

Cambodian Secondary School Teachers' Readiness for Online Teaching During the Covid-19 Pandemic

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CDRI

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Abbreviations

ADB	Asian Development Bank
CDRI	Cambodia Development Resource Institute
CK	Content knowledge
CPK	Content pedagogical knowledge
DFAT	Department of Foreign Affairs and Trade
DoPo	Department of Policy
Edtech	Educational technology
ESWG	Education Sector Working Group
HDI	Human development index
ICT	Information and communication technology
INSET	In-server Training
LMC	Lancang-Mekong Cooperation
LMS	Learning Management System
LSS	Lower secondary school
MoEYS	Ministry of Education, Youth and Sport
NGO	Non-government organisation
NIE	National Institute of Education
PCK	Technological content knowledge
PK	Pedagogical knowledge
PRESET	Pre-service training
PTTC	Provincial teacher training centre
RTTC	Regional teacher training centre
RUPP	Royal University of Phnom Penh
SEIP	Secondary Education Improvement Project
TCK	Technological content knowledge
TK	Technological knowledge
TPACK	Technological pedagogical content knowledge
TPK	Technological pedagogical knowledge
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USS	Upper secondary school

Executive summary

The Covid-19 pandemic locked students all around the world out of school and caused unprecedented educational disruptions for more than two years. Like other countries, Cambodia switched from the traditional physical classrooms to online and distance learning during school closures. Cambodian schools were able to reopen their doors briefly at the end of 2020 after the first nationwide school closure in March earlier that year. However, large-scale community outbreaks in February 2021 forced schools to close again. There have been successful lessons in developed countries where online learning and teaching were used in a form of blended learning, a combination of online and in-person lesson delivery, to help low-performing students in disadvantaged areas. Nevertheless, teachers in developing countries, like Cambodia, were caught unprepared when schools were suddenly shut down and education had to be moved away from traditional in-person classrooms. It is likely that the mere supply of online learning is not sufficient to induce take-up, student engagement and effective learning. Understanding online learning and teaching practises as well as their technological readiness can be indispensable for future policy discussions on how to make education systems more resilient against future shocks and uncertainties. This study intends to review alternative teaching methods during the Covid-19 pandemic and examine teacher readiness in adopting educational technology (edtech) for online teaching as well as factors associated with readiness in the context of secondary schools in Cambodia.

This study employs descriptive statistics to examine teaching practises and teacher readiness, while regression analysis is used to identify factors correlated with teacher readiness for online teaching. To assess teacher readiness, we adopted the Technological Pedagogical Content Knowledge (TPACK), a framework developed by Mishra and Koehler (2006). Data analysis draws on the surveys of 687 teachers at 43 secondary schools in 10 Cambodian provinces, primarily collected by CDRI and the MoEYS in November 2021. Interviews were conducted remotely by ten trained enumerators via Zoom, Telegram, and telephone. The response rate was 86.17 percent.

The findings show that nearly all the sampled teachers experienced teaching online during the school closure, although about a third of them had completely returned to physical in-person teaching at the time of the interview. Although a good share of teachers adopted both synchronous and asynchronous teaching approaches for their online teaching, more than half of teachers who taught online used only one approach (either synchronous or asynchronous). Male teachers at resource schools in urban areas are more likely to use both approaches for their online teaching. The most popular platforms used for synchronous teaching are Google Classroom and Zoom, although some teachers also use Facebook Messenger and Telegram for their live sessions. A concern about the quality of classroom teaching is that nearly 30 percent of those who used a synchronous approach did not prepare new teaching materials other than what they normally used in traditional in-person classrooms. For asynchronous teaching, providing worksheets and reading materials are the most common practises, while very few teachers developed videos or PowerPoint slides for their students.

To prepare themselves for online teaching, teachers took part in capacity development activities, mostly in the form of training workshops or seminars, yet about 20 percent of teachers reported that they did not participate in any capacity development activities during the pandemic. A majority of teachers have access to computers, but most of them used smartphones for online teaching. Another noticeable trend is that a large percentage of teachers have access to school computers and other facilities, but not many of them use the available resources. Based on

the TPACK instrument, Cambodian secondary teachers think their pedagogical and content knowledge is relatively high at 3.92 and 3.88 respectively. However, their technological knowledge is low at 2.87. In other words, Cambodian teachers are not very familiar with technology in general but are more confident in their knowledge of pedagogy and subject content. The regression analysis suggests that at the individual level, factors that influence teacher readiness include gender, age, perceived challenge and perceived effectiveness of online teaching. Experience teaching at private schools and level of student-teacher interaction are also found to be positively associated with teacher readiness, while initial pre-service and in-service training are found to have little to no influence on teacher readiness. Teachers with access to computers seem to demonstrate a higher level of readiness for online teaching. As expected, teachers in Phnom Penh are likely to be more ready for online teaching, but to our surprise, teachers at resource schools exhibit a lower level of readiness than their peers at general schools.

Based on the findings, this study offers some implications for policy discussion and suggestions for further studies. First, there is a need to revisit teacher training curricula and examine if more edtech courses should be introduced in the programs. The MoEYS should also consider providing systematic in-service training courses on edtech for practising teachers, in particular for female and older teachers. Second, online learning is unlikely to stay after the pandemic, as a majority of schools and teachers have completely returned to the physical classroom as normal. The MoEYS should make extra efforts to keep the online approach as a part of learning and teaching. Third, there should be a further investigation into the reasons behind the underutilisation of school resources and how these resources can be effectively put to use. The finding that teachers at resource schools are less prepared raises more questions than answers. Since this is a correlational study, more rigorous studies using quasi-experiment should be done to assess the effectiveness of school resources.

1. Introduction

The Covid-19 pandemic has created educational disruption around the world by forcing schools to close their doors to curb the spread of the virus. At its peak in April 2020, it is estimated that more than 1.6 billion students worldwide were locked out of their schools (Dita et al. 2020). To keep learning ongoing, schools had no choice but to swiftly switch from the traditional physical classroom to new forms of remote teaching and learning modalities such as paper-based worksheets, broadcast media through TV and radio, mobile phone and digital online platforms (UNESCO et al. 2021). Some countries have attempted to reopen their school system only to see it being disrupted again and again by other waves of outbreaks.

On 16 March 2020, the government of Cambodia decided to close all learning institutions, including public and private schools, as preventive measures in response to the increase of Covid-19 cases. Although all schools were reopened to start the new academic year in January 2021, the 20 February incident—a large-scale community outbreak detected after two Chinese nationals snuck out of their quarantine hotel—forced the government to close schools nationwide and move to distance learning again. A joint Covid-19 assessment in Cambodia conducted by the MoEYS in collaboration with development partners in 2020 found that only 70 percent of students engaged in some forms of alternative distance learning, and only 35 percent of them had access to online learning materials (MoEYS and Education Sector Working Group [ESWG] 2021). By the UNDP’s estimation, the Cambodian human development index (HDI) dropped from 0.594 in 2019 to 0.571 in 2020, meaning Cambodia lost the progress the country had made in the past four years due to school closures during the pandemic (Khuon 2021).

When the Internet became widely accessible in the 2000s, online learning and other forms of distance learning were integrated into or used to supplement the traditional classroom, mostly in developed countries. The partial integration of online learning into the physical classroom with some element of student control over the learning process is called blended learning (Horn and Staker 2015, Graham 2012). According to Horn and Staker (2015), the United States adopted blended learning to help underperforming students improve their learning and provide more options for small and remote schools that cannot offer courses with highly qualified teachers in certain subjects. Although the Covid-19 outbreak introduced many challenges in education, it has helped accelerate online learning rapidly, and blended learning has become a buzzword among education researchers. Online learning is expected to permanently change the way students learn and how teachers deliver their lessons. It is likely to remain part of classroom learning, blending with the traditional mortar-and-brick learning even after the pandemic. The hope of going back to the “old standards” is shrinking and the imperative of the “new normal” becomes more and more obvious.

However, there are also many challenges in implementing or integrating online learning effectively, especially in developing countries like Cambodia (MoEYS and ESGW 2021, World Bank 2021). Some key challenges in delivering distance learning during the Covid-19 pandemic include lack of teacher and student preparedness in adopting new technology, lack of necessary digital devices, access to Internet connection, limited institutional capacity to support teachers and poor access to the Internet in rural and remote areas. There are also regional disparities in terms of access to and quality of online learning, as in rural areas the access to the Internet is limited and a large number of students do not have access to digital devices (Marshall 2022). Online learning can provide new opportunities and flexibilities that can be personalised to student needs and levels. Yet, the Covid-19 pandemic came when most education systems and teachers were not ready to reap its benefits (Schleicher 2021).

The evidence on the effectiveness of online learning is still nascent in the context of developing countries, but it is likely the mere supply of online learning is not sufficient to induce take-up, student engagement or effective learning. Cross-country evidence suggests that adoption of distance learning does not ensure quality of learning during the pandemic (Muñoz-Najar et al. 2021). Understanding online learning and teaching practises on the ground during the pandemic and the level of teacher technological readiness can be indispensable inputs for future policy discussions on how to make education systems more resilient against future shocks and uncertainties. In this sense, this study intends to examine the current practises, challenges and possibilities of online learning that can contribute to building back a more resilient education system in Cambodia. Since there are more potential opportunities in integrating or supplementing online learning into the traditional classroom at a secondary education level, this study narrows its focus to only public secondary schools. Specifically, the study has two main objectives:

- To review alternative online teaching modes during the Covid-19 pandemic that have potential for future blended learning integration, as well as teacher challenges at secondary schools in Cambodia
- To examine teacher readiness in adopting educational technology (edtech) in online teaching and factors associated with the readiness

2. Literature review

2.1. The shift to online and distance learning and teaching

By mid-2020, most teachers around the world were forced to cease their traditional in-person classroom activities and switch to remote teaching due to the spread of the pandemic. Depending on the access to digital devices, infrastructure and capacities of students and teachers, schools adopted various forms of remote or distance teaching. Those teaching modes include worksheet handouts, radio or TV broadcastings and online learning. In many cases, the online learning approach is considered to be more effective than other forms of distance learning due to its abilities and flexibility. Online classes (i.e., synchronous and asynchronous) have been adopted depending on the purpose and actual situations on the ground using several types of learning platforms, teaching strategies and learning media (Shi, Tong, and Long 2021; Kuzminska et al. 2021; Setiadi et al. 2021). However, the lack of adequate infrastructure and Internet connection were reported to be key barriers to effective learning and teaching during school closure in developing countries (Azhari and Fajri 2021). In Canada, a study found that the level of teachers' online learning experience and professional development were key factors affecting their self-efficacy for teaching online during lockdown.

