Using mobile technologies to teach 21st century learning skills: a study of teachers' acceptance in Thai secondary schools

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Abstract: Learning in the 21st century emphasises the development of knowledge and skills required of learners, such as creativity, critical thinking and soft skills, which enable learners to exchange information and learn from one another and ultimately become active global citizens. This study investigated the factors affecting the attitudes and intention of secondary school teachers toward using mobile technologies to teach 21st century learning skills in Thai secondary schools. The researcher extended the technology acceptance model (TAM) as the modelling approach to examine the relationships between six factors: subjective norm (SN), constructivist teaching belief (CTB), relative advantage (ADV), school incentives (SCHI), facilitating conditions (FC), and perceived behavioural control (PBC). Data were obtained

from 403 secondary school teachers in the northern, central, northeastern, and southern regions of Thailand through self-report questionnaires, which were analysed using structural equation modelling. The proposed model demonstrated good fit. The study results contribute to existing theories of technology acceptance and extend previous research. This study contributes to the understanding of the use of mobile technologies to teach 21st century learning skills in the context of Thai secondary school. Knowing these secondary school teachers' attitudes toward and behaviours regarding the use of such technology in this context could be informative and advantageous for national school policymakers and educators.

Keywords: mobile technologies; secondary school students; intention to use; technology acceptance model; Thailand.

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1 Introduction

Learning in the 21st century places greater emphasis on the development of each student's abilities and skill and knowledge acquisition than transmissive learning. This way of learning improves such essential skills as creativity, critical thinking, collaboration, and communication, leading to greater knowledge sharing and a stronger global community (Barak, 2017; Hadinugrahaningsih et al., 2017). Teachers must now be able to create a learning environment that promotes the acquisition of necessary 21st century skills by bringing the world into the classroom to create opportunities for

students to interact with each other both within and outside of their learning environments. Mobile learning is often considered an important way for learners to enhance their own education (Topaloglu and Ozkisi, 2017). One approach is to use a variety of teaching strategies to bring out students' full capabilities and to develop their social skills (Crosswell and Beutel, 2017; Darling-Hammond, 2006; Husin et al., 2016). An example involves the use of mobile technologies to access information resources, work together, and collaborate with others anytime and anywhere (Chen et al., 2016; Chiang et al., 2014; Crosswell and Beutel, 2017; Hsieh and Tsai, 2017; Karanfiller et al., 2018; Wright and Lee, 2014; Hsu et al., 2020; Liu et al., 2020; Hwang and Chang, 2021; Liu and Hwang, 2021).

Another example of the use of mobile learning in teaching 21st century skills is the development of an application for mobile devices for elementary school students using an activity-based learning model (Lijanporn and Khlaisang, 2015). Lijanporn and Khlaisang (2015) found that those who used the app showed greater improvements in academic performance than those who did not. In addition, Lee et al. (2016) showed how mobile learning games can benefit the development of learners' critical thinking skills via cooperative reciprocity. Intriguing research has also shown how children's cognitive and social skills can be affected by using humanoid robots (Tuna et al., 2019). Furthermore, Fu and Hwang (2018), who reviewed journal articles from 2006 to 2007 on trends in mobile technology-supported collaboration, found that mobile technologies can engage learners and increase their collaborative learning skill, which is an essential 21st century skill.

Although the benefits of mobile-assisted learning for promoting students' 21st century skills are widely suggested in technology acceptance literature, teachers' technology use intentions have not been examined sufficiently. In addition, existing studies considering external factors belonging to specific cultural contexts (e.g., perceived behavioural control, school influence, peer influence, etc.) were still rare and, thus, deserve further investigation (Huang and Teo, 2020, 2021).

2 Rationale for the study

Studies have been conducted on the issues related to teachers' use of mobile technologies in different countries, and in Thailand, significant problems with teaching 21st century learning skills using such technology have been found (Felisoni and Godoi, 2018; Kim and Garrison, 2009; MacCallum et al., 2014). These problems included how online communication on such devices can disrupt the learning process. Felisoni and Godoi (2018) found that the relationship between students and the extent of their smartphone use affected their ability to learn. This is an indirect effect whereby excessive online communication causes instructors to receive many messages and students must constantly monitor messages in applications. As a result, they cannot complete other tasks. MacCallum et al. (2014) studied the factors influencing the acceptance of mobile learning and found that digital literacy, information communication and technology (ICT) anxiety, ICT teaching self-efficacy, perceived ease of use, and perceived usefulness were important factors influencing behaviour intention to adopt mobile learning as a strategy. Anxiety can increase the rate of outright refusal and lower willingness to use, particularly the fear of using new technology and concerns about

possible negative consequences affecting perceived ease of use and perceived usefulness. Kim and Garrison (2009) studied the factors that influence the acceptance of mobile wireless technology by extending the technology acceptance model (TAM). They found that the mobile wireless technology acceptance model (MWTAM) added the factors of the TAM, including perceived ubiquity and perceived reachability, which substantially influenced the acceptance of mobile wireless technology

21st century learning skills include communication, information, media, technology (Mingsiritham and Koraneekij, 2020), and higher-order thinking skills, such as critical thinking, decision making, problem solving, creativity, and innovation. Learners with these skills will be able to live well and work effectively in the future. They will be capable of adjusting to changes in the global community and being happy and content (Koraneekij and Khlaisang, 2016; Ahmad et al., 2020; Howlett and Waemusa, 2019; Hwang et al., 2020).

