key stakeholders, particularly individuals and institutions with legislative and policy decision-making power, have played an important role in facilitating the implementation of ed-tech in the three regions. These stakeholders are equipped to facilitate ed-tech by increasing political and public buy-in, teacher training opportunities, financial investment and the improvement of infrastructure. By prioritising ed-tech at the national (and regional) level, the ed-tech landscape during and post-COVID-19 has generated opportunities that were otherwise absent from PPIs. Stakeholders with decision-making power, often public entities such as local governments, are an important part to the development and implementation of ed-tech within the regions.

The involvement of different types of stakeholders in ed-tech varied according to country and regional contexts. The political interest in ed-tech is highest in SEA, where regional-level coordination and strategic efforts are in place to drive ed-tech through SEAMEO. There are no regional-level ed-tech policy initiatives in SA nor MENA, but ed-tech-related policies have been present for several years, with the earliest in India dating back to 1986. Many of the policies are being implemented in collaboration with donor agencies, such as the World Bank, UNICEF or the ADB, private sector stakeholders, or other ministries. Partnerships with such agencies have provided expert knowledge and funding opportunities to develop ed-tech in the region that can potentially lead to scaling up and the sustainability of ed-tech. In countries with lower levels of education, donors have been more involved in implementing ed-tech PPIs with the aim of reaching out to the most vulnerable communities and students.

These policies are evolving, particularly since COVID-19, and include components for the development of educational content, teacher training, improving access to digital resources, online assessment tools, and support for administering education. Largely, the COVID-19 pandemic acted as a facilitator of ed-tech PPIs in the region, since the pandemic pushed countries to incorporate technology into education following school closures and the inevitable switch to online learning. All selected countries witnessed a rise in demand for ed-tech during the pandemic. This was broadly witnessed through greater adoption of ed-tech initiatives, increased user bases, and the expansion of services offered by suppliers of ed-tech. On the other hand, the pandemic brought to light several challenges with respect to the ed-tech landscape, most predominantly unequal access to technology and the digital divide.

Though notable opportunities fostered by ed-tech exist, there are also barriers to its development and implementation, intertwined with contextual factors. The lack of basic infrastructure in SA, SEA and MENA impacts the extent to which ed-tech PPIs can be implemented, as access to the internet and electricity is not uniform. Even when students do have access to both, online education has been found to be heavily reliant upon access to technological devices such as mobile phones, laptops or tablets. Internet and mobile phone penetration rates in SA, SEA and MENA are high, but limitations in access to technology continue to impact those in rural areas or living in contexts of poverty.

Low levels of teacher capacity within these regions at present also poses a challenge to its wide scale adoption. Some teachers are not equipped with the adequate knowledge, tools or resources to implement ed-tech programmes or to integrate technological platforms into lesson plans (Mandal & Srinivas, 2022). This means that mainstreaming the use of ed-tech in public and state education is not yet adequately invested in or integrated into classroom settings.

Contextual factors can also provide obstacles to the successful adoption of ed-tech as some cultural attitudes and social expectations place greater importance on more traditional modes of learning than on innovative ed-tech approaches (Pellini et al., 2021). Similarly, political fragility and instability has led to an environment that is not conducive to developing and implementing new PPIs on ed-tech.

Several important conclusions can be drawn from the current state of ed-tech in SA, SEA and MENA in order to address key challenges and inform future research into current gaps in research. Firstly, ed-tech initiatives need to be more coordinated and impact-oriented. Although information on different ed-tech policy initiatives is available, limited information exists on the impact of these initiatives. In some countries, policies and projects with similar aims are ongoing. In others, policies are relaunched with similar aims, which is possibly due to technology advancements necessitating re-evaluation of earlier projects. It could also be due to implementation gaps. Also, the impact of different programmes needs to be assessed to improve the design and implementation of future projects, as well as their sustainability.

Secondly, since ed-tech is evolving quickly, education policies also need to adapt. It is important to have policy committees with representatives from different sectors, such as education, technology, and innovation, to assess and revise existing ed-tech policies for students and teachers. SEAMEO represents a best practice in this regard as it brings together beneficiaries, donor countries, and experts to develop policies to initiate ed-tech PPIs in the region.

