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Factors influencing university teachers' use of a mobile technology-enhanced teaching (MTT) platform

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Abstract

The main purpose of this study was to examine the critical factors influencing university teachers' use of a mobile technology-enhanced teaching (MTT) platform during the new coronavirus (COVID-19) epidemic. An integrated model with multiple factors drawing from the theoretical models and learning theories was proposed in this study to examine university teachers' intentions to use an MTT platform. The multiple factors included the individual factor (e.g., growth mindset, help seeking, and self-efficacy), the social factor (e.g., social norms), and the technological acceptance factor (e.g., perceived usefulness and perceived ease of use). The survey method was used to collect data on university teachers' perceptions of the MTT platform use, and a two-step structural equation modeling approach was used for the data analysis. Based on the path analysis of a total of 214 valid responses, the results identified that growth mindset, help seeking, and self-efficacy from the individual factor, as well as perceived usefulness from the technology acceptance factor were the significant determinants of university teachers' intentions to adopt the MTT. The contributions of this study are twofold. First, the proposed model was derived from multiple literature sources, providing a sound theoretical foundation to understand MTT platform use from an academic angle. Second, university teachers' viewpoints are a unique observation of their actual platform use, providing practical insights into the improvement and maintenance of MTT-related platforms for all educators. The findings are especially valuable during the post-COVID-19 era.

Keywords Growth mindset · Help-seeking · Self-efficacy · Mobile technology-enhanced teaching · Social norms

Introduction

With the increasing acceptance of online learning in recent years, the advance of mobile networks and the Internet, as well as the need for flexibility in the learning process, has led to the emergence of mobile learning (m-learning) (Hwang & Tsai, 2011). Researchers have defined m-learning as the learning model by which learners can learn anytime and

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anywhere through mobile technology, thus realizing the desire of "equal education for all people around the world" (Lai & Hwang, 2015). Through the use of m-learning, learners can gain learning resources from both the real world and the digital world (Chavoshi & Hamidi, 2019; Chu et al., 2010; Wang et al., 2017). M-learning has brought some convenience and benefits to education (Lee & Tsai, 2013); however, it still requires further investigations from multiple perspectives. For instance, Chavoshi and Hamidi (2019) suggested that the important factors affecting the acceptance of m-learning (e.g., technological, pedagogical, social, and individual factors) need to be taken into consideration in m-learning design. However, most studies discussing the effectiveness of mobile learning are from students' perspectives (e.g., Bedford, 2017; Nie et al., 2020; Tseng et al., 2020). In the context of online education, Bao (2020) highlighted the importance of some instructional strategies regarding the effectiveness of m-learning, such as the effective delivery of instructional information from teachers to students, and the relevance between online instructional design and student learning. Bao's research echoes the following view that the teacher is the key factor in the successful implementation of technology in the classroom (Chen et al., 2009; Sánchez-Prieto et al., 2017). Recent research on educational technology also found that teachers' beliefs about the use of technology determine their intentions to adopt technology-enhanced instructional activities and teaching practices (Bai et al., 2019; Ursavaş et al., 2019). Therefore, this study takes university teachers as the research object to examine the factors that affect their intention to use a mobile teaching platform.

The above-mentioned studies have shown that teachers play a critical role in the context of online learning, especially during the new coronavirus (COVID-19) epidemic. The outbreak of COVID-19 has caused many closures of university campuses, but the event has also facilitated the large-scale adoption of online learning and m-learning. According to an international report by the United Nations (UNESCO, 2020), stakeholders and administrators of higher education institutions have no option but to employ the Internet or mobile technologies to continue scheduled academic activities across all schools worldwide. In China, to avoid affecting the progress of students' learning, many schools were forced to initiate extensive online teaching as well. In this manner, it is noteworthy to investigate the factors that influence university teachers' intentions to fully use the online teaching platform in such an uncertain environment. At such time, university teachers' use of digital platforms to continue providing online courses has become a solution to the problem of school closure, with the aim of achieving the objective of "uninterrupted teaching and learning." For example, DingTalk, a mobile technology-enhanced teaching (MTT) platform, has been adopted by many schools in China, providing a comprehensive digital environment for both teaching and learning during the epidemic (Huang et al., 2020).