Even though providing online classes is more common for teachers in developed countries, in developing countries, lack of infrastructure, access to the Internet and digital devices as well as teachers' limited knowledge and skills of educational technology is found to be barriers to effective online teaching and learning during the Covid-19 pandemic. In their studies of secondary schools in Afghanistan, Libya, and Palestine, Khlaif et al. (2021) reported that teachers' unpreparedness for online classes is partly due to a lack of teacher capacity-building in the areas of technology and alternate pedagogies. In addition to teacher capacity-building, the quality of learning and teaching was exacerbated by the poor quality of learning materials (Khlaif and Salha 2020). Given these situations and constraints, it is understandable that teachers are not trained and do not have time to prepare content for distance learning when classrooms were suddenly moved from the traditional face-to-face classrooms.

Like other countries, Cambodian teachers had no choice but to embrace distance learning after the MoEYS issued the directive to close all educational institutions from preschool to higher education on 16 March 2020 (World Bank 2021). However, there are challenges in conducting distance learning and teaching, particularly with online classrooms. According to the MoEYS and ESWG's assessment report (2021), the supply constraints include teachers' access to digital devices at home (53 percent), insufficient Internet access (47 percent) and caregivers' limited information and communication technology (ICT) competencies (33 percent). To address these issues, teachers adopt a home-based learning approach using worksheets (89 percent), teaching students in small groups (85 percent) and contacting students virtually through online communication (75 percent). Furthermore, most teachers and school directors (87 percent) believe they do not have sufficient knowledge and skills to perform their duties effectively during school closures. There is an urgent need for Cambodian teachers to enhance their knowledge and skills on how to develop lesson plans and teaching materials for distance learning and to use social media and online learning platforms in their teaching.

To ensure a smooth transition to online teaching, the MoEYS has put great effort into providing training for teachers in developing teaching materials and guidelines for online classes. However, despite these efforts, only 18 percent received proper training and are well-prepared for the transition toward online/distance teaching (World Bank 2021). In addition, the government and developing partners, including the Asian Development Bank (ADB) and World Bank, also equipped schools with ICT devices and computer labs to support online learning activities. It is crucial for educational institutions to expand the provision of online learning platforms, Internet access and online library materials, and for the government to provide training to teachers throughout Cambodia, including in rural areas (Heng and Sol 2020).

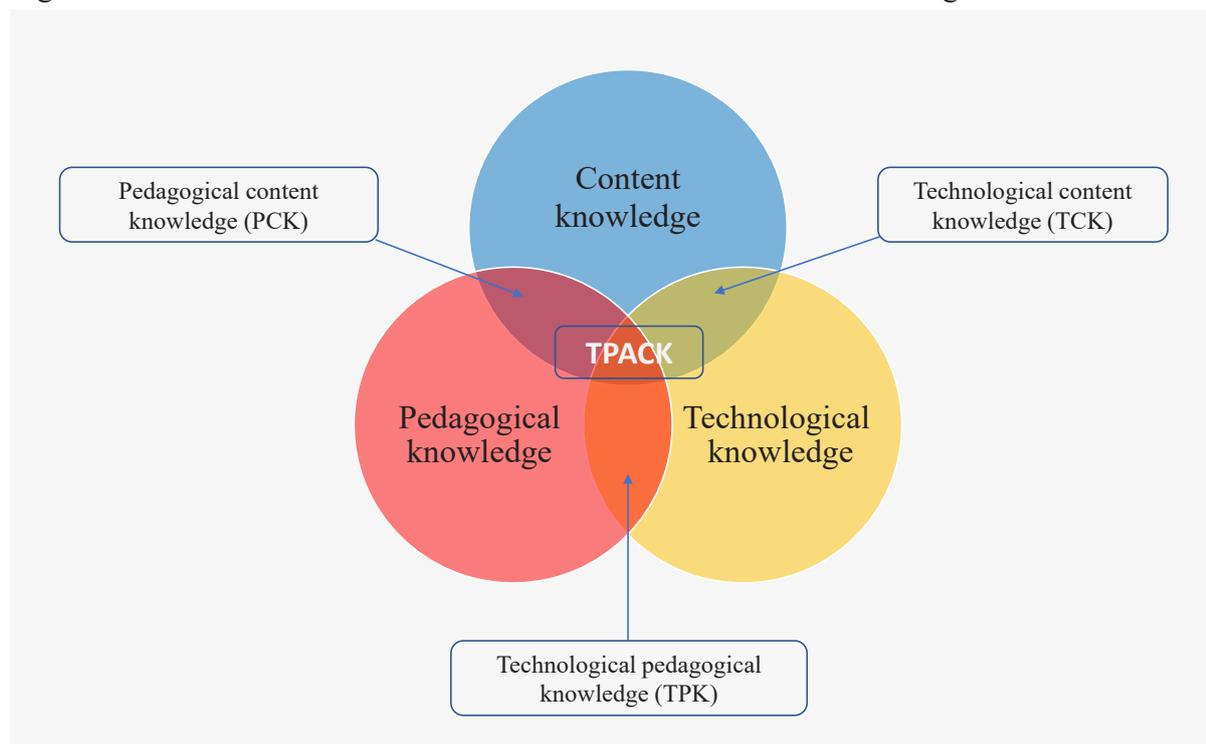
2.2. Teacher readiness for online teaching

Several indicators were developed and used to measure teacher readiness for online teaching even before the outbreak of the Covid-19 pandemic. Cavas et al. (2009) and Panol, Caballes and Vasquez (2020) measured teacher readiness for online teaching mainly from technical and pedagogical perspectives. Ventayen (2018) used a set of indicators that includes technical skills, attitudes toward online learning, time management and time commitment to measure the teachers' readiness for online teaching in the Philippines. Another instrument devised for faculty members was developed by the University of Toledo used by Junus et al. (2021) to measure Indonesian lecturers' readiness in conducting online teaching during the pandemic. The instrument consists of five components, namely basic technical skills, learning management system experience, course planning and time management, communication and course design. Although several survey instruments to capture teachers' readiness for online learning have been developed and tested in empirical studies, TPACK is probably the most frequently used self-reported instrument to measure teacher competencies in adopting online learning or edtech in general education (Dewi et al. 2021).

The TPACK is an inextricable combination measuring knowledge of teaching content, teaching methods and technology. It was developed as an extension of Shulman's (1987) seminal study on pedagogical content knowledge (PCK). PCK indicates teachers' competencies in delivering classroom instruction in accordance with the level of each student, and content knowledge, which implies knowledge of specific subjects. In other words, PCK is a combination of content knowledge, understanding of the learner and teaching methods (Park and Oliver 2008). The TPACK framework adds a technology dimension, or technological knowledge (TK), to the PCK, and focuses more on teachers' challenges of teaching with technology (Koehler and Mishra

2009). The TPACK covers three knowledge areas, known as pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK). As illustrated in Figure 1, the intersection of two knowledge areas are pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK). The TPACK, the central intersection of the three knowledge areas, is the foundation for effective teaching with technology that requires teachers not only to have content knowledge of their teaching subject matters and pedagogical knowledge on how to teach, but also knowledge of how technology can be used effectively in their classroom (Mishra and Koehler 2006).

Figure 1: The TPACK framework of teacher readiness for online teaching



Source: Prepared by the authors based on Mishra and Koehler (2006)'s TPACK framework

In recent years, there have been an increasing number of studies examining teachers' readiness for online teaching in all levels of education from pre-school to higher education using the TPACK, in particular after the shift to online classrooms during the school closure (Ardic 2021; Özgür 2020; Jang and Tsai 2013; Scherer et al. 2021; Fahadi and Khan 2022). The TPACK has been refined through studies in various countries as a framework for measuring teachers' knowledge needed for successful technology integration in classroom teaching. This study adopts the TPACK framework as the instrument to measure teachers' readiness for online teaching as it has been used, both in developed and developing countries, and is considered to be more suitable for the context of secondary school.

2.3. Factors associated with teacher readiness

From an extensive review of existing literature, this section discusses factors associated with teacher readiness for online teaching by grouping them into individual characteristics, teaching attributes, teacher education and training, access to technology and school characteristics.

At the individual level, prior studies examined a wide range of factors including gender, teaching experience, exposure to technology and educational background. Shea (2019) argued

that female teachers are more motivated to conduct online classes and have higher technology competency since female teachers think online teaching is more flexible and convenient. Another study in Turkey found male teachers are more likely to be ready for online teaching readiness and had higher perceived capacities in using technology for teaching (Ergen et al. 2019). A cross-country study conducted during the pandemic showed that besides gender, online teaching experiences are positively correlated with teacher readiness in 64 countries (Scherer et al. 2021). For the educational factors, Hung (2016) found that teachers holding master's degrees possessed a higher level of readiness than those with a bachelor's degree. Another study applying descriptive statistics for a cross-sectional survey of higher education in Spain with 166 teachers found regular online classes and frequent use of technology improves teachers' self-efficacy and leads to high readiness (Muñoz Carril, González Sanmamed and Hernández Sellés 2013). The experience of teachers and the extent to which they are exposed to technology, such as using ICT regularly, should also be taken into account. In Korea and Singapore, teachers' experience with online classes and frequent use of technology helped enhance their ability to quickly solve anticipated classroom or technology-related problems (So et al. 2012). Zou et al. (2021) argued that a key challenge perceived by teachers in China is students' disengagement in online classrooms. During the pandemic in Saudi Arabia, perceived effectiveness of online class was found to be positively correlated with the shift to online teaching (Alqabbani et al. 2021).

Related to the teaching attribute, academic discipline is inconsistently found to influence the readiness of teachers for online teaching. Scherer et al. (2021) noted that academic discipline has different characteristics, cultures and appropriate pedagogical content, which affect teachers' online teaching and learning readiness. In Turkey, Summak, Bağlibel and Samancioğlu (2010) found no significant differences in teachers' readiness for online teaching by subjects. One study in the Philippines found real-time student-teacher interaction is a significant factor for a smooth transition of blended learning, since it is closer to a face-to-face classroom, making it easier for teachers to deliver their lessons (Cahapay et al. 2020)

Through a systematic review, Atmacasoy and Aksu (2018) revealed that pre-service teacher training in Turkish had improved the teachers' readiness for blended learning, as well as their ICT skills. However, using the online learning readiness scale, Dorsah (2021) argued that in Ghana, pre-service teachers are not well-trained in aspects such as computer and Internet self-efficacy, learner control, and online communication for online learning. We know little about the effectiveness of in-service teacher training on teachers' online class readiness. However, it is noted that in-service teacher training in Malaysia contributes to improving teachers' basic ICT skills and knowledge, which is related to their readiness (Mahmud and Ismail 2010).