Not only does the use of mobile technologies in teaching enhance learners' learning achievement, it also helps develop learners' 21st century learning skills. In a study conducted by Hwang and Chang (2021), a bi-directional peer-assessment approach was used in the context of mobile learning, in which students received and responded to the teacher's feedback while doing activities. It was found that in addition to improved students' learning achievement, their critical thinking was strengthened. This is in line with the literature review on mobile learning by Ahmad et al. (2020), the results of which showed that higher-order thinking skills and communication skills could be developed, and these skills are necessary for empowering learners in the 21st century.

In Thailand, a survey on the status of ICT applications for basic education conducted by the Office of the Permanent Secretary at the Ministry of Education (2011) found that the use of ICT in schools is low and often limited to computer teachers. The survey also reported that other teachers who used computers mainly did so for administrative tasks rather than for lesson preparation and delivery. Moreover, some Thai teachers thought that using mobile technologies to support students' learning was somewhat difficult because of their complicated functions and features (Roungrong, 2013; Roungrong, 2015). The 12th Education Development Plan of the Ministry of Education (2017–2021) therefore employed two strategies related to the use of technology in teaching to create equal lifelong learning opportunities through information technology responding to the development of accessible services. The first strategy involved the production and development of human resources and research to satisfy the needs of national development to improve the national economic competitiveness and flexibility, while the second strategy concerned the promotion and development of digital technology for education (Office of Permanent Secretary, Ministry of Education, 2016).

These problems may impede teachers' use of mobile technologies to support learning activities and hinder students' opportunities to learn effectively with technology. Hence, the goal of this research paper is to better understand the factors that affect Thai secondary school teachers' intention to use mobile technologies in their instruction. The six factors addressed in this study are subjective norm (SN), constructivist teaching belief (CTB), relative advantage (ADV), school incentives (SCHI), facilitating conditions (FC), and perceived behavioural control (PBC). They are associated with the development of 21st century learning skills, which include critical thinking, problem solving, creativity, collaboration, and communication. The findings will help us better understand teachers' acceptance and build a framework that promotes mobile technologies in teaching and

reduces the problems identified in the literature. Moreover, the research findings can contribute to the development of both theory and policy-making practice.

3 Literature review

3.1 The base model: TAM

The technology acceptance model (TAM) (Davis, 1989), which posits perceived usefulness and perceived ease of use as two of the most important factors determining people's attitudes toward the use of technology, was used as the primary framework for this study. Despite the popularity that the TAM has gained, it has been criticised for being too parsimonious (Venkatesh and Bala, 2008), as it lacks the clarification of external variables that can also affect usefulness and ease of use. Clarification of external variables is crucially important because researchers need to consider contextual and cultural factors when applying the TAM in their research (Huang et al., 2021; Teo, 2009).

The TAM regards perceived usefulness as one of the two important antecedents to individual technology users' attitudes and behavioural intention. Perceived Usefulness (PU) measures the level of personal belief regarding whether the use of a system or application can improve an individual's productivity (Davis, 1989). It significantly affects the attitude of a person (ATU) toward the use of a system (Teo et al., 2016) and behavioural intention (BI) (Davis, 1989; Teo et al., 2018). Liu et al. (2014) synthesised research papers on mobile learning at the K-12 levels and found that the use of mobile learning in instruction helped improve learning achievement and students' learning attitudes. Students can gain learning experience from situations with support from a variety of mobile devices. They can access content, communicate with other students and instructors, and work collaboratively with other students anywhere and at any time. Çuhadar (2014) studied the adoption of tablet PCs as an innovative tool for student and teachers and found that PU affected the use of tablet PCs, leading to positive ATU and BI because tablet PCs had programs that teachers could use to develop their instruction. Briz-Ponce et al. (2017) studied the learning behaviour of students using mobile technologies and found that PU affected ATU, as the use of mobile technologies helped develop students' learning process. In addition, ATU can provide guidance or requirements to certify an application. Hur et al. (2015) explored student teachers' intention to use mobile devices for teaching and found that PU affected BI because mobile devices were useful for learning, enhanced teaching effectiveness, and helped increase students' commitment to the lesson. Thus, PU has been found to have a positive effect on intention to use in instruction (Davis, 1989).

In the Thai context, Chatmaneerungcharoen (2012) studied the acceptance of e-learning by instructors and students at Kasetsart University, Kamphaengsaen Campus. The study indicated that instructors accepted the use of e-learning as a complement to classroom teaching. E-learning improved students' learning by enabling them to research more information. It also made their instruction more modern and useful. As a result, students displayed high levels of PU and BI. This accords with the Education Development Plan of the Ministry of Education (2017–2021), which has a policy of applying information technology in instruction that focuses on the development of various learning media to enable all groups of people to easily and conveniently access e-

learning with no limits on time or place. E-learning media that can be used via mobile communication devices are currently being developed (Office of Permanent Secretary, Ministry of Education, 2016). This is in accordance with the National Reform Plan for Education (Independent Committee for Education Reform, 2019) which established the policy to build a professional learning community (PLC) as a platform for teachers to exchange and learn from their experience of teaching in response to changes in the 21st century. In addition, Khlaisang et al. (2019) studied the acceptance of using smart applications in flipped learning to promote 21st century learning skills in university students in Thailand. The results indicated that facilitating conditions (FC) significantly influenced perceived ease of use (PEU) and learners' behavioural intentions to use (BI). Furthermore, a study by Kumar et al. (2020) investigated the factors influencing the use of mobile-based assessments to assess undergraduate students' 21st century skills. It was found that, besides perceived ease of use (PEU) and learners' behavioural intentions to use (BI), social influence (SI) also influenced teachers' behavioural intentions to use (BI).