Some recent studies have also reported that such platforms tend to be released hastily (Chen et al., 2020; Demuyakor, 2020). In this study, the authors are conservative about the effectiveness of MTT platforms. This raises a challenge: what are the significant factors influencing university teachers' adoption of an MTT platform? Many past studies on mobile learning were carried out by teachers voluntarily; however, this is the first time that all schools have been closed, and online teaching has been fully launched, not only in China but also in many other areas of the world. To address this challenge, university teachers' perspectives were investigated to provide the most critical opinions after their actual usage of an MTT platform. Multiple aspects derived from the literature, including individual, social, and technological acceptance factors, were considered in this study to examine university teachers' intentions to use the MTT platform. Accordingly, three research questions of this study were specified. First, among the individual factors, what construct will significantly affect university teachers' intentions to adopt an MTT platform? Second, how

will the social factor affect university teachers' intentions to use an MTT platform? Last, will the technology acceptance factors significantly affect university teachers' intentions to adopt an MTT platform? The hypothetical relationships among factors of interest are provided in the next section.

The contributions of this study are twofold. First, derived from multiple literature sources, the proposed model aims to provide a theoretical foundation to understand MTT platform use from an academic perspective. Second, university teachers' viewpoints are a unique observation of actual platform use, providing practical insights into the improvement and maintenance of MTT-related platforms for all educators. The results will be particularly valuable during the new coronavirus epidemic and even the post-COVID-19 era. The structure of this article is divided into the following sections. The literature review section depicts recent mobile learning research, three influential factors through a theoretical lens, and the development of hypothetical relationships with teachers' intentions to adopt m-learning platforms. Next, the research method including the procedures of data collection and data analysis employed in the study are described. The results are then reported and interpreted. Lastly, the findings are discussed and concluded.

Literature review: theoretical framework and hypotheses development

Past m-learning research has pointed out that when evaluating teachers' adoption of mobile technology, multiple aspects need to be considered (Beteille et al., 2020; Hsieh & Tsai, 2017). In this study, multiple intention-based models were adopted to explore university teachers' beliefs about various aspects of the use of mobile technology-enhanced teaching (MTT) platforms. Among the theoretical intention-based models, the technology acceptance model (TAM) is the most used theoretical model for predicting and explaining users' intentions to use mobile learning systems (Hsu, 2016; Lai et al., 2016; Mittal & Alavi, 2020), including teachers' intentions (Beteille et al., 2020). In the TAM framework, perceived usefulness (PU) and perceived ease of use (PEU) are two key determinants of a particular technology adoption, such as mobile learning systems. Hsu (2016) used PU and PEU as the two determinants of mobile-assisted language learning use, while Lai et al. (2016) adopted PEU as one predictive factor of high education teachers' mobile learning environment use. Recently, Mittal and Alavi (2020) found that both PU and PEU were significant factors in the context of university teachers' mobile learning acceptance.

In addition to TAM, Lai (2020) adopted the unified theory of acceptance and use of technology (UTAUT) to examine the use of mobile learning devices by older adults. Four antecedents in the model were found: performance expectancy, effort expectancy, social influence, and facilitating conditions. Note that perceived usefulness shares similar concepts with performance expectancy (Chiu & Wang, 2008), and perceived ease of use could be used to represent effort expectancy (Venkatesh & Morris, 2000). The theory of planned behavior (TPB) provides another theoretical lens to understand human–computer interactive behavior and individual behavior of technology adoption. Three antecedents of users' behavior intention are attitude, social norms, and perceived behavior control. Based on the TPB, Nie et al. (2020) examined factors which influence the check-in services in mobile English learning. Note that Thompson et al. (1991) suggested that social influence in UTAUT is similar to the subjective norms within TPB. According to the above three theoretical intention-based models, the current study adopted subjective norms as the proxy variable of the social factor (based on the TPB), and perceived usefulness, as

well as perceived ease of use, for the technology acceptance factor (based on the TAM and UTAUT) to examine the most influential determinants of MTT adoption among university teachers.