Needless to say, online classrooms cannot happen without proper technology infrastructure. Therefore, access to and use of technology are considered important in contributing to teacher readiness. Studies have shown that access to ICT devices is positively associated with teacher readiness (Mwapwele et al. 2019; Nikolopoulou et al. 2021). Furthermore, having stable Internet connection is vital to online learning and teaching in developing countries (Mncube, Olawale and Hendricks 2019). The World Bank (2021) stresses that the unequal diffusion of the Internet and ICT across Cambodia poses challenges for distance learning, particularly in remote areas.

According to Hung (2016), institutional support by schools, such as supervisor support, colleague support, and a positive organizational atmosphere, can also improve teachers' online responsiveness. Hsu and Chen (2021) applied a two-level hierarchical liner model (HLM) to

test how school level innovation diffusion affect EFL teachers in Taiwan. They found that diffusion of technology at the school level significantly influences Taiwanese EFL teachers' TPACK, even though the study failed to control for some important variables (i.e., age, teaching experience and gender) in their analytical framework. Teacher readiness is also found to be affected by what type of schools they are affiliated with. This was shown to be the case in Alper's (2020) study in Turkey during the Covid-19 pandemic when mathematic teachers at private schools could move to distance education quickly and smoothly. As suggested in the case of Indonesia, teachers in rural areas with weaker Internet connections exhibit a lower level of readiness for online teaching (Azhari and Fajri 2021, Lase et al. 2022).

Although there is growing attention on teacher competence for online teaching and more studies related to the topic have been conducted in recent years after the Covid-19 pandemic, none of them are in the context of Cambodian secondary schools. Reports published by MoEYS and Education Sector Working Group [ESWG] (2021) and World Bank (2021) provided us with some statistics related to distance and online education during Covid-19 and challenges in conducting online learning. However, little is known about how much Cambodian teachers are ready to embrace educational technology for online teaching, not to mention the factors that can influence their readiness.

3. Methodology

To explore alternative teaching practises adopted by Cambodian teachers during the Covid-19 pandemic, the study applies descriptive statistics and cross-tabulation by gender (female and male), location of school (rural and urban) and type of school (general school and resource school) to see the difference between the sub-groups. In this study, the TPACK is used to measure the teacher readiness for online teaching and a set of ordinary least square (OLS) regression models are employed to examine factors influencing the readiness of teachers in Cambodian secondary schools. The conceptual framework, data and model specifications are elaborated in the section below.

3.1. Conceptual framework

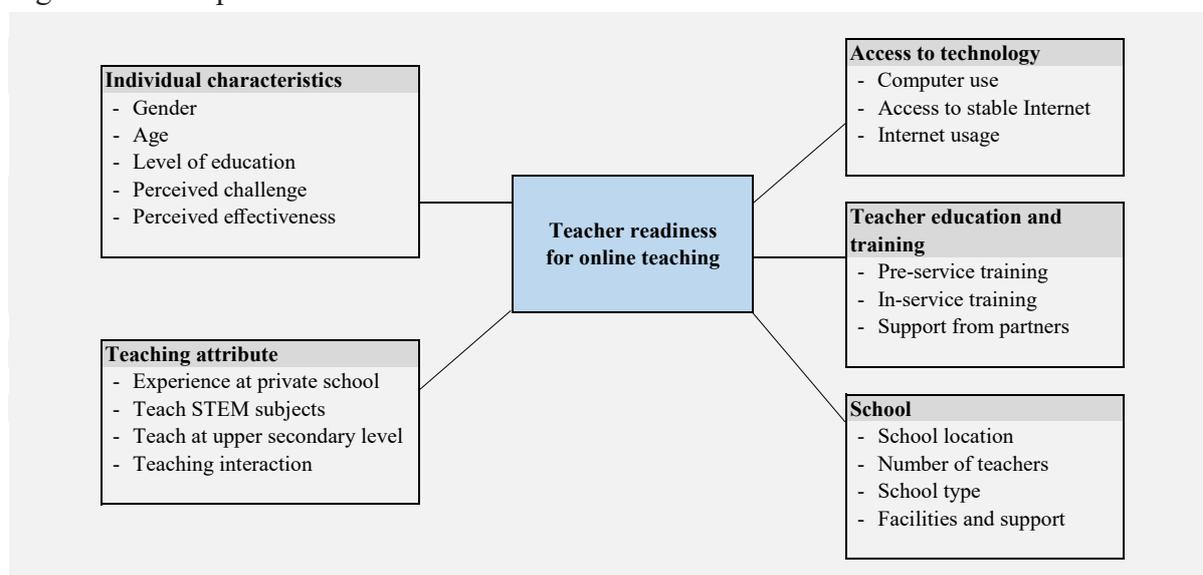
One of the main objectives of this study focuses on secondary school teachers' readiness for online teaching during the Covid-19 pandemic in Cambodia and the factors associated with teacher readiness. The current study adopts Mishra and Koehler's (2006) TPACK framework discussed in Section 2 to measure teacher readiness in applying technology in their teaching. The self-reported TPACK instruments were commonly used to assess teacher competencies in using technological tools well before the widespread Covid-19 pandemic. Several studies used it to capture teacher competencies in adopting edtech during the pandemic (Boonsue et al., 2021; Hsu & Chen, 2021; Scherer et al., 2021). A 33-item five-point Likert scale questionnaire is used to measure secondary school teachers' TPACK. The instruments were adopted from Schmid, Brianza and Petko (2020) with slight modifications to fit the Cambodian context. The TPACK instrument questionnaire can be found in Appendix A.

Based on the literature reviewed in the section above, Figure 2 illustrates the conceptual framework for the analyses in this study. Potential factors assumed to have influences on teacher readiness for online teaching can be grouped into five categories: individual characteristics, teaching attributes¹, access to technology, teacher education and training (pre-service and in-

¹ Teaching experience is not included in the models, as it is closely related to teachers' age.

service training) and school characteristics. A series of regression analyses are performed to detect factors influencing teacher readiness for online teaching.

Figure 2: Conceptual framework



Source: Prepared by the authors

3.2. Data

3.2.1. Sampling and sample size

For the sample selection, the study employs a three-stage sampling method to select the participants. First, to ensure that it covers all the regions (central plain, coastal and sea, plateau and mountains, Tonle Sap and the capital), 10 provinces are purposively selected as target provinces. Those provinces are Battambang, Kampong Cham, Kampong Speu, Kampong Thom, Kampot, Koh Kong, Otdar Meanchey, Phnom Penh, Prey Veng and Ratanak Kiri. Since the study has a special focus on resource secondary schools supported by the ADB's Second Upper Secondary Education Sector Development Program (USESDP 2), all 21 resource secondary schools in the 10 provinces were selected. In addition to the resource schools, the study also includes another 22 general schools randomly selected from the list of secondary schools in the 10 provinces. In total, 43 secondary schools were selected. As reported in Table 1, among the selected schools, 27 are in rural areas and 16 are in urban areas. When schools are grouped by education cycle, 14 schools offer only lower secondary education from grades 7 to 9, two schools provide only upper secondary education from grades 10 to 12, and the remaining 27 schools can accommodate both lower and upper secondary education from grades 7 to 12.

Table 1: Sampled schools

	Area		Education Cycle			All
	Rural	Urban	LSS Only	USS Only	LSS and USS	
General school	18	4	14	0	8	22
Resource school	9	12	0	2	19	21
Subtotal	27	16	14	2	27	43

Source: Authors' calculation based on the teacher survey

After the selection of the secondary schools, the research team obtained lists of teaching staff of the sampled schools from the MoEYS's Department of Personnel for stratified random sampling. The number of teachers selected per school was based on the size of teaching staff.

3.2.2. Data collection

Since Covid-19 had not subsided by the time of the survey, all interviews were conducted remotely using KoboToolbox. Video conference using Zoom was the preferred platform to conduct the interviews; however, due to Internet connection issues and respondents' preferences, Telegram and telephone were also used for some interviews. Before starting the data collection, 10 enumerators were trained, and a pre-test was conducted. The team interviewed 55.49 percent of respondents via Zoom, 35.98 percent through telephone, 2.29 percent through Telegram and the remaining 6.25 percent were interviewed using more than one means of communication. The response rate was 86.17 percent. The research team was able to trace all the randomly selected teachers, but some teachers were dropped because either they had moved to another school, taken a non-teaching role or were on sick leave at the time of the survey. In total, the survey collected complete information from 687 teachers. The survey was conducted by the trained enumerators between 1 November and 24 November 2021. The information collected from the questionnaire survey included i). Teacher demographic information; ii). Initial training and professional development; iii). Teaching during Covid-19; iv) Access to and use of ICT facilities and services; v). Teacher readiness (TPACK); and vi). Impact of Covid-19 on teaching and learning.

3.3. Empirical method

Following the conceptual framework, the equation for estimations of teachers' readiness is expressed as follows:

$$TR_{ij} = \beta_0 + \beta_1 Individual_{ij} + \beta_2 Teaching_{ij} + \beta_3 Tech_{ij} + \beta_4 TET_{ij} + \beta_5 School_j + \varepsilon_{ij}$$

where TR_{ij} denotes the teacher readiness of teacher i teaching at school j . $Individual_{ij}$ is a set of factors related to individual characteristics (i.e., gender, age, level of education, perceived challenge and perceived effectiveness of online learning); $Teaching_{ij}$ denotes a set of factors related to teaching attributes (i.e., experience teaching at private school, teaching STEM subject, level of teaching grade and interaction with students); TET_{ij} denotes a set of variables related to teacher education and training (i.e., duration of pre-service training, technological pedagogical knowledge acquired at pre-service training and capacity development activities during the pandemic); $School_j$ is a set of factors related to affiliated schools (i.e., school location, number of teachers, school facilities and type of school), and ε_{ij} is the error terms. As recommended by Abadie et al. (2017), standard errors in all models are clustered at the school level for the sampling design reason. As mentioned earlier, the study adopted a multiple-stage sampling method by first selecting 10 provinces, from which 43 schools were chosen. At the final stage, teachers were randomly selected from each school. The motivation to adjust the standard errors is because the outcome residuals (or unobserved factors) are likely to be correlated within the same school, so it is more appropriate to cluster the standard errors at the school level.

Descriptive statistics for the variables used in the regression models are displayed in Table 2. Although the number of total observations in this study is 687, only 637 observations of those who have experienced teaching online, as well as complete information on each variable were kept in the regression estimation.