Thus, the following hypotheses are proposed:

H1: PU is significantly associated with ATU.

H2: PU is significantly associated with BI.

Perceived ease of use (PEU) measures the degree to which a person believes that the use of a system or application is easy (Davis, 1989). Nikou and Economides (2017) found that PU and PEU influence the acceptance of mobile learning. Their research also found that PEU influenced PU. Students tended to use a mobile-based assessment system when they had positive perceptions of the ease and usefulness of the system in supporting learning and enhancing their experience. This concurs with Wai et al. (2018), who found that PEU affected PU of mobile applications for education and positively influenced attitudes toward using applications in learning. In addition, Camadan et al. (2018) noted that PEU affected ATU in their study of behaviour in the use of tablet PCs by instructors.

The following hypotheses are thus proposed:

H3: PEU is significantly associated with PU.

H4: PEU is significantly associated with ATU.

3.2 Subjective norm

Subjective norm (SN) refers to how a person perceives the ways that most people important to him/her think he/she should or should not behave – that is, it concerns individual behaviour (Fishbein and Ajzen, 1975). In the education context, support from people who are important to instructors and student teachers influences their use of computers in their teaching and their attitudes towards computer use and technology adoption (Teo, 2010). In addition, SN indicates a person's perception of the support he or she receives for the use of a mobile learning management system (LMS) in instruction from influential people (Shin and Kang, 2015). In the mobile learning context, this influence may come from people with higher social status, such as teachers or staff in educational institutions. Teo et al. (2014) surveyed technology acceptance among student teachers in the Thai context and found that among five factors affecting technology acceptance, subjective norm was a significant factor that explained BI.

The following hypothesis is thus proposed:

H7: SN is significantly associated with BI.

3.3 Constructivist teaching belief

Teaching belief indicates the method that a teacher wishes to use in instruction, which affects decisions and behaviour in instruction. Constructivist teaching belief (CTB) is the belief in student-centred instructional activities that promote independent learning, group discussion, and self-directed learning (Teo et al., 2008). Teo et al. (2018) found that CTB is related to ATU and BI. Teachers who believe in CTB are more likely to use technology than teachers who hold to traditional teaching styles. They also found that teachers involved in the development of teaching professionals believed that teachers had more opportunities to experience and realise the benefits of using technology, and they encouraged teachers to accept CTB. In addition, Teo and Zhou (2017) found that PU affected CTB, and they encouraged instructors to be determined in their use of technology. Such use can develop thinking skills, communication, and the presentation of ideas, and can support a constructivist learning environment.

Thus, the following hypothesis is proposed:

H8: CTB is significantly associated with PU.

3.4 Relative advantage

Relative advantage (ADV) is the degree to which the innovation or technology used is considered better than previous innovation or technologies and is related to compatibility (Moore and Benbbat, 1991; Bennett and Bennett, 2003). In the education context, relative advantage is the degree to which teachers believe that the technology used is better than the previous technology in terms of enhancing teaching efficiency, increasing opportunities for learners to participate in the use of technology, improving students' comfort with the technology, and the technology's compatibility with their teaching values and philosophy (Bennett and Bennett, 2003). Poelmans and Wessa (2015) used a constructivist framework for a blended e-learning environment and found that system quality and teacher support were critical success factors both directly and indirectly. They were found to be relatively advantageous, with high satisfaction and commitment to continuous use. Mobile learning has certain advantages over traditional learning because of the features that set smartphones apart from other technologies and platforms, as well as the ubiquity, flexibility, accessibility, and connectivity of these devices, which have expanded educational opportunities across economic and social levels. Mobile learning also encourages students to take greater responsibility than traditional learning does (Arpaci, 2015). Al-Adwan et al. (2018) found that ADV was an important factor in enhancing students' learning efficiency via mobile learning as. Students were more likely to use mobile learning because they were aware of its benefits. In addition, Lee et al. (2011) found that ADV affected PU in an e-learning system.

Thus, the following hypothesis is proposed:

H9: ADV is significantly associated with PU.

3.5 School incentives

School incentives (SCHI) represent individuals' perceptions of the level of motivation from the school. Motivation may include bonuses, promotions, or awards (Lai and Chen, 2011), as well as school technology policies that influence teachers' use of technology in the classroom (Blackwell et al., 2013; Wong, 2015). Lai and Chen (2011) found that teachers were more willing to teach using blogs if they were given an award or if the school included the blogs in its teacher performance assessments. Blackwell et al. (2013) found that professional development and work in schools with technology policies were related to the increasing use of computers. Khlaif (2018) found that teachers used more tablets and mobile technology in instruction if the school and the Ministry of Education were involved in the use of success stories and teacher incentives.

In Thailand, the 12th Education Development Plan of the Ministry of Education (2017–2021) implemented the following strategies related to the use of technology in instruction: 1) the production and development of human resources and research to meet the needs of national development to enhance the competitiveness and flexibility of the national economy and 2) the promotion and development of digital technology for education. The aim is to provide Thai people with equal opportunities for lifelong learning through information technology in response to the development of accessible services (Office of Permanent Secretary, Ministry of Education, 2016). This is in line with the objectives of the Ministry of Information and Communication Technology (2011), which focuses on utilising ICT to reduce gaps and create opportunities for people to benefit from equal development.

The following hypothesis is thus proposed:

H10: SCHI is significantly associated with ATU.