Beyond the social and technology acceptance factors, the literature has shown that when considering personal characteristics in the context of technology use, the growth mindset and self-efficacy are two important variables affecting their adoption of mobile learning systems (Bai & Wang, 2020; Richardson et al., 2020). Applying Dweck's mindset theory of motivation, Richardson et al. (2020) conducted a survey and concluded that teachers' mindsets and motivational attitudes (e.g., motivation and efficacy) will affect their teaching behaviors. These two important motivational beliefs (i.e., growth mindset and self-efficacy) have also been confirmed in other relevant research on mobile teaching and learning, including English language learning (Bai & Wang, 2020), first-time online learning engagement (Tseng et al., 2020), and science learning (Bedford, 2017). In the study of mobile teaching and learning in the context of the COVID-19 pandemic, Santi et al.'s (2020) research identified that teachers' self-efficacy of digital skills was related to the use of mobile technology in education. It should be noted that perceived behavioral control in the TPB model encompasses two components: facilitating conditions and self-efficacy (Taylor & Todd, 1995). When it comes to technology adoption, digital capabilities or perceived self-efficacy are often adopted. Moreover, researchers have also reported that help seeking is considered as a self-regulatory strategy that positively influences students' learning and achievement (Won et al., 2021). In a study of web-based courses, students' academic help-seeking behaviors were found to be related to their general self-efficacy (Cheng & Tsai, 2011). The relationship between online help seeking and subsequent self-regulated learning was also confirmed in a study of preservice teachers (Liu, 2017). Detailed information of the above-mentioned research with the theoretical lens and key constructs are also summarized in Table 1.

The above research has suggested that the teacher's role is critical to the effectiveness of mobile learning. However, most teachers in the past studies used teaching platforms voluntarily. In other words, they had a certain degree of confidence in the teaching platforms they chose. In the face of the sudden outbreak of COVID-19, university teachers were forced to adopt online courses due to the closure of universities. In this circumstance, teachers' intentions to use online platforms would be different from those of voluntary teachers. Moreover, most previous studies used a single theory to understand users' willingness to adopt online courses. In this research, however, we proposed a research framework with multiple theoretical models and learning theories to examine university teachers' intentions to use MTT platforms, as shown in Fig. 1. In this study, university teachers' intentions are proposed to be jointly determined by their individual factors (including growth mindset, help seeking, and self-efficacy), social factors (i.e., subjective norms) and technology acceptance factors (e.g., perceived ease of use and perceived usefulness). Three influential factors of main interests and the hypothetical relationships between university teachers' intention to use mobile technology-enhanced teaching (MTT) platforms are depicted as follows.

Individual Factors

Researchers have considered individuals' motivational beliefs as important predictors of behavioral intentions to use technology (Chavoshi & Hamidi, 2019; Davis, 1989; Wang & Wang, 2009). Among various aspects, three individual variables that meet the main

Table 1 A list of recent m-learning research: theoretical lens and key constructs used