Table 2: Descriptive statistics

	Obs.	Mean	Std. Dev	Min	Max
Teachers' readiness for online teaching					
- TPACK	637	3.427	0.699	1	5
- TPK	637	3.577	0.605	1	5
- TCK	637	3.293	0.737	1	5
- TK	637	2.887	0.691	1	5
- Overall	637	3.576	0.408	2.09	5
Individual characteristics					
- Male	637	0.562	0.497	0	1
- Age	637	40.515	8.880	22	66
- Education level (Base group is associate degree and high school)					
Bachelor's degree	637	0.612	0.488	0	1
Master's degree or PhD	637	0.110	0.313	0	1
- Perceived challenge*	637	2.650	0.353	1.571	3.714
- Perceived effectiveness**	637	48.653	17.293	3	100
Teaching attributes					
- Teach at private schools	637	0.399	0.490	0	1
- Teach science	637	0.488	0.500	0	1
- Teach upper secondary level	637	0.571	0.495	0	1
- Student interaction	637	3.500	0.492	1.4	5
Teacher education and training					
- PRESET duration (Year)	637	1.922	0.789	1	5
- INSET (TPK)	637	0.199	0.400	0	1
- INSET (edtech)	637	0.708	0.455	0	1
- ADB project support	637	0.217	0.412	0	1
- SIEP project support	637	0.057	0.231	0	1
Access to technology					
- Computer	637	0.479	0.500	0	1
- Wi-Fi or cable Internet at home	637	0.374	0.484	0	1
- Wi-Fi or cable Internet at school	637	0.330	0.470	0	1
- Weekly hours of Internet usage	637	8.093	9.263	0	70
School characteristics					
- Phnom Penh	637	0.228	0.420	0	1
- Urban school	637	0.565	0.496	0	1
- Resource school	637	0.689	0.463	0	1
- Number of teachers (ln)	637	4.281	0.846	1.609	5.521
- School facilities	637	0.357	0.057	0.25	0.5

Source: Authors' calculation based on the teacher survey

Note: * Perceived challenge is estimated based on seven five-Likert scale indicators related to teaching challenges during the pandemic.

** Teachers were asked to rate the effectiveness of online teaching using a scale from 0 to 100.

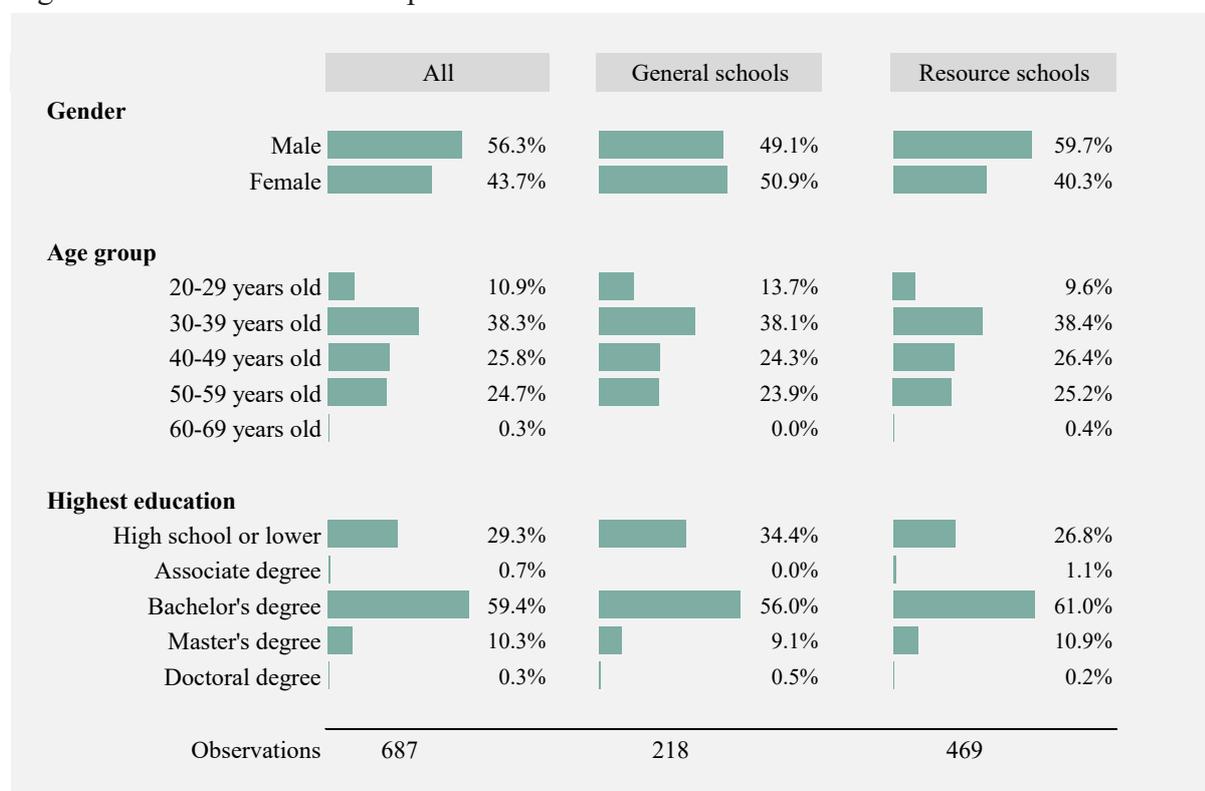
4. Results

4.1. Characteristics of respondents

The teacher survey was conducted with 687 teachers, 56.3 percent of whom are males and 43.7 percent are females. When the samples are grouped by school type, the male ratio at resource schools is much higher than female, while in general schools the number of female teachers is slightly higher than their male counterparts. The high male ratio at resource schools is likely because there are more male teachers at an upper secondary education level. As shown in Table 1, all resource schools are either upper secondary schools or complete secondary schools (offering both lower and upper secondary education), while a majority (over 60 percent) of general schools provide only lower secondary education. It is worth noting the ADB project supports only the upper secondary schools, but not lower secondary schools.

Figure 3 presents characteristics of the respondents. The average age of the teaching force is 40.97 (40.19 at general schools and 41.33 at resource schools). About 10 percent of our respondents are aged between 20 and 29 years old, and more than a third (38.3 percent) of the teachers are in their 30s. More than half of the surveyed teachers were aged 40 years or older. There is no noticeable difference in age between teachers at general schools and resource schools, although teachers at general schools are relatively younger. About 60 percent of the surveyed teachers hold bachelor's degrees and the other 10 percent obtained master's degrees, while nearly 30 percent of them only completed high school education or lower. Teachers with lower levels of education are concentrated among lower secondary school teachers.

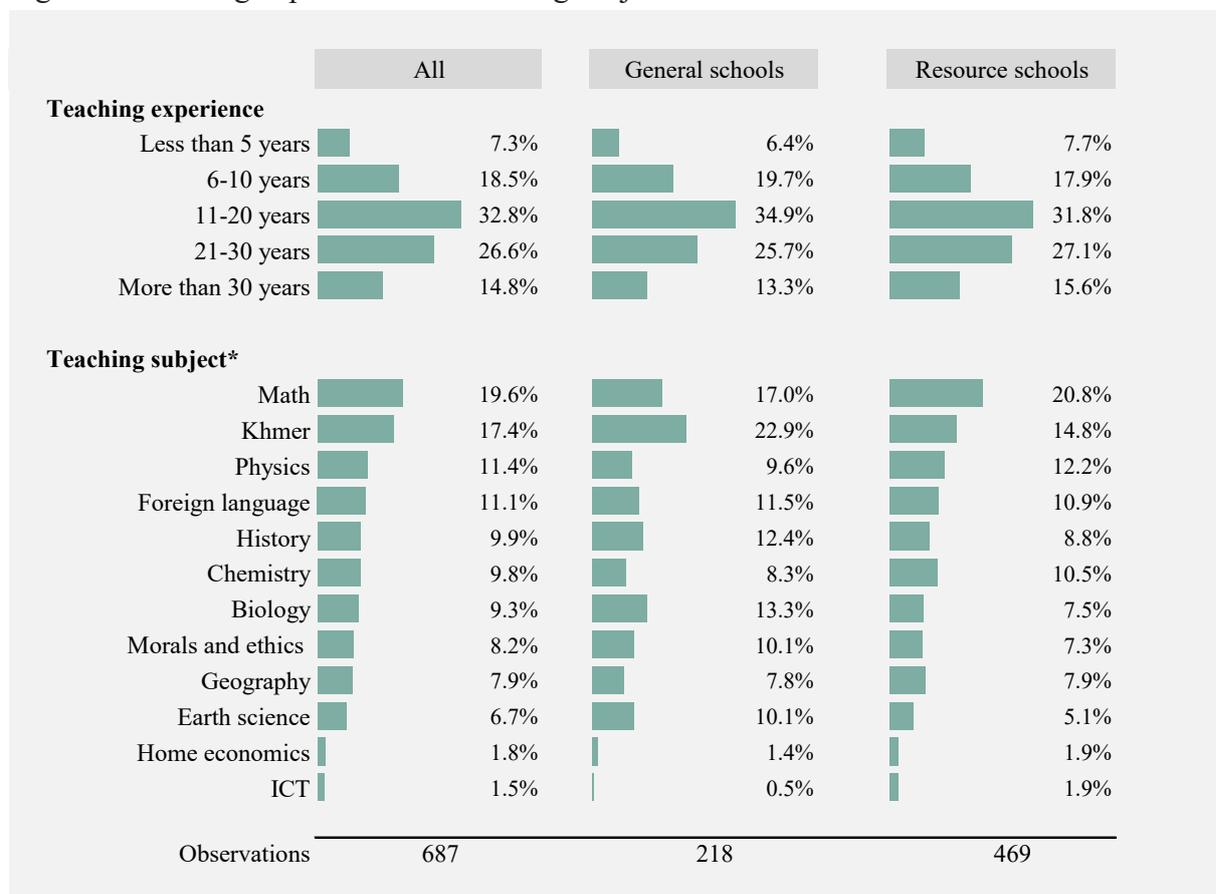
Figure 3: Characteristics of respondents



Source: Authors' calculation based on the teacher survey

Figure 4 illustrates teaching backgrounds of the respondents. On average, our respondents have been in teaching careers for 18.63 years (19.24 years for males and 17.85 years for females). Only 7.3 percent of the sampled teachers have teaching experience for fewer than five years, while 41.5 percent of them have been in the teaching career for more than 20 years, and 14.9 percent have been teaching for over 30 years. More than one-third of secondary school teaching workforces in the study are either teaching mathematics or Khmer. Over one-fifth (22.9 percent) of respondents at the general schools taught Khmer, and 20.8 percent of the respondents at resource secondary schools are mathematics teachers. The ratio of ICT is still very low, as only 1.5 percent of surveyed teachers reported they are ICT teachers. The shortage of ICT teachers at general secondary schools seems to be severe, as only 0.5 percent of interviewed respondents are ICT teachers. The ICT teacher ratio at resource schools is nearly four times higher at 1.9 percent.