Thirdly, it is apparent that different opportunities and challenges faced by the subregions have resulted in interest and investments in ed-tech. For example, in India, the vast population of digitally literate young people have received the interest of venture capitalists and bilateral donors. In Pakistan, poor educational outcomes have resulted in higher interest from NGOs and donor agencies. A better understanding of these dynamics can be used to leverage funds for expanding access to quality education using ed-tech.

Ed-tech programmes have been launched mainly with the intention of improving access to quality education. Although many programmes have paid attention to reducing the digital divide, the emphasis given to this is less. Given the fast pace at which ed-tech is developing and the high costs involved in improving access to digital services, inequalities in access to education are likely to increase unless more efforts are made to reduce the gaps in access to digital services.

There is high interest by the private sector to invest in ed-tech given the potential for profit making. These should be leveraged to promote ed-tech development yet, at the

same time, better information on access to ed-tech services needs to be made available so that donors are encouraged to invest in local ed-tech PPIs.

Some of the challenges in improving access to ed-tech are socio-cultural. Hence, along with investing in infrastructure and improving access to digital devices, attention should be paid to building awareness in the importance of allowing child-safe access to the digital environment.

In the future, there is a lot of capacity for growth as the incorporation of technology is still currently a relatively new concept in the region. Over the years there has been a rapid acceleration in the use and implementation of ed-tech in Asia, particularly since and as a result of the COVID-19 pandemic. Future research on ed-tech in the region should focus on building a stronger base of quantitative data with which to measure the impact and success of initiatives and to improve them for the future. Through these recommendations and learnings from existing PPIs, it is clear that ed-tech has the potential to reach many more students, as well as teachers and families, to improve quality education and to reduce inequalities. It is a constantly evolving landscape and will grow as PPIs adapt around it, but the future of ed-tech is bright and holds the possibility of contributing to improving education for all students.

References

Abudheen, S. (2022). Vietnam's Marathon Education raises 7-figure USD seed capital led by Vulcan Capital. e27. https://e27.co/vietnams-marathon-education-raises-7-figure-usd-seed-capital-led-by-vulcan-capital-20221007/

Afkar, R & Yarrow, N. 2021. *Rewrite the future: How Indonesia's education system can overcome the losses from the COVID-19 pandemic and raise learning outcomes for all.* World Bank. https://documents1.worldbank.org/curated/en/589551630680730676/pdf/Rewrite-the-Future-How-Indonesias-Education-System-can-Overcome-the-Losses-From-the-COVID-19-Pandemic-and-Raise-Learning-Outcomes-for-All.pdf

Akura. (2019). School Management System for school students. *Aspitio.* https://www.aspitio.com/

Amrita. (n.d.). Online Labs (OLabs) for School Lab Experiments – Interactive Simulations. https://www.amrita.edu/project/online-labs/

Asian Development Bank. (2020). *Regional : Technology-Enabled Innovation in Education in Southeast Asia*. https://www.adb.org/projects/54098-001/main

Association for the Development of Education in Africa. (2014). *The Integration of ICT Into Education and Training Systems in Africa: The Cases of Argentina, Burkina Faso, Côte d'Ivoire, Paraguay, Senegal, Tunisia and Uruguay.* https://www.adeanet.org/sites/default/files/etudes_en_web.pdf

Awam, M.F., Ahmad, T., Qaisar, S., Feamster, N., & Sundaresan, S. (2015). *Measuring Broadband Access Network Performance in Pakistan: A Comparative Study* [Paper presentation]. 40th Annual IEEE Conference on Local Computer Networks, Clearwater Beach, Florida, USA. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7365903

Baloch, I., & Taddese, A. (2020). *Ed-tech in Pakistan: A Rapid Scan* (Country Scan No. 10). Ed-tech Hub. https://docs.edtechhub.org/lib/FIQDEKCI

Belgian Development Agency. (n.d.). *Technical Note: Joint Financing Arrangement (JFA) Occupied Palestinian Territory.* https://www.diplomatie.be/oda/23404_PROGDESCR_Technical_note_NI3016980_PZA1503511.pdf

Bhattacharya, Nandakumar, Dasgupta, & Murthy. (2023). *Adoption of Quality ed-tech Products in India: A Case Study of Government Implementation Towards a Sustainable ed-tech Ecosystem.* Global Education Monitoring Report Team, UNESCO. https://doi.org/10.54676/XVKH9

Bhubaneswar (2021). TBC.