Authors	Year	Context	Subjects	Theoretical lens	Key constructs
Bai & Wang	2020	English language learning	690 students	Expectancy-value theory	Mindset, self-efficacy, intrinsic value
Lai	2020	Mobile learning	238 older adults	UTAUT	Social influence, facilitating conditions, and performance expectancy
Mittal & Alavi	2020	Mobile learning	212 higher education teachers	TAM	PEU, PU, self-enhancement, constructivist belief, technological barriers, attitude
Nie et al.	2020	Mobile English learning check-in services	676 mobile English learners	TPB	Attitude, perceived behavioral control, subjective norm, social image
Richardson et al.	2020	Science, technology, engineering, and mathematics (STEM)	67 teachers	Dweck's mindset theory of motivation	Mastery orientation, mindset
Santi et al.	2020	Mobile teaching and learning	125 teachers		Self-efficacy
Won et al.	2021	College students' academic help-seeking as self-regulated learning	307 college students	Self-regulation theory	Help seeking
Tseng et al.	2020	Online courses for the first time	254 first-time online students	Integrated model	Mindset, self-efficacy, online engagement
Liu	2017	Online learning	462 preservice teachers	Integrated model	Self-efficacy, help seeking, perceived benefit
Hsu	2016	EFL (English as a Foreign Language)	158 teachers	TAM	PEU, PU, attitude, content knowledge
Lai et al.	2016	Mobile learning	1239 students & 429 teachers	TAM	Timely guidance, PE
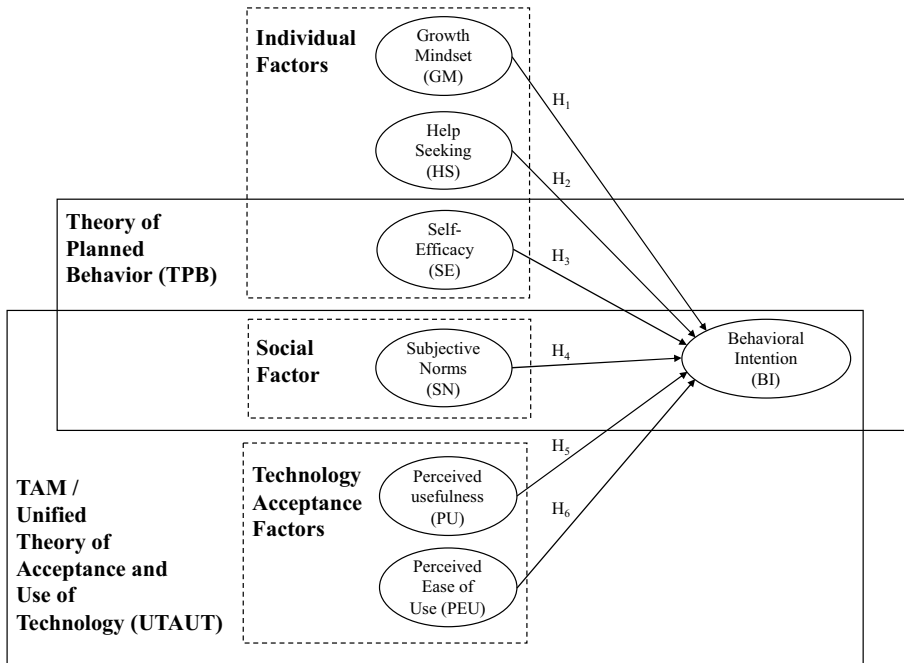
Fig. 1 Proposed research model

interest of this research context, namely growth mindset, help seeking, and self-efficacy, are employed in this study. Growth mindset has been recognized as an important motivational belief that can help students make significant changes in their learning, especially in the learning achievements of Asian students (Bai & Guo, 2019). Growth mindset (GM) refers to an individual's belief that their ability is malleable and can be developed through effort (Dweck, 2006). Dweck's research found that an individual's mindset (i.e., how they perceive their abilities) plays an important role in their motivation and achievement, and if we change an individual's mindset, it will also enhance their achievement. This is because people with a growth mindset are more likely to recognize the effort required for learning and are more likely to persevere in the face of adversity (Bai & Wang, 2020; Bedford, 2017).

While some studies have focused on the benefits of students with a growth mindset, others have found that teachers' beliefs affect how students perceive their abilities (Seaton, 2018; Zeng et al., 2019). These studies further demonstrated the impact of training on continuous changes in teachers' mindsets and teaching practices. For example, Smith et al. (2016) pointed out that teachers' willingness to adopt new teaching methods, coupled with students' ability to use mobile devices, will enhance the learning and teaching experience. Richardson et al. (2020) further confirmed that teachers' mindsets and motivational attitudes affect their use of effective teaching practices. Based on the literature, we inferred that teachers may not be familiar with MTT platform use, but if they have positive beliefs about their ability to learn and use mobile technology in their teaching practices, they will be more motivated to use the technology. From the discussion above, the following hypothesis was therefore proposed:

H1 Growth mindset positively influences university teachers' behavioral intention to use the MTT platform.