Figure 4: Teaching experience and teaching subjects



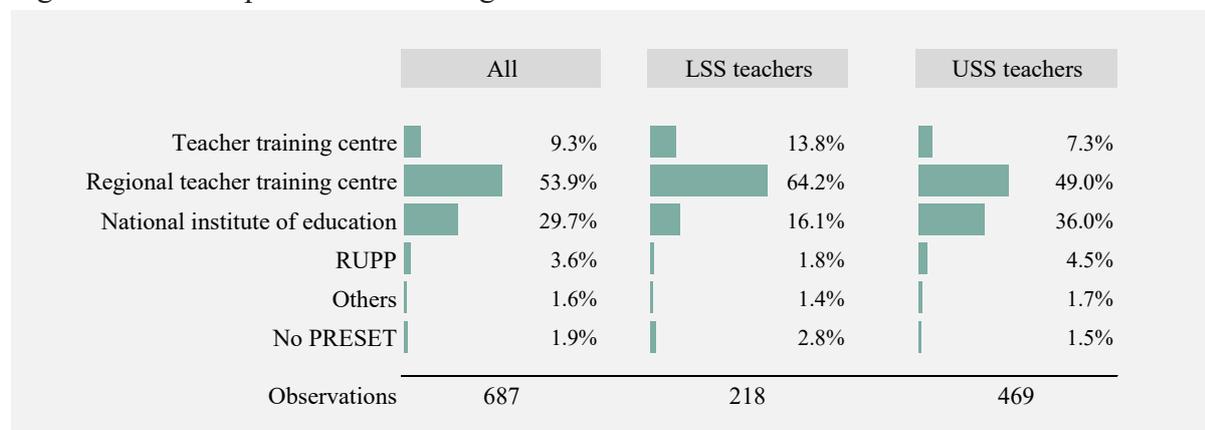
Source: Authors' calculation based on the teacher survey

* Some teachers taught more than one subject.

As seen in Figure 5, nearly all the sampled teachers received some sort of initial pre-service teacher training. Among the 687 respondents, more than half of the teachers received their initial teacher training at regional teacher training centres (RTTC), and 29.7 percent of them graduated from the National Institute of Education (NIE). However, 9.3 percent of teachers reported they received pre-service teacher training at provincial teacher training centres (PTTC), where the training courses are designed for primary school teachers. Normally, two-year training at RTTC is a requirement for a lower secondary school teacher, while upper secondary teachers need to take a four-year bachelor's degree and one-year pedagogical training at the NIE. Yet

only 36 percent of upper secondary school teachers obtained their pre-service teacher training at the NIE. Another 3.6 percent of teachers received their pedagogical training at the Royal University of Phnom Penh (RUPP).

Figure 5: Teacher pre-service training



Source: Authors' calculation based on the teacher survey

Among those who received initial teacher training, less than half (43.6 percent) of them were trained on how to use ICT hardware or software during their training (see Table 3). Furthermore, less than one-fifth (19.6 percent) of the teachers reported they were taught how to use technology for teaching activities during their pre-service training, and only 17.7 percent think they can use technology to enhance their teaching and learning activities. Their pre-service training is far from sufficient to shift to online learning when schools were forced to close due to the Covid-19 pandemic, as only 5.4 percent of them believed the training equipped them with adequate skills and knowledge for online teaching. This ability also depends on where the training was provided. Teachers who were trained from the NIE are more likely to be familiar with ICT and able to integrate educational technology into their teaching. As shown in Table 3, while more than 40 percent of NIE graduates were trained to use technology for teaching activities, only 6.3 percent of PTTC graduates and 12.4 percent of RTTC graduates received such training. None of the teachers from PTTCs believed their initial teacher training was adequate to prepare them for online teaching.

Table 3: ICT skills and training at teacher training

	All	PTTC	RTTC	NIE	Others
Were trained how to use ICT hardware and software	43.6%	25.0%	36.2%	69.1%	8.3%
Were trained how to use technology for teaching activities	19.6%	6.3%	12.4%	40.2%	0.0%
Were able to use technology to enhance learning teaching	17.7%	4.7%	11.9%	35.3%	0.0%
Adequate PRESET to switch to online teaching	5.5%	0.0%	3.2%	12.3%	0.0%
Observations	674	64	370	204	36

Source: Authors' calculation based on the teacher survey

4.2. Online teaching and teacher training during the Covid-19 pandemic

4.2.1. Online teaching during the pandemic

Nearly all (94.47 percent) of the interviewed teachers have experienced teaching online after the school closure in March 2020. As shown in Table 2's Panel A, among those who were teaching at the time of interviews, about one-third (33.4 percent) of them have completely switched back to physical classroom teaching. Another 59.9 percent still taught solely online, and 6.7 percent used both online and conventional in-person teaching approaches. The degree of switching back to complete physical teaching varies greatly from school to school. While virtually all teachers at some schools have completely returned to physical classrooms, teachers at some schools still completely rely on online approach. It is worth pointing out that in November 2021, the MoEYS allowed grades 9 and 12 to resume physical classrooms so students could prepare for their examinations. On the same day the data collection started on 1 November 2021, the MoEYS expanded the reopening of schools to include all grades from primary to upper secondary education. Female teachers and teachers at general schools in rural areas have a higher rate of continuing to teach online without returning to physical classrooms or combining online and offline teaching approaches. While nearly half of the teachers in urban areas returned to physical classrooms (either completely or partially), more than 70 percent of teachers in rural areas still continued using online teaching as the only option.

Table 4's Panel B reports the approaches that teachers used to deliver their online teaching. More than half of the teachers with online teaching experience adopted either synchronous (real-time teaching using platforms such as MS Teams, Google Meet) or asynchronous (teaching using prepared materials which students can access at their available time) approaches for their online classroom activities (22.8 percent for synchronous and 34.4 percent for asynchronous). The remaining 42.8 percent used a mixture of both approaches to teach their students. Male teachers, teachers in urban areas and teachers at resource schools are more likely to use both approaches in their teaching during the pandemic. Using asynchronous teaching alone is very common at general schools and schools located in rural areas.

Table 4: Means of teaching delivery and online teaching approach

	Gender		Location		Type		All
	Male	Female	Rural	Urban	General school	Resource school	
A. Means of teaching delivery							
- 100% online teaching	58.2%	62.2%	70.7%	51.4%	69.1%	55.6%	59.9%
- 100% in-person teaching	36.7%	29.1%	26.9%	38.6%	27.9%	36.0%	33.4%
- A combination of both	5.2%	8.7%	2.5%	10.0%	2.9%	8.4%	6.7%
Observation	368	275	283	360	204	439	643
B. Online teaching approach							
- Synchronous	22.0%	23.8%	15.2%	28.5%	15.7%	26.1%	22.8%
- Asynchronous	30.7%	39.1%	43.7%	27.4%	51.0%	26.7%	34.4%
- Both approaches	47.3%	37.0%	41.2%	44.1%	33.3%	47.2%	42.8%
Observation	368	281	277	372	204	445	649

Source: Authors' calculation based on the teacher survey.

Synchronous teaching approach

Figure 6 reports how teachers who used synchronous teaching approaches changed their teaching materials by introducing additional ones. Overall, 71.1 percent of teachers introduced new materials in their teaching. It is rather surprising that nearly 30 percent of teachers did not introduce any additional teaching materials in their synchronous teaching, since online teaching is supposed to be different from the in-person classroom approach. This reflects that initial pre-service and in-service training could not equip teacher with sufficient knowledge and skills to effectively switch to online teaching. Interestingly, teachers in rural areas are more likely to add new teaching materials (75.2 percent) than urban teachers (64.1 percent) in their synchronous sessions. The gender difference and difference between resource schools and general schools is not noticeable. For those who introduced new teaching materials, more than half of their teaching material was changed. In contrast to the earlier findings that rural teachers are more likely to add new materials, the degree of change in teaching materials among urban teachers is much higher. On average, urban teachers changed 62.2 percent of their teaching material, while rural teachers only changed 35.8 percent. Male teachers and teachers at resource schools also reported adding more new teaching materials in their synchronous teaching.

Regarding platforms used for synchronous teaching, Google Classroom and Zoom are the most commonly used platforms among Cambodian teachers. Nearly a third of them (28.2 percent) and 17.6 percent of them also used Telegram and Facebook Messenger for synchronous teaching respectively. However, it is unclear whether these messaging applications were used in combination with video conference platforms as communication tools or were used for live synchronous teaching.

Figure 6: Introduction of new teaching materials and platform used for synchronous teaching

	All	Female	Male	Rural	Urban	General school	Resource school
New teaching materials	71.1%	69.6%	72.2%	75.2%	64.1%	70.0%	71.5%
Changes in teaching materials	53.5%	38.6%	63.1%	35.8%	62.2%	34.5%	59.2%
Platform							
Google classroom	70.0%	66.7%	72.2%	75.6%	66.7%	66.0%	71.2%
Zoom	59.6%	55.0%	62.7%	48.1%	66.3%	52.0%	62.0%
Telegram	28.2%	29.8%	27.1%	30.1%	27.0%	31.0%	27.3%
Facebook messenger	17.6%	16.9%	18.7%	26.3%	12.6%	20.0%	16.9%
MS teams	9.6%	12.9%	7.5%	5.8%	11.9%	8.0%	10.1%
Facebook live	2.6%	1.8%	3.1%	2.6%	2.6%	2.0%	2.8%
Observations	426	171	255	156	270	100	326