BYJU's (n.d.) https://byjus.com/

Buchanan, R. (2020). Through growth to achievement: Examining ed-tech as a solution to Australia's declining educational achievement. *Policy Futures in Education*, *18*(8), 1026–1043. https://doi.org/10.1177/1478210320910293

Business Standard. (2022, November 21). Samsung backed ed-tech firm TagHive's Class Saathi App set to record 300 per cent Y-O-Y growth. https://www.business-standard.com/content/press-releases-ani/samsung-backed-ed-tech-firm-taghive-s-class-saathi-app-set-to-record-300-per-cent-y-o-y-growth-122112100460_1.html

Care Egypt Foundation. (2021). *Ana we Madrasty flyer.* https://care.org.eg/reports-resources/

Cameron, A., Pham, T. H., Atherton, J., Nguyen, D. H., Nguyen, T. P., Tran, S. T., Nguyen, T. N., Trinh, H. Y. & Hajkowicz, S. (2019). *Vietnam's future digital economy – Towards 2030 and 2045: Summary report*. CSIRO, Brisbane.

Colás-Bravo, P. (2019). Special Issue "ICT in Education and Sustainable Futures". *Sustainability.* https://www.mdpi.com/journal/sustainability/special_issues/ICTESF

Commonwealth of Learning. (2019). *Preventing Child, Early and Forced Marriage (CEFM) through Open, Distance and Technology-Based Education: Final Report*. https://www.che.ac.ls/wp-content/uploads/2019/09/18-GIRLS-Inspire-Final-Report-Preventing-Child-Early-and-Forced-Marriage-CEFM-Through-Open-Distance-and-Technology-Based-Education.pdf

CommsUpdate. (2023, March 15). MTC unveils 'Edunet 10' connectivity programme. https://www.commsupdate.com/articles/2023/03/15/mtc-unveils-edunet-10-connectivity-programme/

Curtis, H., Hogeveen, B., Kang, J., Le Thu, H., Rajagopalan, R. P., & Ray, T. (2022). *Digital Southeast Asia (Issue 57). Australian Strategic Police Institute*. https://www.aspi.org.au/report/digital-southeast-asia-australia-india-cooperation-post-covid

Desouza, K.C. (2023, August 9). Realizing Indonesia's Digital Transformation Ambition: From AI to IoT. *IBM Center for The Business of Government*. https://www.businessofgovernment.org/blog/indonesia-digital-transformation

Dialog Foundation. (n.d.). Nenasa TV. https://dialogfoundation.org/what-we-do/nenasa-tv/

Education Cluster & United Nations International Children's Emergency Fund. (2020). *Education Cluster Strategy - Palestine 2020-2021.* https://reliefweb.int/report/occupied-palestinian-territory/education-cluster-strategy-palestine-2020-2021?_gl=1*jm54f0*_ga*MTYyMjE4NTI5Ny4xNjk3MjEwMzc1*_ga_E60ZNX2F68*MTcwMjQ1ODAwMi4zLjAuMTcwMjQ1ODAwMi42MC4wLjA

Elgohary, E. M. (2022). The Role of Digital Transformation in Sustainable Development in Egypt. *The International Journal of Informatics, Media and Communication Technology, 4* (1), 11-121. https://ijimct.journals.ekb.eg/article_219953_202086f3e5fee132747d6eaa7a5b4667.pdf

EQUALS Global Partnership. (n.d.). ICT for Girls Programme in Pakistan: Unlocking the potential of women and girls through ICT skills. https://www.equalsintech.org/casestudies-dsh-1/ict-for-girls-programme-in-pakistan%3A-unlocking-the-potential-of-women-and-girls-through-ict-skills

E-thaksalawa, (n.d.) About us. https://www.e-thaksalawa.moe.gov.lk/En/en-about.php