Pintrich et al. have defined help-seeking (HS) as an individual's ability to use external resources to solve problems, and it can also be seen as an individual's ability to cope with pressures or difficulties (Pintrich et al., 1991). Other researchers have referred to help seeking as an informal interpersonal activity, in which individuals deliberately approach others they believe can provide them with the skills, abilities, or resources needed to solve certain problems (Bamberger, 2009; Geller & Bamberger, 2012). Help seeking includes the selection of subjects for seeking help, the use of social media, and potential information for seeking help actions (Liu, 2017). When students encounter problems that they cannot solve by themselves, they can seek help from teachers and peers who can support them in finding or developing solutions (Jong, 2019). If individuals believe that their ability can be enhanced, they will make more effort and be more persistent in improving their skills, and will adaptively seek help when facing setbacks (Bai et al., 2019; Dweck, 2006). In other words, asking for help is a useful strategy for promoting learning (Liu, 2017).

In the teachers' context, prior research has confirmed the relationship between teachers' help seeking and job performance (Butler, 2007). Recently, Bai et al. (2019) indicated that teachers' help seeking positively impacted their intention to use technology. Compared with seeking help in a traditional classroom environment, seeking help online has potential advantages. Moreover, almost all schools were forced to fully implement online teaching during the beginning of the epidemic. In such a challenging situation, the internet community and online learning environment provide teachers with opportunities to obtain external information. Therefore, teachers may overcome the limitations of time and space and seek help to solve problems by interacting online with other colleagues and online communities (Liu, 2017). For teachers in this study, we assume that when they encounter problems such as how to use MTT for online teaching in full courses, they may seek help to successfully adopt this technology. Thus, the following hypothesis was proposed:

H2 Help seeking positively influences university teachers' behavioral intention to use the MTT platform.

Researchers have reported that self-efficacy is also an important personal attribute in using technology because it is a domain-specific belief that is closely related to students' previous learning experiences of a given task (Bai et al., 2019). Bandura (2001) defined self-efficacy as a belief in one's ability, confidence, and expectation to perform a specific task. Prior research has also pointed out that students' behaviors can be predicted by their beliefs about their ability to accomplish a task (i.e., self-efficacy) (Bandura, 2001; Eccles & Wigfield, 2002).

From another perspective, researchers also pay more attention to the influence of self-efficacy on teachers' behaviors when using technology-enhanced platforms (Joo et al., 2018). In particular, self-efficacy is a critical factor affecting teachers' behaviors in their teaching (Tschannen-Moran & Hoy, 2001). Teacher self-efficacy is defined as their personal beliefs about their abilities and skills to facilitate student learning (van Dinther et al., 2013). Those with higher teacher self-efficacy were found to have greater commitment to teaching, and to be more willing to adopt advanced teaching methods that are closely related to student learning (Joo et al., 2018; Tschannen-Moran & Hoy, 2001). In this study, university teachers' self-efficacy for mobile technology is their judgment of their

own abilities to successfully adopt an MTT platform. This means that teachers will have a higher tendency to employ an MTT platform if they believe they are competent (Kang & Shin, 2015; Teo & Zhou, 2014). Thus, the following hypothesis was proposed:

H3 Self-efficacy positively influences university teachers' behavioral intentions to use the MTT platform.

Social Factor

The theory of planned behavior (TPB) explains how the informational and motivating factors influence particular individual behavior (Ajzen, 1991). According to the theory of reasoned action (TRA) (Fishbein & Ajzen, 1975) and the theory of planned behavior (TPB) (Ajzen, 1991), subjective norms (SN) is a critical determinant from a social perspective for predicting an individual behavior intention, especially in contexts of learning technology adoption (Hsiao & Tang, 2014).