Source: Authors' calculation based on the teacher survey

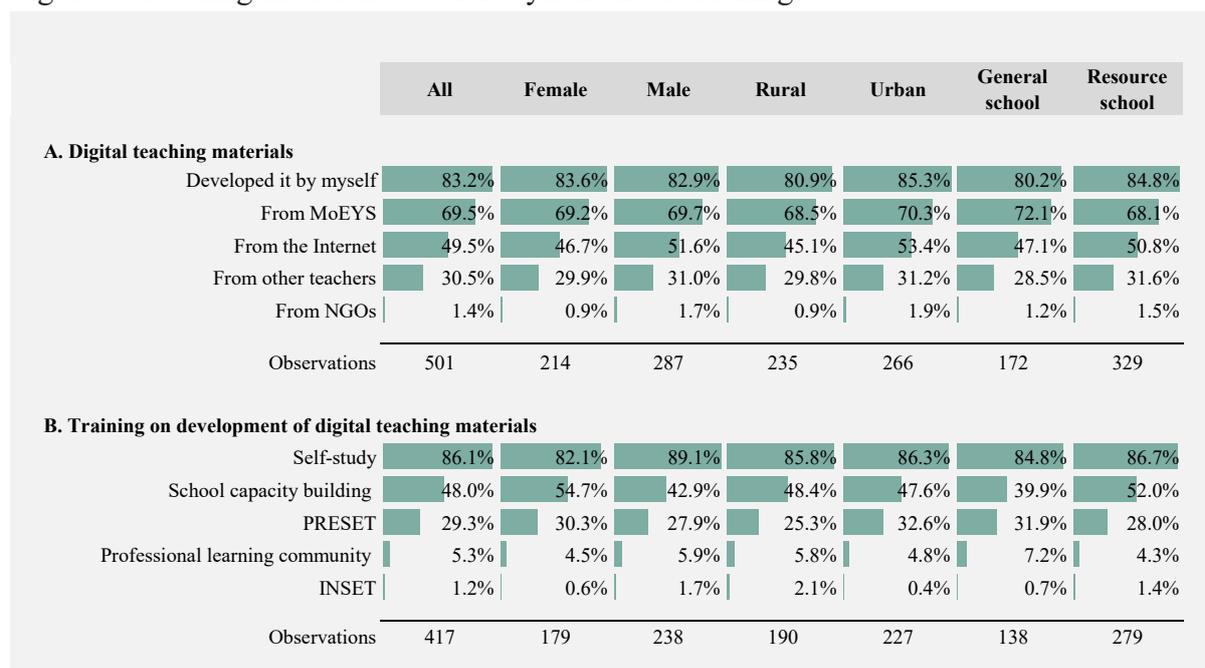
On average, teachers reported around half of their students were able to join synchronous sessions, and among those who joined live sessions, about half of them pay attention in class. In another words, around 25 percent students actively participated in synchronous teaching.

Asynchronous teaching approach

In asynchronous teaching, teaching materials are one of the most important elements to enhance the quality of teaching. Figure 7 shows how digital teaching materials were developed and how

teachers were trained to create digital teaching content for asynchronous teaching. As illustrated in Figure 7's Panel A, teachers used different types of digital materials for their teaching during the pandemic. A vast majority, or 83.2 percent of teachers, reported developing teaching material by themselves and another 69 percent of them used teaching materials developed by the MoEYS. Besides the digital content from the MoEYS, 49.5 percent of teachers also utilised materials available on the Internet and 30.5 percent of teachers used materials from their teaching peers for asynchronous teaching. Only 1.4 percent of teachers used materials developed by NGOs. Although there are some differences by gender, geographical location and types of school, the variations are not very noticeable in general.

Figure 7: Teaching materials used for asynchronous teaching



Source: Authors' calculation based on the teacher survey

Among those who developed digital teaching materials, the survey further asked how they learned to develop the content. As shown in Panel B, nearly all of them (86.1 percent) reported they learned by themselves how to prepare the materials and about half of them (48 percent) also received some sort of training programme offered through their schools. Less than a third of teachers were trained on how to prepare digital content during their pre-service teacher training. Very few of them acquired knowledge and skills related to digital content development through professional development (5.3 percent) and in-service training outside their schools (1.2 percent). The percentage of self-taught female teachers is slightly lower than their male counterparts (82.1 percent versus 89.1 percent), but they are more likely to join school capacity development programs (54.7 percent versus 42.9 percent). In comparison to general schools, teachers at resource schools tend to have more opportunities to receive training through school capacity development programs (39.9 percent versus 52.0 percent).

Figure 8 illustrates what kinds of content teachers provided to their students for asynchronous teaching during the school closure. The most popular materials used for asynchronous teaching are worksheets and reading materials 90.6 percent and 68.1 percent respectively of teachers provided them to students to learn by themselves at home. Less than 40 percent of teachers provided recorded videos for students to watch at a convenient time, and less than 10 percent

distributed PowerPoint slides to students as additional learning materials. The share of male teachers who distributed recorded videos and narrated PowerPoints was much higher than their female counterparts. The percentage of teachers at general schools providing recorded videos to their students was found to be higher than resource schools' teachers.

About 200 out of 501 teachers who adopted asynchronous teaching reported recording videos for students' self-study. Of those who did, nearly all teachers (92.3 percent) used smartphones for their recording and only 27.9 percent and 5.3 percent of them used computers and video cameras for recording. Male teachers, teachers in urban areas and teachers at resource schools tended to have more access to laptop computers and video cameras for recording.

Figure 8: Distribution of teaching materials and video recording

	All	Female	Male	Rural	Urban	General school	Resource school
A. Learning materials distributed							
Worksheets	90.6%	91.1%	90.2%	91.9%	89.5%	93.0%	89.4%
Reading materials	68.1%	68.7%	67.6%	66.8%	69.2%	65.7%	69.3%
Recorded video	39.5%	34.1%	43.6%	39.6%	39.5%	46.5%	35.9%
Links to online learning platforms	29.9%	23.8%	34.5%	25.1%	34.2%	26.2%	31.9%
PowerPoint slides	9.8%	8.9%	10.5%	6.0%	13.2%	7.0%	11.2%
Narrated PowerPoint	7.4%	3.7%	10.1%	7.2%	7.5%	8.7%	6.7%
Observations	501	214	287	235	266	172	329
B. Device used for video recording							
Smartphone	92.3%	93.4%	91.7%	95.9%	89.2%	94.2%	91.0%
Laptop	27.9%	23.7%	30.3%	22.7%	32.4%	19.8%	33.6%
Video camera	5.3%	3.9%	6.1%	2.1%	8.1%	3.5%	6.6%
Observations	208	76	132	97	111	86	122

Source: Authors' calculation based on the teacher survey

4.2.2. Teacher capacity development during the pandemic

Nearly 80 percent of the sampled teachers participated in some sort of capacity development activities after the school closure in March 2020. In other words, over one-fourth of teachers (22.4 percent) did not join any capacity development program during the school closure. As illustrated in Figure 9's Panel A, among various capacity development activities, attending training courses or workshops (57.2 percent) is the most common activity, followed by attending education conferences or seminars (26.6 percent) and conducting individual or collaborative research (21.7 percent). Some teachers also took part in professional networking, mentoring and peer observation activities, yet these are less common activities undertaken by Cambodian teachers, at least during the school closure. Male teachers, teachers in urban schools and teachers at resources schools are more active or have more opportunities in joining capacity building activities. While the share of teachers attending training courses at general schools is 41.7 percent, the share at resource schools is 64.4 percent. Male teachers are more likely to join training courses and conduct individual or collaborative research than female teachers. Similar patterns are found between teachers in urban and rural schools.

Nearly two years after the school closure, most secondary school teachers thought they didn't have adequate capacity for conducting effective online teaching, as nearly 90 percent of those who took part in capacity development activities claimed that training courses they received were not sufficient for them and indicated a desire to receive more capacity development programs in the future. Female teachers in rural schools are in higher need of more capacity building activities. Interestingly, teachers at resource schools also showed more interest in having additional training than teachers in general schools, although they had more opportunities to join training programs during the school closure.

Figure 9: Teacher capacity development activities during the pandemic

	All	Female	Male	Rural	Urban	General school	Resource school
A. Capacity development activities							
Attending training course or workshop	57.2%	51.7%	61.5%	55.1%	58.8%	41.7%	64.4%
Attending education conference or seminar	26.6%	26.7%	26.6%	27.9%	25.6%	22.9%	28.4%
Individual and collaborative research	21.7%	18.0%	24.5%	16.6%	25.6%	19.7%	22.6%
Participating in professional network	9.0%	8.7%	9.3%	8.0%	9.8%	9.6%	8.7%
Mentoring and peer observation	6.4%	7.7%	5.4%	5.3%	7.3%	8.3%	5.5%
Qualification program	2.3%	2.3%	2.3%	2.0%	2.6%	2.8%	2.1%
Never participated	22.4%	26.0%	19.6%	24.6%	20.7%	34.9%	16.6%
Observations	687	300	387	301	386	218	469
B. Need further capacity training for online training							
Yes	89.5%	92.3%	87.5%	92.5%	87.3%	88.0%	90.1%
No	10.5%	7.7%	12.5%	7.5%	12.7%	12.0%	9.9%
Observations	534	227	307	201	332	227	307

Source: Authors' calculation based on the teacher survey

As shown in Figure 10's Panel A, more than half of teachers who participated in capacity development programs claimed they gained new general ICT skills and knowledge for their teaching (57.7 percent) as well as pedagogical skills for online teaching (56.2 percent). Although, it also means that more than 40 percent of teachers thought they did not acquire new ICT and online teaching skills during the period. However, it is unclear whether they failed to learn those skills, or they thought they already possessed adequate ICT skills and knowledge. A significant share of teachers (47.4 percent) also reported gaining new knowledge and skills related to their respective subject fields. The percentage of male teachers at resource schools in urban areas who gained general ICT skills for teaching is higher than their female teaching peers at general schools in rural areas. But the differences in acquired pedagogical skills for online teaching between gender, school location and type of school are less noticeable.

Figure 10's Panel B reports the training topics. "How to use learning management systems," such as Google Classroom or Microsoft Teams, was the most common training topic during the pandemic. Less than half of the teachers (42.5 percent) were trained on how to develop teaching and learning materials for online classrooms, and only about one-fifth of them (22.3 percent) were trained on how to record videos. This explains why not many teachers produced video content as an additional teaching material for asynchronous teaching.

Figure 10: Content of capacity development programs

	All	Female	Male	Rural	Urban	General school	Resource school
A. Skills and knowledge learnt during covid-19							
General ICT skills for teaching	57.7%	53.4%	60.7%	52.0%	61.9%	51.4%	59.9%
Pedagogical skills for online teaching	56.2%	56.6%	55.9%	57.3%	55.4%	52.8%	57.4%
Knowledge and skills of subject fields	47.4%	44.8%	49.2%	44.1%	49.8%	50.7%	46.2%
Pedagogical skills and knowledge	18.9%	16.7%	20.4%	17.6%	19.9%	23.2%	17.3%
School management and administration	10.1%	8.6%	11.2%	11.9%	8.8%	12.7%	9.2%
							0.4
B. Training topic							
Use of learning management system (LMS)	86.1%	88.2%	84.7%	85.0%	87.0%	80.3%	88.3%
Developing teaching and learning materials	42.5%	44.3%	41.2%	46.3%	39.7%	45.8%	41.3%
Video recording	22.3%	17.2%	25.9%	22.0%	22.5%	15.5%	24.7%
Observations	534	221	313	227	307	227	307

Source: Authors' calculation based on the teacher survey

4.2.3. Access to and use of technology

A majority of teachers have access to desktop computers at their schools, yet less than 10 percent of surveyed teachers used school computers in the last month. The number of teachers with access to and use of desktop computers at home were low, but more than 40 percent of teachers reported using laptop computers at home in the same period. A vast majority of teachers (92.1 percent) had access to the Internet, but mostly through their personal smartphone's cellular Internet. Nearly all teachers (98.3 percent) owned and used smartphones. Although nearly 20 percent of surveyed teachers had access to tablets at schools, only 1.7 percent of teachers claimed they used school tablets in the previous month. More than 90 percent of teachers said they either used school printers or had access to them, but less than a third of sampled teachers used them in the past month. Like access to desktop computers at schools, the majority of teachers had access to computer labs, but many of them did not use them in the past month. Only 3.8 percent of interviewed teachers used school equipment for video recording.