European Training Foundation. (2020). *Tunisia: Education, Training and and employment 2020*. https://www.etf.europa.eu/sites/default/files/document/Country%20Fiche%202020%20Tunisia%20-%20Education_%20Training%20and%20Employment%20Developments.pdf

Fabre, A. & Straub, S. (2021, September). *The Impact of Public-Private Partnerships (PPPs) in Infrastructure, Health and Education*. (Working Paper N° 986). Toulose School of Economics. https://www.tse-fr.eu/sites/default/files/TSE/documents/doc/wp/2019/wp_tse_986.pdf

Glasner, J. (2022, August 25). Ed-tech Funding Falls Sharply. *Crunchbase news*. https://news.crunchbase.com/edtech/venture-funding-falls-sharply-2022/

Global Education Monitoring Report Team. (2021). Concept note for the 2023 Global Education Monitoring Report on technology and education. *UNESCO*. https://unesdoc.unesco.org/ark:/48223/pf0000378950/

Global Education Monitoring Report Team & SEAMEO Regional Open Learning Center. (2023). *Technology in education: a case study on Indonesia*. https://unesdoc.unesco.org/ark:/48223/pf0000387827

Global Education Monitoring Group. (2023). Egypt: technology. UNESCO. https://education-profiles.org/northern-africa-and-western-asia/egypt/~technology

Government of Sindh. (n.d.). *School Education Sector Plan and Roadmap for Sindh (2019 – 2024)*. School Education and Literacy Department. https://rsu-sindh.gov.pk/contents/publications/SESP&R%202019-24.pdf

Government of Punjab. (n.d.). *Punjab IT Policy 2018*. Punjab Information Technology Board. Pakistan.

Haßler, B, Nicolai, S., McBurnie, C., Jordan, K., Wilson, S., & Kreimeia, A. (2020). *Ed-tech and COVID-19 response*. [Save Our Future] (Background Paper No. 3). Education Commission. https://doi.org/10.5281/zenodo.3983877

Hennessy, S., Jordan. K., Wagner, D.A., & Ed-tech Hub team. (2021). P*roblem Analysis and Focus of Ed-tech Hub's Work: Technology in Education in Low- and Middle-Income Countries*. [Working Paper 7]. Ed-tech Hub. https://doi.org/10.5281/zenodo.4332693

Information and Communication Technology Agency. (n.d.). *Programme for a Digitally Inclusive Sri Lanka*. ICTA. https://www.icta.lk/icta-assets/uploads/2020/01/ICTA-Project-Information.pdf

International Telecommunication Union. (n.d.). The development of communication technologies in Tunisia. https://www.itu.int/itunews/manager/display.asp?lang=en&year=2005&issue=09&ipage=tunisia&ext=html

Jalbout, M., & Farah, S. (2016). *Will the technology disruption widen or close the skills gap in the Middle East and North Africa*. (Global Economy and Development Working Paper No. 5). Brookings. https://www.brookings.edu/wp-content/uploads/2016/07/Technology-Disruptionv5.pdf

Jha, A., & Jha, N. (2022). Exploring the Role of Ed-Tech Start-Ups and Digital Divide in Online Learning During the Coronavirus Pandemic in the Indian Education System. In A. Courtney-Dattola (Ed.), H*andbook of Research on Adapting Remote Learning Practices for Early Childhood and Elementary School Classrooms* (pp. 222-248). IGI Global. https://doi.org/10.4018/978-1-7998-8405-7.ch014

Kang, B. (2021). How the COVID-19 Pandemic Is Reshaping the Education Service. In Lee, J., Han, S.H. (Eds.), *The Future of Service Post-COVID-19 Pandemic, Volume 1: Rapid Adoption of Digital Service Technology* (pp. 15–36). https://doi.org/10.1007/978-981-33-4126-5_2

Kenton, W. (2023). Political economy definition, history, and applications. *Investopedia*. https://www.investopedia.com/terms/p/political-economy.asp#:~:text=Political%20economy%20is%20an%20interdisciplinary,work%20in%20the%20real%20world