3.6 Facilitating conditions

Facilitating Conditions (FC) are the level at which each person believes that the organisation's infrastructure, technical structure, accessibility to technology resources, and administration will support the use of technology (Teo and Zhou, 2017; Villani et al., 2018; Teo et al., 2018). Teo (2009) stated that FC is an environmental factor that affects perceptions of ease of use. FC factors that affect the acceptance of classroom usage of mobile technology include the school structure, learning environment, technical support, and resources. Teo et al. (2018) found that FC affected PEU and ATU through the provision of support and knowledge while technology is used in instruction. This is in line with the findings of Sánchez-Prieto et al. (2016), who stated that FC had a positive relationship with PEU in the use of mobile devices for the teaching of primary school education methods. Such findings are in agreement with Teo (2009), who studied the attitudes toward computer use among student teachers and found that FC affected PEU.

The following hypothesis is thus proposed:

H13: FC is significantly associated with PEU.

3.7 Perceived behavioural control

Perceived behavioural control (PBC) is the perception of convenience, ease, or difficulty in showing behaviour. PBC affects the intention to show behaviour and can predict

behaviour. PBC also demonstrates an individual's belief about factors that support or discourage the showing of behaviour. PBC includes perceived self-efficacy and perceived controllability (Ajzen, 2002). Teo (2012) argued that PBC influences individual decisions through BI and affected PEU.

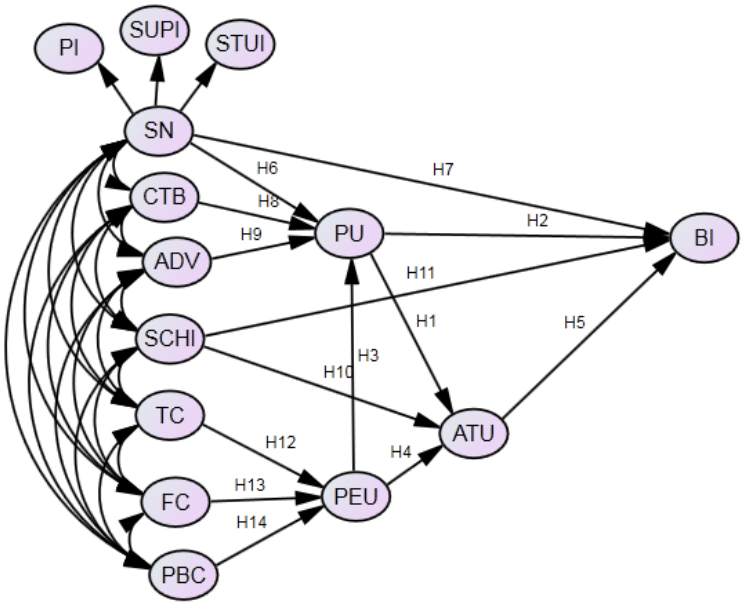
Thus, the following hypothesis is proposed:

H14: PBC is significantly associated with PEU.

4 Aim of this study and research question

This study explores the acceptance levels of secondary school teachers in Thailand of using mobile technology to teach 21st century learning skills. It thus adds to the body of literature on technology acceptance theories and sheds light on how to effectively implement mobile technologies to teach 21st century learning skills to secondary school students. Thus, the research question is, "How well does the research model explain secondary school teachers' intention to use mobile technologies to teach 21st century learning skills?" The research model is presented in Figure 1.

Figure 1 Research model



Notes: PU = perceived usefulness, PEU = perceived ease of use, ATU = attitude toward using, BI = behavioural intention, FC = facilitating conditions, ADV = relative advantage, TC = technology complexity, SN = subjective norm, PBC = perceived behavioural control, SCHI = school incentives, SUPI = superior influence, CTB = constructivist teaching belief, PI = peer influence, STU = student influence, SE = standardised coefficients.

5 Method

5.1 Participants

A stratified sampling method was used to gather data from January to March 2018. The participants were 403 secondary school teachers from the four major regions (northern, central, northeastern, and southern) of Thailand. The majority of the teachers held Bachelor's degrees (60.3%), and many also had Master's degrees (39.5%). Regarding the teaching positions in their schools, 21.3% were assistant teachers, 24.6% were practitioner teachers; 30.3% were at the professional level, 22.6% at the senior professional level, and 1% were expert-level teachers. The participants came from various teaching fields, such as Thai language (11.9%), math (16.4%), home economics and technology (13.6%), science (21.1%), foreign language (10.7%), social studies, religion, and culture (12.9%), health and physical education (5.5%), art, music, and dance (6%), and student development activities (7%) including community service, counselling, and scouts. Of the participants, 35% were male and 65% were female. The mean of their ages was 38.43 (SD = 10.29), and they ranged from 23 to 60 years old. Regarding technology use, they reported their years of experience using technology, specifically, computers (M =15.16, SD = 5.56), phones (M = 8.08, SD = 4.11), and the internet (M= 12.42, SD = 4.68).

5.2 Instrument and procedure

We used a self-designed survey to investigate Thai teachers' intentions to use mobile technologies to teach 21st century skills. The survey consisted of two parts. The first inquired regarding teachers' demographics, such as gender, age, school locations, teaching qualifications, and experience using technology. The second concerned 14 variables adapted from diverse sources (see Appendix A): perceived usefulness (5 items), perceived ease of use (5 items), attitude toward use (4 items), behavioural intention (3 items), facilitating conditions (3 items), relative advantage (4 items), technology complexity (4 items), subjective norm (4 items), perceived behavioural control (3 items), school incentives (3 items), superior influence (4 items), constructivist teaching belief (5 items), peer influence (4 items), and student influence (4 items). We tested the items underlying these constructs using a 7-point Likert scale (1 = "strongly disagree," 7 = "strongly agree").