Table 5: Access to digital devices and services

	At Home			At School		
	Use	Access Only*	No Access	Use	Access Only*	No Access
Desktop computer	6.7%	3.9%	89.4%	9.8%	74.1%	16.2%
Laptop computer	42.9%	8.4%	48.6%	2.2%	37.1%	60.7%
Wi-Fi	37.3%	0.7%	62.0%	32.3%	47.9%	19.8%
Cellular Internet	92.1%	1.3%	6.6%	0.0%	0.0%	0.0%
Smartphone	98.3%	0.4%	1.3%	0.1%	1.9%	98.0%
Tablet	6.3%	1.9%	91.8%	1.7%	17.0%	81.2%
Printer	16.4%	2.5%	81.1%	31.0%	60.6%	8.4%
Cloud storage	32.3%	3.1%	64.6%	4.9%	20.2%	74.8%
Computer lab	-	-	-	14.0%	65.4%	20.7%
Video recording equipment	-	-	-	3.8%	32.0%	64.2%

* Had access but did not use it in the past month (October 2021). The number of observations is 687.

Source: Authors' calculation based on the teacher survey.

Among the interviewed teachers, only 38.4 percent used computers (either desktops or laptops) for at least one hour in the last seven days for teaching purposes, and 35.4 percent used computers for non-teaching purposes. The average weekly hours they spent using computers were 8.81 hours for teaching activities and 11.02 hours for non-teaching activities. During the same period, the percentage of teachers using smartphones or tablets was much higher at 80.8 percent for teaching purposes and 92.4 percent for non-teaching purposes. Nearly all teachers reported they used the Internet for 8.37 hours on average for teaching and 14.76 hours for non-teaching activities.

Table 6: Percentage of users and hours spent online in the last seven days

	Teaching			Non-teaching		
	% of users	Hours spent	Obs.	% of users	Hours spent	Obs.
Computer	38.4%	8.81	264	35.4%	11.02	243
Smartphone or tablet	80.8%	9.54	555	92.4%	15.16	635
Internet	82.0%	8.37	563	97.7%	14.76	671

Source: Authors' calculation based on the teacher survey

4.3 Teacher readiness and factors influencing the readiness

4.3.1. Technological pedagogical content knowledge (TPACK)

The TPACK instrument in this study is constructed based on 33 indicators, five PCK indicators, four CK indicators, five TK indicators, four TPK indicators, five TCK indicators and five TPCCK indicators. To assess the internal reliabilities of the instrument, Cronbach Alpha tests were performed for each component of the overall teacher competencies and reported in Table 7. Most of the Cronbach Alpha values are acceptable (higher than 0.70), except the pedagogical knowledge with a Cronbach Alpha value of 0.65. The reliability of the overall instrument is very high with a Cronbach Alpha value of 0.93. Based on the self-evaluation, Cambodian secondary teachers think their pedagogical knowledge (PK) and content knowledge (CK), are relatively high at 3.92 and 3.88 respectively; however, their technological knowledge is relatively low at 2.87. This means Cambodian teachers are not very familiar with technology in general, but are more confident they have good knowledge of pedagogy and subject content. Although teachers report having low technological knowledge, in the areas where technology knowledge (TK) interacts with PK or CK, on average their score was higher than the media point of 3.00, 3.55 for technological pedagogical knowledge (TPK) and 3.27 for technological content knowledge (TCK).

Table 7: Descriptive statistics of TPACK and reliability of test results

	Number of Items	Mean Score	SD	Cronbach's Alpha
Pedagogical knowledge (PK)	5	3.92	0.36	0.65
Content knowledge (CK)	4	3.88	0.45	0.70
Technological knowledge (TK)	5	2.87	0.69	0.82
Pedagogical content knowledge (PCK)	5	4.00	0.36	0.79
Technological pedagogical knowledge (TPK)	4	3.55	0.63	0.77
Technological content knowledge (TCK)	5	3.27	0.75	0.79
Technological pedagogical content knowledge (TPACK)	5	3.39	0.73	0.88
Overall	33	3.56	0.42	0.93

Source: Authors' calculation based on the teacher survey.

Table 8 lists the TPACK means by component and the overall mean by gender, region and type of schools. Male teachers clearly score higher than their female peers in all components, but the regional difference between urban and rural is much less noticeable. Overall, general schools show higher readiness than resource schools. Nevertheless, these comparisons are conducted without any statistical test. Results from regression analysis, in which other factors are controlled for, are explained in the section below.

Table 8: TPACK by gender, region and school type

	Gender		Location		Type	
	Male	Female	Rural	Urban	General School	Resource School
Pedagogical knowledge (PK)	3.97	3.87	3.92	3.93	3.98	3.90
Content knowledge (CK)	3.93	3.83	3.89	3.88	3.94	3.86
Technological knowledge (TK)	2.99	2.73	2.83	2.91	2.93	2.85
Pedagogical content knowledge (PCK)	4.04	3.96	4.00	4.00	4.06	3.98
Technological pedagogical knowledge (TPK)	3.63	3.45	3.54	3.56	3.59	3.54
Technological content knowledge (TCK)	3.38	3.13	3.30	3.25	3.42	3.20
Technological pedagogical content knowledge (TPACK)	3.52	3.23	3.40	3.39	3.51	3.34
Overall	3.64	3.46	3.56	3.57	3.64	3.53
Observation	387	300	301	386	218	469

Source: Authors' calculation based on the teacher survey

4.3.2. Factors influencing teachers' readiness for online teaching

The main outcomes of interest in this study are the TPACK, the central intersection of content knowledge, pedagogical knowledge and technological knowledge. Its results are reported in column (1) of Table 9. In addition to the TPACK variable, we are also interested in looking at the subdomains of technological knowledge (TPK and TCK) as well as technological knowledge domain (TK) and overall score from the 33 indicators.

The regression results show that individual characteristics that influence teacher readiness for online teaching include gender, age, perceived challenge in conducting online learning and perceived effectiveness of online learning. Male teachers are very likely to be more ready to effectively use technology in their classroom teaching, as they have higher scores on the TPACK and the other four outcomes of interest. Holding other factors constant, the TPACK score of male teachers is 0.230 higher than their female teaching peers. Age is also consistently found to be negatively associated with teacher readiness. This means that the older teachers become, the more difficult it is for them to adopt educational technology in all estimations. A one-year increase in age reduces the TPACK score by 0.011 and the association is statistically significant at one percent. Teacher perception of challenges in conducting online teaching is positively correlated with teacher readiness. Its effect is particularly large on the TK component. To put it in other words, those who think it is challenging to conduct online classrooms are likely to possess low general knowledge and skills in technology. Another noticeable factor is teacher perception of the effectiveness of online teaching. It is positively correlated with all components, except TK. However, the study does not detect a noticeable, significant relationship between the level of education and teacher readiness for online teaching, except

the positive relationship at a 10 percent significance level between graduate degrees (master's or PhD) and TPK.

Table 9: Regression results on teacher readiness

	(1) TPACK	(2) TPK	(3) TCK	(4) TK	(5) All
Individual characteristics					
- Male	0.230*** (0.061)	0.136*** (0.043)	0.257*** (0.066)	0.215*** (0.057)	0.156*** (0.035)
- Age	-0.011*** (0.003)	-0.014*** (0.003)	-0.016*** (0.003)	-0.019*** (0.003)	-0.007*** (0.002)
- Education level (Base group is associate degree and high school.)					
Bachelor's degree	0.032 (0.058)	0.077 (0.055)	0.045 (0.072)	-0.012 (0.058)	0.008 (0.036)
Master's or PhD	0.092 (0.077)	0.141* (0.081)	0.109 (0.095)	0.003 (0.075)	0.060 (0.045)
- Perceived challenge	-0.170** (0.077)	-0.199** (0.085)	-0.169** (0.082)	-0.259*** (0.065)	-0.103* (0.052)
- Perceived effectiveness	0.003*** (0.001)	0.003** (0.002)	0.005*** (0.001)	0.002 (0.001)	0.003*** (0.001)
Teaching attributes					
- Teach at private schools	0.155** (0.059)	0.125** (0.057)	0.054 (0.058)	0.095** (0.046)	0.069** (0.034)
- Teach science	-0.021 (0.047)	0.054 (0.038)	-0.024 (0.055)	0.059 (0.040)	0.006 (0.024)
- Teach upper secondary level	0.046 (0.059)	-0.046 (0.056)	-0.042 (0.057)	0.069 (0.053)	-0.014 (0.034)
- Student interaction	0.414*** (0.050)	0.281*** (0.041)	0.326*** (0.045)	0.299*** (0.056)	0.266*** (0.029)
Teacher education and training					
- PRESET duration (year)	-0.017 (0.030)	0.018 (0.030)	-0.042 (0.032)	-0.030 (0.029)	-0.003 (0.016)
- INSET (TPK)	-0.012 (0.061)	0.027 (0.053)	0.041 (0.068)	0.127* (0.073)	0.036 (0.039)
- INSET (edtech)	0.059 (0.057)	0.051 (0.052)	0.016 (0.063)	0.054 (0.046)	0.029 (0.023)