Khan, S., Hasan, M. & Clement, C. (2012). Barriers to the introduction of ICT into education in developing countries: The example of Bangladesh. *International Journal of Instruction, 5*(2), 61-80. https://www.e-iji.net/dosyalar/iji_2012_2_4.pdf

Komasaru, U.I.W. (2011). *Success of E-Sri Lanka in rural ICT development: A study of e-nenasala telecenters in Rathnapura district* [Master Dissertation, University of Kelaniya]. http://repository.kln.ac.lk/handle/123456789/1033

Lisa, A., Faridi, A., Bharati, D. A. L., & Saleh, M. (2021). A TPACK-in Practice Model for Enhancing EFL Students' Readiness to Teach with Ed-Tech Apps. *International Journal of Interactive Mobile Technologies, 15*(17), 156–176. https://doi.org/10.3991/ijim.v15i17.23465

Major, L., Francis, G. A., & Tsapali, M. (2021). The effectiveness of technology-supported personalised learning in low- and middle-income countries: A meta-analysis. *British Journal of Educational Technology, 52*(5), 1935-1964. https://bera-journals.onlinelibrary.wiley.com/doi/epdf/10.1111/bjet.13116

Mallet (2019). TBC.

Mandal, M., & Srinivas, K. (2022). Education Technology in Schools: Locating the Teacher in the Changing Landscape Of Teaching-Learning: A Study In Secondary Schools. *The International Review of Information Ethics, 32*(1). https://doi.org/10.29173/irie492

Medium. (2016, November 30). E-learning in Palestine. https://medium.com/@enabel/e-learning-curriculum-in-palestinian-primary-and-secondary-education-b59f474a4dad

Ministry of Communications and Information Technoloy. (2020). *MCIT Yearbook 2020*. https://mcit.gov.eg/Upcont/Documents/Publications_142021000_MCIT%20Yearbook%202020.pdf

Ministry of Communications and Information Technoloy. (2021). *MCIT Yearbook 2021*. https://mcit.gov.eg/Upcont/Documents/Publications_2952022000_MCIT%20Yearbook%202021.pdf

Ministry of Education. (n.d.). *Information and Communication Technology (ICT).* Government of India. https://www.education.gov.in/ict_overview#:~:text=The%20Information%20and%20Communication%20Technology%20(ICT)%20in%20Schools%20was%20launched,through%20computer%20aided%20learning%20process

Ministry of Education. (n.d.). *Strategic Plan for Pre-University Education 2014 – 2030: Education Egypt National Project*. Government of Egypt. https://planipolis.iiep.unesco.org/sites/default/files/ressources/egypt_strategic_plan_pre-university_education_2014-2030_eng_0.pdf.

Ministry of Education. (2020). *Sri Lanka: General Education Sector Development Plan (2020 - 2025).* Ministry of Education of Sri Lanka.

Ministry of Education and Higher Education. (2017). Education sector strategic plan 2017-2022: *An Elaboration of The Education Development Strategic Plan III (2014-2019).* Government of Palestine.

Ministry of Education and Training. (2017, May 23). *Directing and operating document*. https://moet.gov.vn/van-ban/vbdh/Pages/chi-tiet-van-ban.aspx?ItemID=2264#divShowDialogDownload

Ministry of Education, Youth and Sport. (2014). *EMIS Master Plan 2014-2018*. https://planipolis.iiep.unesco.org/index.php/es/2014/emis-master-plan-2014-2018

Ministry of Education, Youth and Sports. (2016). *Policy Guidelines For New Generation Schools: For Basic Education in Cambodia.* https://planipolis.iiep.unesco.org/sites/default/files/ressources/cambodia_new_generation_school_policy_guidelines.pdf

Ministry of Education, Youth and Sports. (2018). P*olicy and Strategy on Information and Communication Technology in Education.*

Ministry of Finance Republic of Indonesia. (2021). *APBN 2021: Stimulus and Resilience.*

Ministry of Human Resource Development. (2012). *National Policy on Information and Comuunication Technology (ICT) in School Education*. Department of School Education and Literacy, Government of India.

Ministry of Human Resource Development. (2020). *National Education Policy 2020*. Government of India.