Data were collected from February to March 2018 with the assistance of our contacts at these schools. Teachers took about 15 minutes to fill out the paper questionnaire, and then they were fully informed of the voluntary nature of participating in this study.

5.3 Ethical considerations

In this study, the researchers have obtained consent from the participants to give their responses. The informed consent was distributed to the teachers involved in our survey and the signed privacy consent forms were collected. The researchers ensured the anonymity of the participants as well as their freedom to withdraw from the study anytime with no need to explain reasons. The data were kept during the study and was destroyed upon completion of the study. Only researchers would have access to the data.

5.4 Data analysis

Several steps were undertaken in the data analysis. First, we computed the descriptive statistics using SPSS 24.0 to gather demographic information on the participants and to test the univariate normality of the data. Second, we used a structural equation modelling (SEM) approach that included measurement tests and structural models to examine the factor structures of the constructs and their relationships. In the measurement model, confirmatory factor analysis (CFA) with the maximum likelihood estimation method was performed using AMOS 22.0 to test the factor loadings of each indicator for the proposed variables. The composite reliability (CR) and the average variance extracted (AVE) were examined to determine the reliability and validity of the constructs. Finally, we tested the hypothesised relationships proposed in this study.

6 Results

6.1 Descriptive statistics

The descriptive statistics obtained suggest that the means of the variables used in this study are all above the mean level, ranging from 4.20 to 5.47 (SD from 1.00 to 1.18). The skewness and kurtosis range from -.97 to -.36 and from .36 to 1.64, respectively, meeting the cutoff criteria of |3| and |8| suggested by Kline (2005). This indicates that univariate normality was achieved.

6.2 Measurement model

The results of the measurement model indicate that all of the item loadings were above .70, revealing that these items were significant for indicating their constructs (Hair et al., 2010). As shown in Table 1, both the composite reliability (CR) and the average variance extraction (AVE) met the respective recommended criteria of 0.70 (Gefen et al., 2000) and 0.50 (Fornell and Larcker, 1981). Multivariate normality was ensured by calculating Mardia's coefficient (145.025), which was less than the value of 3,135 derived from the formula p (p+2)), where p is the number of indicators (Raykov and Marcoulides, 2012). The following model fit indices were used in this study to test its model fit: the chi-square divided by its degrees of freedom (χ^2/df), with a value lower than 3.0, suggested good model fit (Hair et al., 2010); the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI), with values greater than .90, indicated acceptable fit (Hair et al., 2010); and the Root Mean Square Error of Approximation (RMSEA) and the Standardised Root Mean Residual (SRMR), with values lower than .80, suggested a good fit (Hair et al., 2010). Thus, the measurement model achieved acceptable model fit (χ^2/df = 2.406, CFI = .935, TLI = .928, RMSEA = .059 [.057, .062], SRMR = .587).

Table 1 Factor loading results

Constructs	*Items*	*SE*	*t-Value*	*CR*	*AVE*
Perceived usefulness (PU)	PU1	0.841	–	0.952	0.799
	PU2	0.884	28.56		
	PU3	0.913	24.79		
	PU4	0.917	24.98		
	PU5	0.912	24.72		
Perceived ease of use (PEU)	PEU1	0.904	–	0.931	0.73
	PEU2	0.90	28.30		
	PEU3	0.704	17.36		
	PEU4	0.866	25.83		
	PEU5	0.883	27.01		
Attitude towards using (ATU)	ATU1	0.952	–	0.915	0.733
	ATU2	0.962	42.64		
	ATU3	0.767	21.82		
	ATU4	0.715	19.02		
Facilitating conditions (FC)	FC1	0.83	–	0.922	0.799
	FC2	0.932	24.25		
	FC3	0.916	23.66		
Relative advantage (ADV)	ADV1	0.919	–	0.972	0.898
	ADV2	0.964	38.53		
	ADV3	0.963	38.47		
	ADV4	0.943	35.47		
Technology complexity (TC)	TC1	0.799	–	0.931	0.771
	TC2	0.92	22.04		
	TC3	0.92	22.02		
	TC4	0.867	20.09		
Subjective norm (SN)	SN1	0.72	–	0.895	0.682
	SN2	0.802	24.77		
	SN3	0.886	16.60		
	SN4	0.884	16.56		
Perceived behavioural control (PBC)	PBC1	0.907	–	0.932	0.82
	PBC2	0.955	32.30		
	PBC3	0.851	24.96		
School incentives (SCHI)	SCHI1	0.836	–	0.936	0.83
	SCHI2	0.952	26.39		
	SCHI3	0.94	25.83		

Table 1 Factor loading results (continued)

Constructs	*Items*	*SE*	*t-Value*	*CR*	*AVE*
Superior influence (SUPI)	SUPI1	0.822	–	0.939	0.793
	SUPI2	0.907	23.30		
	SUPI3	0.913	23.55		
	SUPI4	0.917	23.74		
Constructivist teaching belief (CTB)	CTB1	0.854	–	0.953	0.804
	CTB2	0.914	33.29		
	CTB3	0.964	29.28		
	CTB4	0.955	28.66		
	CTB5	0.782	19.64		
Behavioural intention (BI)	BI1	0.961	–	0.977	0.935
	BI2	0.98	54.82		
	BI3	0.96	47.95		
Peer influence (PI)	PI1	0.907	–	0.893	0.678
	PI2	0.83	23.63		
	PI3	0.809	22.39		
	PI4	0.739	18.99		
Student influence (STUI)	STUI1	0.897	–	0.962	0.862
	STUI2	0.937	42.62		
	STUI3	0.946	32.17		
	STUI4	0.934	31.10		

Notes: PU = perceived usefulness, PEU = perceived ease of use, ATU = attitude towards using, BI = behavioral intention, FC = facilitating conditions, ADV = relative advantage, TC = technology complexity, SN = subjective norm, PBC = perceived behavioral control, SCHI = school incentives, SUPI = superior influence, CTB = constructivist teaching belief, PI = peer influence, STU = student influence, SE = standardised coefficients.