SN represents the perceived social pressure from important others (e.g., family or friends) to engage in a particular behavior. In the context of e-learning, SN represents important other people's support for adopting technology (Chu & Chen, 2016). The positive relationship between SN and intention to adopt mobile learning tools has been confirmed (e.g., Chu & Chen, 2016), because individuals not only use mobile application tools, but sometimes also need to share their learning records on social networking sites (Nie et al., 2020). Based on the Unified Theory of Technology Acceptance and Use (UTAUT), Lai (2020) identified social influence as a significant determinant of mobile learning. Note that Thompson et al. (1991) pointed out that social influence within UTAUR is similar to SN within TRA or TPB. Therefore, this study adopted SN as the only determinant of social influence factors.

Some studies on teachers' technology acceptance have reported that SN has no predictive power for teachers' intention to use technology (Ma et al., 2005; Teo et al., 2016; Yuen & Ma, 2008). However, other researchers have identified SN as an important social variable in explaining teachers' intentions to adopt technology (Ajzen, 1988; Ursavaş et al., 2019; Wang & Wang, 2009). For example, the support of other teachers and researchers is an important factor in increasing teachers' ability to use technology successfully (Chen et al., 2009). In this study, SN refers to a teacher's perception of the opinions or suggestions of other teachers or school authorities regarding the acceptance of MTT platform use. Therefore, the following hypothesis was proposed:

H4 Subjective norms positively influence university teachers' behavioral intention to use the MTT platform.

Technological Acceptance Factor

In the field of educational research, the technology acceptance model (TAM) is widely employed to explain teachers' intentions to use new technology-enhanced teaching activities (Sánchez-Prieto et al., 2017; Teo, 2019; Wang & Wang, 2009). Whether to integrate technology into teaching is a complex decision that is influenced by various factors. In addition to individual beliefs (Bai et al., 2019; Dweck, 2006; Seaton, 2018) and social influences (Chiu & Tsai, 2014; Huang et al., 2019; Zhao et al., 2018), the acceptance factors of technology are especially addressed in the current study.

According to Davis (1989), perceived usefulness (PU) and perceived ease of use (PEU) are fundamental determinants of technologies/systems adoption. While PU refers to the degree to which the individual believes that using the technologies/systems will improve their job performance, perceived PEU refers to the degree to which the individual considers that using the technologies/systems will be free of effort (Davis, 1989). In this sense, users will proactively adopt technology when they believe it to be helpful. From the perspective of utilitarianism, perceived usefulness is considered to be a key influencing factor of the behavioral intention to use innovative self-service technology (Hsiao et al., 2020). Moreover, when users think that a specific technology can be used more easily and efficiently to complete their tasks, they are more likely to adopt it (Sánchez-Prieto et al., 2017; Wang & Wang, 2009).

Recent studies have used TAM to explain teachers' intentions and behaviors to integrate technology into teaching, and to predict its explanatory power (Al-Emran et al., 2018; Teo, 2019; Teo et al., 2016). Some researchers have indicated the importance of teachers' perceptions of using technology-based platforms for teaching, and concluded that PEU and PU of mobile technology directly influence teachers' behavioral intentions to adopt mobile technology (Chavoshi & Hamidi, 2019; Hsieh & Tsai, 2017).

When teachers are more familiar with or more confident in using mobile technology, they will find that it is easier to use it to assist with online teaching (Motaghian et al., 2013), which in turn will affect their perceptions and behavior regarding continued adoption of the technology (Al-Emran et al., 2018). In line with the above-mentioned research, the present study explored the acceptability of teachers' adoption of MTT platforms, and the impacts of PU and PEU on their behavioral intentions of using MTT in their future teaching practices. Thus, the following hypotheses were proposed:

H5 Perceived usefulness positively influences university teachers' behavioral intentions to use the MTT platform.

H6 Perceived ease of use positively influences university teachers' behavioral intentions to use the MTT platform.