Ministry of Information Technology and Telecommunication. (2018). *Digital Pakistan Policy*. https://moib.gov.pk/Downloads/Policy/DIGITAL_PAKISTAN_POLICY%2822-05-2018%29.pdf

Mogheith, A., AbdelAziz, A., Ali, L. (2019). *Technology Integration in Education in Egypt*. The Public Policy HUB, The School of Global Affairs and Public Policy The American University in Cairo. https://documents.aucegypt.edu/Docs/GAPP/Public%20Policy%20Hub%20Webpage/14-%20Integrating%20Technology%20in%20Education-%20En.pdf

Moustafa, N., Elghamrawy, E., King, K., & Hao, Y. (2022). Education 2.0: A Vision for Educational Transformation in Egypt. In Reimers, F.M., Amaechi, U., Banerji, A.,

& Wang, M. (Eds.), *Education to Build Back Better.* Springer, Cham. https://doi.org/10.1007/978-3-030-93951-9_3

Munoz-Najar, A., Gilberto, A., Hasan, A., Cobo, J., Azevedo, J., & Akmal, M. (2022). *Remote Learning During COVID-19: Lessons from Today, Principles for Tomorrow (English).* World Bank Group. http://documents.worldbank.org/curated/en/160271637074230077/Remote-Learning-During-COVID-19-Lessons-from-Today-Principles-for-Tomorrow

Nagari, A. (2020, August 20). At least 27% students do not have access to smartphones, laptops for online classes: NCERT survey. *Hindustan Times.* https://www.hindustantimes.com/education/at-least-27-students-do-not-have-access-to-smartphones-laptops-for-online-classes-ncert-survey/story-sp8nb0QZoBXXJ8ZsCLb3yJ.html

Nagesh, R., Dreesen, T., van Cappelle, F., & Chopra, V. (2021). Reopening With Resilience: Lessons from Remote Learning during COVID-19 in South Asia. *Innocenti Research Reports.* https://www.unicef-irc.org/publications/1311-reopening-with-resilience-lessons-from-remote-learning-during-covid-19-south-asia.html#:~:text=Large%20differences%20in%20students'%20access,engagement%20and%20support%20from%20educators.

National Education Commission. (2022). *National Education Policy Framework (2020-2030).* National Education Commission.

Nguyen, T. C., Hafeez-Baig, A., Gururajan, R., & Nguyen, N. (2021). The hidden reasons of the Vietnamese parents for paying private tuition fees for public school teachers. *Social Sciences & Humanities Open, 3*(1), 100105. https://doi.org/10.1016/j.ssaho.2021.100105

Nguyen, D. (2022, March 9). How to invest in vietnam's ed-tech industry. *Vietnam Briefing.* https://www.vietnam-briefing.com/news/how-to-invest-in-vietnams-edtech-industry.html/

Orange Foundation. (n.d.). The Digital Schools program: actively supporting education for the poorest. https://www.fondationorange.com/en/digital-schools-program-actively-supporting-education-poorest

Pellini, A., Nicolai, S., Magee, A., Sharp, S., & Wilson, S. (2021). *A Political Economy Analysis Framework for Ed-tech Evidence Uptake.* [Working Paper]. Ed-tech Hub. https://doi.org/10.5281/zenodo.4540204

Pillay, H & Hearn, G. (2009). Public-private partnerships in ICT for education. In S. Akhtar & P. Arinto (Eds.)., *Digital Review of Asia Pacific 2009–2010, pp. 77-87.* https://digital-review.org/uploads/files/pdf/2009-2010/ppp_in_ict4e.pdf

Pratama, A. H. (2021, October 8). Ruangguru becomes profitable, revenue grows by 4x. *Tech in Asia.* https://www.techinasia.com/ruangguru-becomes-profitable-sales-growth-4x

Pratama, A. H. (2019, December 25). Indonesia's top edtech startup raises $150m round led by General Atlantic, GGV Capital. *Tech in Asia.* https://www.techinasia.com/ruangguru-150m-series-c-general-atlantic-ggv-capital