6.3 Structural model

The structural model also achieved acceptable model fit (χ^2/df = 2.583, CFI = .931, TLI = .925, RMSEA = .063 [.060, .065], SRMR= .0774). The results indicated that of the 14 relationships proposed in this study, 10 were supported and 4 were not supported (see Table 2).

Specifically, teachers' behavioural intentions to use mobile technologies were found to be significantly influenced by perceived usefulness (H2) and subjective norm (H7), but not by their attitudes (H5) and school incentives (H11). The variance for behavioural intention explained was 42%. The results suggested that attitude towards using mobile technologies was significantly associated with perceived usefulness (H1), perceived ease of use (H4), and school influence (H10), and these three variables explained 34% of the variance in attitude. Perceived usefulness was found to be significantly influenced by perceived ease of use (H3), constructivist teaching belief (H7), and relative advantage (H9), but not by subjective norm (H6). Perceived ease of use was significantly influenced

by facilitating conditions (H13) and perceived behavioural control (H14), but not by technology complexity (H12). The variances in perceived usefulness and perceived ease of use explained by their antecedents were 25% and 48%, respectively. The three variables proposed to indicate subjective norm, namely, superior influence, peer influence, and student influence, all significantly predicted subjective norm, with standardised estimates of .919, .986, and .908, respectively.

Table 2 Results of testing the hypotheses

Hypothesis	*Relationship*	*Standardised regression coefficient*	*Result*
H1	PU→ATU	.540***	Supported
H2	PU→BI	.286***	Supported
H3	PEU→PU	.513***	Supported
H4	PEU→ATU	.206***	Supported
H5	ATU→BI	.083	Not supported
H6	SN→PU	.013	Not supported
H7	SN→BI	.484***	Supported
H8	CTB→PU	.227***	Supported
H9	ADV→PU	.282***	Supported
H10	SCHI→ATU	.186***	Supported
H11	SCHI→BI	.037	Not supported
H12	TC→PEU	.010	Not supported
H13	FC→PEU	.399***	Supported
H14	PBC→PEU	.491***	Supported

Notes: PU = perceived usefulness, PEU = perceived ease of use, ATU = attitude towards using, BI = behavioral intention, FC = facilitating conditions, ADV = relative advantage, TC = technology complexity, SN = subjective norm, PBC = perceived behavioral control, SCHI = school incentives, SUPI = superior influence, CTB = constructivist teaching belief, PI = peer influence, STU = student influence, SE = standardised coefficients.

7 Discussion

The current study examined the intentions of Thai secondary school teachers to use mobile technologies to teach 21st century skills by using an extended technology acceptance model. The results indicated the validity of the TAM in explaining teachers' behavioural intentions to use technologies in an under-researched developing country. The relationships proposed in the research model are further explored as follows.

7.1 Supported relationships in the research model

Of the 14 hypothesised relationships, most were supported. Of the five relationships proposed in the original TAM, four were supported: PU→ATU, PU→BI, PEU→PU, and PEU→ATU. Most of the extended variables were supported: SN→BI, CTB→PU, ADV→PU, SCHI→ATU, FC→PEU, and PBC→PEU. A detailed discussion is provided in the following paragraphs.

In line with the TAM literature (e.g., Davis, 1989; Teo et al., 2018), perceived usefulness (PU) plays an important role in influencing Thai secondary school teachers' attitudes toward using mobile technologies (ATU) (H1) and their intentions to use (BI) (H2). It is understandable that the Thai educators in this study were most concerned with the capability of mobile technologies to facilitate education in 21st century skills, such as creativity, critical thinking, collaboration and communication, and knowledge sharing (Barak, 2017). Perceived ease of use (PEU) was found to significantly influence Thai teachers' perceptions of usefulness (PU) (H3) and attitude (ATU) (H4), indicating that when Thai teachers perceive mobile technologies as effortless or not difficult to use, they are likely to think of using them as useful for teaching and to form positive attitudes towards their use, echoing previous studies (Davis, 1989; Teo et al., 2018). These findings are consistent with those of Yakubu et al. (2018), who found that teachers can benefit in a variety of ways from mobile technologies regardless of their physical location. For the extended variables, subjective norm (SN) was found to significantly influence Thai teachers' intentions to use mobile technologies (BI) (H7), which is in accordance with the TAM literature (e.g., Venkatesh and Bala, 2008). The strong influence of SN on BI (β = .484) indicates that when Thai teachers perceive support for their use of mobile technologies in their teaching from peers, superiors, and students, they are more likely to use them. This finding also indicates Thailand's highly collectivist cultural orientation (Hofstede, 2011; Pimpa, 2012). According to Pimpa (2012), Thais tend toward collectivist thought; therefore, if group members suggest and adopt mobile for in teaching, others will follow suit.

Constructivist teaching belief (CTB) was found to be significantly associated with perceived usefulness (PU) in this study (H8), indicating that teachers holding the belief that knowledge is built and developed through communication and interaction are more likely to believe that teaching with mobile technologies is useful, which matches the results of the study of Chinese English teachers of Teo et al. (2018).