	(1) TPACK	(2) TPK	(3) TCK	(4) TK	(5) All
- ADB support	0.064 (0.060)	0.082 (0.055)	0.104 (0.065)	0.029 (0.068)	0.035 (0.037)
- SIEP support	-0.181** (0.074)	-0.105 (0.069)	-0.108 (0.082)	-0.121 (0.076)	-0.091* (0.047)
Access to technology					
- Computer	0.090* (0.047)	0.083 (0.055)	0.096 (0.067)	0.164** (0.063)	0.061* (0.033)
- Wi-Fi or cable Internet at home	0.018 (0.056)	0.038 (0.054)	0.086 (0.071)	0.094* (0.049)	0.043 (0.036)
- Wi-Fi or cable Internet at school	0.018 (0.042)	-0.004 (0.043)	0.010 (0.048)	-0.037 (0.055)	-0.015 (0.025)
- Duration of Internet use	0.003 (0.003)	0.001 (0.002)	0.001 (0.002)	-0.000 (0.002)	-0.000 (0.002)
School characteristics					
- Phnom Penh	0.209*** (0.057)	0.065 (0.048)	0.200** (0.097)	0.057 (0.066)	0.097*** (0.036)
- Urban school	-0.014 (0.055)	0.059 (0.048)	-0.022 (0.082)	0.164** (0.067)	0.050 (0.037)
- Resource school	-0.111** (0.052)	-0.057 (0.067)	-0.202** (0.081)	-0.162** (0.076)	-0.069** (0.033)
- Number of teachers (ln)	-0.088** (0.040)	-0.046 (0.040)	-0.041 (0.050)	-0.061 (0.049)	-0.070*** (0.024)
- School facilities	-0.412 (0.386)	-0.187 (0.404)	-0.307 (0.513)	-0.420 (0.480)	-0.142 (0.258)
Constant	2.946*** (0.380)	3.437*** (0.385)	3.198*** (0.450)	3.285*** (0.344)	3.236*** (0.237)
Observations	637	637	637	637	637
R-squared	0.296	0.263	0.275	0.348	0.347

Robust standard errors clustered at school level in parentheses

*** p<0.01, ** p<0.05, * p<0.10

Source: Authors' estimation based on the teacher survey

Teaching attributes that are found to be correlated with teacher readiness in this study are teaching experience at private schools and student-teacher interaction. Nearly 40 percent of teachers at public secondary schools used to teach or were teaching at private schools at the time of the survey. The results show these experiences were beneficial for teachers when classrooms

moved online. Teachers with experience at private school score 0.155 higher on the TPACK and the association is statistically significant at a 5 percent level. It also correlated with the other three outcome variables, but the relationship with TCK is not statistically significant. Teacher-student virtual interactions during the school closure are found to be robustly connected with teacher readiness. All the correlations in the five models are statistically significant at a 1 percent level. However, there are no significant differences in readiness level between teachers teaching science subjects and non-science subjects, nor between teachers in lower secondary and upper secondary levels.

For the factors related to teacher education and training, the study incorporates both initial pre-service training, in-service training during the pandemic and support teachers received through ADB and World Bank's SIEP projects. Surprisingly, this study does not find strong connections between any examined factors and teacher readiness for online teaching. Although there is a positive relationship at a 10 percent significance level between TPK in-service training and TK in model (4), the relationships with other outcomes are not statistically significant. The results in model (1) and (5) indicate negative associations between SIEP support and the TPACK as well as between SIEP support and overall score.

Two factors related to access to technology, use of computers and hours of Internet usage for teaching purposes in the past seven days, were added to the estimation models. Teachers who used computers in the last seven days seem to demonstrate a higher level of readiness, and its relationships are statistically significant between 5 and 10 percent. However, the correlations between the duration teachers spent on the Internet and teacher readiness are statistically insignificant in all five models.

Another interest of the study is to investigate school factors that influence teacher readiness. Location, type of school and number of teachers employed are found to affect teacher readiness for online classrooms. In comparison to their provincial peers, teachers working at schools in Phnom Penh have higher scores on the TPACK by 0.209. This factor is also positively correlated with TCK and overall scores. For TPK and TK, the differences between capital and provincial teachers are statistically insignificant. For the regional difference between teachers in rural and urban schools, teachers in urban schools are likely to have higher scores than teachers in rural schools only in the TK component, while the association in the other four models is insignificant. Another surprising finding is that teachers at resource schools tend to be less ready than teachers at general schools. The number of peer teachers is found to have negative effects on the TPACK and overall score, but not the other three outcomes of interest. Additionally, school facilities seem to have no effect on teacher readiness as well. From the findings in earlier sections, a good proportion of teachers have access to computers and other ICT facilities at their schools, but do not use them. A majority of teachers used smartphones instead of computers for online teaching.

5. Conclusion and implications

5.1. Conclusion

Covid-19 forced schools around the world, including Cambodia, to shut their doors and move from conventional face-to-face teaching and learning to online platforms and distance learning. The wider literature suggests that many teachers in the Global South, such as Cambodia, lacked proper training and preparation to effectively transition to online teaching. In addition to the lack of training and preparedness, Cambodian teachers faced many challenges, including lack of digital devices and support from students' parents, in integrating technology into their virtual

classrooms. However, the transition to online classrooms can be a good opportunity for us to rethink how we can make the education system more resilient to future shock or uncertainty. Nevertheless, it is unclear how ready and competent Cambodian teachers are. To contribute to policy discussion, this study set out to examine online teaching practices, teacher readiness for online learning and the factors associated with readiness at secondary schools in Cambodia during the Covid-19 pandemic.

Findings from this study suggest that while most teachers at secondary schools who participated in the study experienced online teaching during school closures, although lesson delivery approaches varied widely. However, soon after the MoEYS announced schools were to reopen, large number of teachers completely shifted back to physical teaching and learning and very few teachers used blended approach of online and in-person teaching. Coupled with the insufficient materials for online teaching, the fact that a majority of teachers deliver their online teaching through smartphones is due to limited access to computers and TK and suggests that online classrooms are less interactive and of lower quality. On the other hand, school resources seem to be underutilised. Nearly 87.9 percent of teachers at resource secondary schools reported having access to school desktop computers, but only around 10 percent of these teachers used them in the past seven days.

In the three knowledge domains, Cambodian teachers score the lowest in TK and the highest in PK, suggesting a lack of ICT training either in pre- or in-service. At individual levels, factors that are found to have influenced teacher readiness include gender, age, perceived challenge and perceived effectiveness of online classrooms. Teaching experience at private schools and student-teacher interaction are also found to have positive effects on readiness, while teacher education and training seems to be rather ineffective in preparing teachers for online classrooms. Having access to computers can improve teacher readiness, yet it seems teachers do not benefit from school facilities. It is also reflected by the fact that a large proportion of teachers had access to school computers and other facilities, but did not use them. Teachers in Phnom Penh are more prepared for virtual classrooms, while teachers at resource schools are less ready to embrace technology in their teaching. This hints that providing equipment and materials alone might not lead to desired outcomes.

5.2. Implications and limitations

Drawing on the study's results, the following policy implications and further studies should be considered.

- Nearly all teachers in the study reported that their initial teacher training programs did not equip them with sufficient skills or knowledge for online teaching. Moreover, our results indicate the need for more ongoing in-service training to equip practising teachers with more skills and knowledge for online teaching. In this sense, there is a need to revisit teacher training curricula and examine if more edtech courses should be introduced in the programs and to provide systematic INSET training courses on edtech for practising teachers. Female and older teachers also deserve extra support, as they exhibit a lower level of readiness. The fact that most teachers acquired new skills and knowledge through informal professional development activities (i.e., self-study and learning from their peers) during the pandemic is encouraging.
- With the current trends (at the time of the survey), online learning is unlikely to stay after the pandemic and a majority of schools and teachers will return to the physical classroom as normal. Considering the benefits and potential of online learning and uncertainties in

the future, the MoEYS should make extra efforts to keep the online approach as a part of learning and teaching, at least at schools with adequate resources. If used effectively, online learning can supplement traditional physical learning and teaching to enhance educational quality and reduce inequality.

- A large majority of teachers had access to school computers and other digital devices but did not use them. There should be a further investigation on the reasons behind the underutilisation of school resources and how these resources can be effectively put into use. Lessons from other developing countries have suggested that the provision of resources alone cannot fulfil its potential if users do not possess proper access and skills to make use of the resources (Wolfenden, Buckler, and Kenraro 2012).
- The findings suggesting that teachers at resource schools are less prepared than general schools raise more questions to be answered in future studies. However, it is worth reiterating that this is just correlation, not causation. Further investigation should be made to examine how resources are put into use.

This study is not without limitations. First teacher readiness is measured by a set of self-reported questions that can suffer from “social desirability bias.” To the authors’ best knowledge, this is the first study in examining teacher technological readiness in Cambodian secondary schools. Future studies from different angles or approaches should be done to triangulate the findings and further investigate the effectiveness of teachers’ education and training, as well as school resources.

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Appendix A: TPACK instrument

Item	Mean
Pedagogical knowledge (PK)	3.925
a1. I can adapt my teaching based upon what students understand or do not understand.	4.023
a2. I can adapt my teaching style to different learners.	3.977
a3. I can assess student learning in multiple ways.	3.993
a4. I am familiar with common student understandings and misconceptions.	3.610
a5. I know how to organize and maintain classroom management.	4.020
Content knowledge (CK)	3.883
b1. I have sufficient knowledge about my teaching subject.	3.923
b2. I know the theories and concepts of my teaching subject.	3.988
b3. I have various ways and strategies of developing my understanding of my teaching subject.	3.974
b4. I am familiar with recent research in my teaching subject.	3.646
Technological knowledge (TK)	2.872
c1. I keep up with important new technology.	3.533
c2. I know about a lot of different technology.	2.803
c3. I have the technical skills I need to use technology.	2.854
c4. I know how to solve my own technical problems.	2.569
c5. I can learn about technology easily.	2.600
Pedagogical content knowledge (PCK)	4.002
d1. I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject.	3.852
d2. I know how to develop appropriate tasks to promote students' complex thinking of my teaching subject.	3.872
d3. I can explain essential content of my teaching subject in ways that students can understand.	4.096
d4. I know how to evaluate students' performance in my teaching subject.	4.093
d5. In my teaching subject, I can identify student errors from where there are difficulties in understanding and give appropriate feedback.	4.098
Technological pedagogical knowledge (TPK)	3.553
e1. I can choose technology that enhances students' learning.	3.345
e2. I can adapt the use of the technology that I am learning about to different teaching activities.	3.313
e3. I always think about how to use technology in my classroom.	3.654
e4. My teacher training programme has caused me to think more deeply about how technology could influence my classroom teaching.	3.902
Technological content knowledge (TCK)	3.271
f1. I can explain which technology has been used in research in my field.	3.342
f2. I know which new technology is currently being developed in the field of my subject.	3.166
f3. I know how to use technology to participate in scientific discourse in my field.	3.316
f4. I know technology that helps me understand my subject.	3.329
f5. I know how to use essential technology that is specific to my subject.	3.202
Technological pedagogical content knowledge (TPACK)	3.394
g1. I can use strategies that combine content, technology and teaching approaches that I learned.	3.454
g2. I can choose technology that enhances the content of a lesson.	3.489
g3. I can select technology to use in my classroom that enhances what I teach, how I teach, and what students learn.	3.491
g4. I can teach lessons that appropriately combine my teaching subject, technology and teaching approaches.	3.480
g5. I can help other teachers coordinate the use of content, technology and teaching approaches at my school.	3.055

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