Rao, J., & Prasad, R. (2016). Educational Technology Policies in India and Access. *Commonwealth of Learning (COL) & Open University Malaysia (OUM).* http://hdl.handle.net/11599/2569

Regan, P. M., & Khwaja, E. T. (2019). Mapping the political economy of education technology: A networks perspective. *Policy Futures in Education, 17*(8), 1000-1023. https://doi.org/10.1177/1478210318819495

Reimers, F. & Opertti, R. (Eds.). (2021). L*earning to build back better futures for education: lessons from educational innovation during the COVID-19 pandemic.* UNESCO International Bureau of Education. https://unesdoc.unesco.org/ark:/48223/pf0000383825

Rodriguez-Segura, D. (2022). Ed-tech in developing countries: A review of the evidence. *The World Bank Research Observer, 37*(2), 171-203. https://doi.org/10.1093/wbro/lkab011

Rowell, L. (2010). How Government Policy Drives e-Learning. *eLearn, 10*(3). https://doi.org/10.1145/1872818.1872821.

Ruangguru. (2022). A*nnual Impact Report 2022: Delivering Educational Impacts for the Next Generation.* Ruangguru.

Sanyal, B. C. (2001, September 10-12). *New functions of higher education and ICT to achieve education for all. International Institute for Educational Planning.* [Paper presentation]. Expert Roundtable on University and Technology-for-Literacy/Basic Education Partnership in Developing Countries, Paris, France. UNESCO

SEAMEO. (n.d.). https://www.seameo.org/Main_about/415

Shafritz, J. (2004). The Dictionary Of Public Policy And Administration. Routledge.

Sheikh, M. & Nadeem, U. (2023). Government Embracing Ed-tech: The Case of the TeleSchool App. *Tabadlab.* https://tabadlab.com/the-case-of-teleschool/

Skills Nation. (2022). Singapore: State of Ed-tech Report 2022. https://skillsnation.co/sea_edtechreport/

Smaali Bouhlila, D., Jules, T. D., Hentati, I., Arnold, R. (2022). Navigating through the COVID-19 pandemic. Unfinished learning in primary and secondary education in Tunisia. Tertium comparationis, 28(3), 274-299. https://www.pedocs.de/volltexte/2022/25328/pdf/TC_2022_3_SmaaliBouhlila_et_al_Navigating_through_the.pdf

Smart. (2023). *Smart Axiata continues its support for UNESCO's Basic Education Equivalency Programme.* https://www.smart.com.kh/smart-axiata-continues-its-support-for-unescos-basic-education-equivalency-programme/

Statista Research Department. (2023). Share of primary school students who had access to ICT in Indonesia in 2022, by device. https://www.statista.com/statistics/1394742/indonesia-ict-access-among-primary-school-students-by-device/

Suriastini, W., Pujiastuti, S., Herawati, F., Naryanta, Moddilani, G., & Pellini, A. (2020). *COVID-19 and the education response in Indonesia: exploring the learning crisis. Case study.* EdTech Hub. https://docs.edtechhub.org/lib/VZ3IMPYX

TagHive. (n.d.). Class Saathi by taghive: Powered by Samsung. https://tag-hive.com/

Times of India. (2022). TBC

The World Bank. (2020a). *Individuals using the Internet (% of population).* https://data.worldbank.org/indicator/IT.NET.USER.ZS

The World Bank. (2020b). *The Promise of Education in Indonesia.* https://documents1.worldbank.org/curated/en/658151605203420126/pdf/The-Promise-of-Education-in-Indonesia.pdf

The World Bank. (2021a). *Mobile cellular subscriptions (per 100 people).* https://data.worldbank.org/indicator/IT.CEL.SETS.P2

The World Bank. (2021b). *World Bank Open Data.* https://data.worldbank.org/

The World Bank. (2023). *School enrollment, primary (% gross) - IDA total.* https://data.worldbank.org/indicator/SE.PRM.ENRR?locations=XG

The World Bank. (2018). *School enrollment, secondary (% net).* https://data.worldbank.org/indicator/SE.SEC.NENR

Trust, T., Krutka, D. G., Carpenter, J. P. (2016). "Together we are better": Professional learning networks for teachers. *Computer & Society, 102*, 15-34. https://doi.org/10.1016/j.compedu.2016.06.007