Relative advantage (ADV) was also found to be an important antecedent of perceived usefulness (PU) among Thai teachers (H9). This is understandable, as ADV measures teachers' perceptions of the degree to which mobile technologies are perceived to provide greater benefits for teaching 21st century skills. Mobile technologies are advantageous in facilitating teachers' and students' real-time communications via cross-personal or inter-personal interactions in the learning community. Kanbul and Güldal (2019) showed that appropriate communication and information must be provided via mobile devices to best support communication design and professional development, which can further improve students' critical thinking and communicative skills. Therefore, teachers perceive the use of mobile technologies as helpful in their teaching process. The significant relationship between ADV and PU also echoes the findings of previous studies (e.g., Gangwar et al., 2015; Kim and Shin, 2015).

The teachers perceived school incentives (SCHI) as significantly improving their attitudes toward mobile technologies (ATU) (H10), which is an interesting finding in the Thai school context. This is in line with previous works that found that school incentives represent the level of individual perceptions about motivation from school, which includes bonuses, promotions, and awards (Lai and Chen, 2011; Blackwell et al., 2013; Wong, 2015). Khlaif (2018) also found that teachers used more mobile technologies to teach if the school and the government were involved in the teacher incentives and the sharing of success stories.

This study found that facilitating conditions (FC) (H13) and perceived behavioral control (PBC) (H14) are significant antecedents to perceived ease of use (PEU), which is in line with the findings of previous studies (e.g. Teo et al., 2018; Venkatesh, 2000). Although the predictive role of FC has been diminishing in developed countries because of the rapid development of advanced technologies, it still significantly influences teachers' PEU in developing countries such as Thailand. This study measured PBC – teachers perceived knowledge, resources, self-efficacy, and perceived controllability (Ajzen, 2002) in using mobile technologies in teaching – and the relationship between PBC and PEU. The findings were in line with Teo (2012), indicating that when teachers perceive themselves as having sufficient ability to use mobile technologies, they are more likely to think of them as effortless to use.

7.2 Unsupported relationships

Of the total 14 hypotheses, the following 4 were not supported: ATU→BI, SN→PU, SCHI→BI, and TC→PEU.

The results suggest that attitude toward using does not have a significant influence on BI (H5). This shows that in-service teachers' attitudes toward using a technology may in fact be less important than how useful and easy to use they believe the technology to be. As found by Teo et al. (2018), teachers tend to care more about the effectiveness and efficiency of a technology than about their personal feelings toward that technology.

Contradicting previous studies (e.g., Venkatesh and Bala, 2008), subjective norm (SN) was found to be not significantly associated with perceived usefulness (PU) (H6) among Thai teachers. This suggests that although teachers' intentions may be influenced by other significant people in their lives, when referring to their experience using mobile technologies in teaching 21st century skills, Thai teachers are more likely to take practical functions into consideration rather than forming perceptions of usefulness by only listening to others' opinions and suggestions. This is understandable given that usefulness and intentions are not the same thing, although they are highly related (Davis, 1989).

Unlike in Lai and Chen's 2011 study, which indicated that school incentives had a significant impact on students' use of technologies, school incentives did not have a significant relationship with BI (H11) even though they significantly influenced the attitudes of teachers. The unsupported ATU→BI relationship may have some connection with this. In addition, as the participants were schoolteachers rather than students, the use of mobile technologies in teaching was probably not related to the kinds of rewards that are appealing to students.

Technology complexity (TC) is reported to have a significant influence on perceived ease of use (PEU) (H12) in the technology acceptance literature (e.g., Venkatesh and Bala, 2008). However, it lacks significance among Thai teachers in the current study. Unlike workers in industrial and business settings (Venkatesh and Bala, 2008) and preservice teachers (Teo, 2009), in-service teachers accumulated sufficient knowledge and skills to use mobile technologies through their daily usage and technology training; therefore, they may not consider using mobile technologies as being complex or difficult, which may help explain the lack of significance of the TC and PEU relationship.

7.3 Contributions, limitations, and further studies

The results from the Thai educational context using an extended technology acceptance model enrich the understanding of the validity of the TAM in explaining users' intentions. Some inconsistencies suggested in this study provide cause to consider the contextual and cultural influences on technology users' acceptance. In addition, the results could help administrators and policy makers make informed decisions on how best to improve the level of technology use by Thai teachers. Facilitating conditions have a positive influence on teachers' perceived ease of use; thus, school leaders may decide to improve their schools' hardware and software. The results also suggest that Thai teachers should take their own initiative to improve their technological skills to better integrate technologies in teaching 21st century skills.

The current study has some limitations. First, a self-reported survey was used to collect the data, which might lead to concerns regarding the response validity (Fan et al., 2006). Second, other variables that potentially influence Thai teachers' acceptance of mobile technologies, such as perceived enjoyment (Venkatesh and Bala, 2008) and cultural influence (Tarhini et al., 2016; Teo and Huang, 2019), were not examined. Finally, a cross-sectional study such as this is always limited in identifying associations between variables (Pearl, 2012).

Further studies should take potential factors into consideration by considering the content, contextual, and cultural factors that affect teachers' intentions to use mobile technologies. In addition, researchers are suggested to adopt other research designs, such as qualitative study, to achieve in-depth understanding and design thorough experiments to uncover causal relationships.

8 Conclusions and suggestion

This study examined the factors that influenced Thai secondary school teachers' intentions to use mobile technologies in teaching. The results indicated the validity of the TAM in explaining teachers' technology acceptance in an under-researched Asian context, Thailand. This study is significant in that the results contribute to both theory and policy making practice, as mentioned above. The results further provide useful suggestions for teacher development programs and teacher training. All six factors, including subjective norm (SN), constructivist teaching belief (CTB), relative advantage (ADV), school incentives (SCHI), facilitating conditions (FC), and perceived behavioural control (PBC), have played important roles in instructional design during the COVID-19 pandemic and lesson planning for the new normal learning. The Ministry of Education (2020) has proposed learning management guidelines for online instruction and Distance Learning Television (DLTV). There are four alternatives: online, on-air, on-hand and on-site, which can be chosen according to their suitability for meeting the students' learning needs. The Ministry of Education aims to assist students to access lessons and enable teachers to manage their instruction more efficiently. Training sessions, for instance, have been conducted on technology use, teachers' attitude formation towards technology use, and instructional design modelling that requires students to appropriately play their knowledge and skills in current real-world situations.

Using mobile learning to teach 21st century learning skills could foster learners' creativity, innovation, and higher-order thinking skills and enhance learners' motivation

and experience in learning anywhere, at any time (Ahmad et al., 2020). This is consistent with the study by El-Sofany and El-Haggar (2020) which stated that mobile learning could help develop learners' positive thinking, collaboration, and communication, as well as create positive perception and flexibility in learning and accessing learning resources. Similarly, Khlaisang (2018) developed the CU Flipped Smart application for mobile learning using teaching strategies and flipped technology to teach 21st century skills. Considering the use of mobile technologies to promote learners' 21st century skills together with the six aforementioned factors, it is apparent that these factors will support secondary school teachers' instructional management in terms of activity design, teaching method selection, and learners' motivation enhancement based on the contexts of students, schools and communities.

The COVID-19 pandemic has given rise to online learning being the new normal; learning in the post-COVID-19 era is likely to continue to change, as well. Further research might investigate these six factors in the contexts of teachers and students to draw up guidelines for future instructional development.

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Appendix A

Perceived usefulness (PU) (adapted from Davis, 1989)

1 Using APP would help me to complete my teaching learning more quickly.

2 Using APP would improve my performance.

3 Using APP would increase my productivity.

4 Using APP would improve my effectiveness.

5 Using APP would benefit to my work.

Perceived Ease of Use (PEU) (adapted from Davis, 1989)

1 Learning how to use APP is easy for me.

2 I find it to be easy to use APP to do what I want.

3 My interaction with APP does not require much effort.

4 It is easy for me to become skilful using APP.

5 I find APP is easy to use.

Attitude towards Use (ATU) (adapted from Davis, 1989)

1 APP makes teaching more interesting.

2 Teaching with APP is fun.

3 I like to use APP.

4 I look forward to those aspects of my teaching that require me to use APP.

Facilitating conditions (FC) (adapted from Teo et al., 2018)

1 When I need help to use APP, specialised instruction is available to help me.

2 When I need help to use APP, a specific person is available to provide assistance.

3 When I need help to use APP, guidance is available to me.

Relative advantage (ADV) (Moore and Benbasat, 1991)

When comparing to previous learning, using APP:

1 Improve the quality of my teaching.

2 Make it easier to my teaching.

3 Enhance my teaching effectiveness.

4 Increase my productivity.

Technology complexity (TC) (Thompson et al., 1991)

1 Using APP take too much of my time.

2 Teaching with APP is so difficult to understand what is going on.

3 It takes too long to learning how to use APP so that it is not worth the effort.

4 Using APP is a complicated activity.

Perceived behavioural control (PBC) (Ajzen, 2002; Taylor and Todd, 1995)

1 I can control over using APP.

2 I have the knowledge necessary to use APP.

3 I have the ability to use APP.

4 I have the resources necessary to use APP.

School Incentives (SCHI) (Lai and Chen, 2011)

1 My willingness to teach with APP would be influenced when the rewards provided by the institution.

2 My willingness to teach with APP would be influenced when the teaching performance evaluation indicated by the institution.

3 My willingness to teach with APP would be influenced when the timely motivation provided by the institution.

Supervisor Influence (SUPI) (Lai and Chen, 2011)

1 Head of my department thinks that using APP is valuable for teaching.

2 Head of my department's opinions are important to me.

3 School administrator's opinions about using APP are important to me.

4 If the supervision of my department senior friends started using APP for teaching, it would encourage me to do the same.

Peer influence (PI) (Lai and Chen, 2011)

1 My friends think that using APP would make my teaching more value.

2 My friends' opinion is very important to me.

3 If most of my friends start using APP, I will start using the APP too.

4 My colleagues advise me to use APP.

Student influence (STUI) (Lai and Chen, 2011)

1 My students think that I should use APP for my teaching.

2 Students have expectation that I will use APP for my teaching.

3 Students like teachers who use APP for teaching.

4 Students want me to use APP for my teaching.

Constructivist teaching belief (CTB) (Teo et al., 2018; Teo et al., 2008)

1 When using APP, effective teaching encouraging more discussion and hands-on activities for students is provided.

2 When using APP, students are given many opportunities to express their ideas.

3 When using APP, there is a democratic and free atmosphere which stimulates students to think and interact.

4 When using APP, every student is unique or special and deserves an education tailored to his or her particular needs.

5 When using APP, the focus of teaching is to help students construct knowledge from their learning experience instead of knowledge delivery.

Behavioural intention (Davis, 1989)

1 In intend to continue using APP in the future.

2 I expect to teach with APP in the future.

3 I plan to teach with APP in the future.