United Nations Educational, Scientific and Cultural Organization. (2023). *Basic Education Equivalency Programme (BEEP).* https://www.unesco.org/en/articles/basic-education-equivalency-programme-beep

United Nations International Children's Emergency Fund. (2022). *Education overview.* https://data.unicef.org/topic/education/overview/

United Nations Relief and Works Agency for Palestine Refugees in the Near East. (2021, April 19). Unrwa Launches Innovative Centralized Digital Learning Platform For Half A Million Palestine Refugee Students. https://www.unrwa.org/newsroom/press-releases/unrwa-launches-innovative-centralized-digital-learning-platform-half-million

United Nations (2023). TBC.

Vegas, E., Shah, S., & Fowler, B. (2021). Ed tech and educational opportunity during COVID-19 school closures: A case study of Chennai. *The Brookings*. https://www.brookings.edu/articles/ed-tech-and-educational-opportunity-during-the-covid-19-school-closures/

Venturra. (2022, September 21). Marathon education. https://www.venturra.com/company/marathon-education/

Weber, A. (2019). E-Learning In The Middle East And North Africa (Mena) Region: Review Of Trends From The First Comprehensive Regional Handbook [Paper presentation].11th International Conference on Education and New Learning Technologies, Palma, Spain. https://doi.org/10.21125/edulearn.2019.1566

WonderTree. (2023). Games for special education - interactive therapy activities wondertree. https://wondertree.co/

Wright, B. (2021, February 4). South East Asia: The New Hotspot for international expansion. *theHRDIRECTOR*. https://www.thehrdirector.com/features/globalisation/south-east-asia-the-new-hotspot-for-international-expansion/

Zubairi, A., Kreimeia, A., Kaye, T., & Ashlee, A. (2021). *Country-Level Research Review: Ed-tech in Bangladesh*. [Country summaries and case studies]. Ed-tech Hub. https://doi.org/10.5281/zenodo.5651981

Annexes

Annex 1. Codes/Themes identified in the analysis

Research Question	Themes/Codes
Importance of Ed-tech	Contribute towards SDG4 "Quality Education"
	Reduce gaps, inequalities/Improve access to vulnerable groups (SDG 10)
	Solving the issue of lack of infrastructure, resources
	Success of Ed-tech based on the number of beneficiaries and expansion over time
	Caters to children with disabilities
	Improve the resilience of the education system
	Innovative education
	Support self-learning
	Reducing costs
	Improve efficiency and time saving
	Teacher in-service education/training
	Connecting students, teachers, parents, admin staff
	Ed-tech as a supplementary resource in schools
	Improve connectivity
	Contribute towards SDG3 "Healthy lives and wellbeing"
	Laws, policies, and regulations
	Accountability

Facilitating factors of ed-tech	Collaborations
	Alternate financing
	Policy priorities
	Teacher training
	Infrastructure availability
	Improved access to technology
	CSR projects
	Improved attitudes towards Ed-tech
	Increased use of technology
	Internal frameworks
	Will and interest of governments
	Will and interest of the private sector
	International organisations - Stakeholders
	Private sector stakeholders
	Public sector stakeholders
Barriers to ed-tech	Lack of teacher training
	Limited resources (infrastructure, hardware etc.) availability - users
	Affordability (users)
	Unequal access (users)
	Insufficient network coverage (users)
	Limited human resources (experts, personnel etc.) – supply side
	Lack of funding (supply side)
	Governance and Institutional inadequacies
	Negative attitudes towards Ed-tech (users)
	Inadequate coverage (Supply side)
	Cultural factors
	Lack of vision and strategy
	Inadaptability of organisations
	Lack of student competencies
	Deterioration of infrastructure
	Lack of maintenance

Impact of COVID-19	Accelerated use of Ed-tech
	Impact of COVID-19
	Laws, regulations, and support mechanisms
	Supply-side expansion of Ed-tech
	New collaborations
	Future planning
	Lessons learnt

Note. The codes/themes are listed in the order of importance such that the themes that were cited the most are listed first. Elaborated by the authors.

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