Methodology

Procedure and subjects

To meet the emergent need for the large-scale adoption of online teaching, participants had experience using other technology-enhanced platforms for teaching purposes, including online presentations and searching for teaching videos. All of the participants were university teachers in China, and were recruited for this study on a voluntary basis. In this study, the online courses were implemented through DingTalk, which is currently an actual MTT platform adopted by many universities in China. However, participants reported that they were not familiar with DingTalk, and had no experience of completing an entire lecture through using DingTalk in class. To maintain the validity of the online questionnaire, the following procedure was adhered to. First, at the beginning of the study, all participants were asked to complete three courses of training to familiarize them with the DingTalk platform. The training courses included course design for online learning, operation of the mobile system, and essentials of live distance learning.

DingTalk is designed for PC and mobile use, providing users with multiple solutions to deliver their online courses. The instructional services included live-streaming of lectures, real-time class announcements and discussion, notifications, student learning reports, and live interactions, such as "like." Fig. 2 shows a live-streaming class on DingTalk.

Next, after completing the training courses, participants were invited to answer the questionnaire online. A 29-item questionnaire (see Table 6 in Appendix) was used to collect the empirical data by online survey. The authors of this study took 3 weeks to gather the data from the online questionnaire. The process of data collection was completed on February 20, 2020. As a result, a total of 260 questionnaires were collected. Among them, we found that 45 participants were non-experienced users of online teaching; they were therefore excluded as they did not meet the requirements of this study. In addition, one incomplete questionnaire was also excluded as the participant missed answering some measurement items. After screening out 46 questionnaires, a total of 214 were found to be valid and were thus treated as the final dataset for the subsequent analysis. The main characteristics of the 214 responses are described as follows. Overall, teachers between 30 and 49 years old accounted for the majority of the sample (65%), while junior teachers (under 30) and senior teachers (50 and over) were approximately 15% and 20%, respectively. Male and female teachers made up 46% and 54% of the sample. As for the teaching fields, most of the teachers were from the field of arts and humanities (including arts, law, languages, education, history, and philosophy; accounting for 61%). The remaining teachers were from the school of science and engineering (26%) and the business school (13%). Regarding the experience of technology-enhanced teaching, less than a quarter of teachers were new to certain types of technology-enhanced teaching (1–3 years), while more than 75% were experienced users who had adopted technology in their courses for more than 3 years. Detailed information is shown in Table 2.

Fig. 2 A live-streaming class on DingTalk

Table 2 Characteristics of the sample (n = 214)

Characteristics	Number	Percentage
Age of teachers		
20–29	33	15.4
30–39	59	27.6
40–49	80	37.4
50 and over	42	19.6
Gender of teachers		
Male	98	45.8
Female	116	54.2
Domain of teaching		
Arts and humanities	131	61.2
Agriculture, engineering, and medical sciences	56	26.2
Economics and business	27	12.6
Experience of technology-enhanced teaching		
1–2 years	50	23.4
3–5 years	72	33.6
6–10 years	53	24.8
Over 10 years	39	18.2

Measurement development

All measurement items used in this study were adapted from published sources (Bai et al., 2019; Kao & Tsai, 2009; Teo et al., 2016; Ursavaş et al., 2019; Wang & Wang, 2009). Moreover, in order to design the questionnaire content during the coronavirus pandemic, two experts in the field of online teaching and learning were consulted for this study. They assisted in confirming that all items in the questionnaire were in line with teachers' familiar tone of expression and could be applied to understand teachers' actual feelings and behaviors regarding their MTT platform use.

The questionnaire used in this study was adapted from previous research, including participants' demographic information and 22 items belonging to six constructs. These items and their corresponding constructs are as follows: GM (three items, e.g., "I can learn a lot from my mistakes when using the mobile technology-enhanced teaching (MTT) platform"), HS (four items, e.g., "I ask the instructor to clarify procedures I don't understand well"), SE (four items, e.g., "I am confident that I have adequate ability to operate the MTT platform"), SN (five items, e.g., "The authorities of my institution agreed to use the MTT platform in my teaching"), PU (four items, e.g., "Using the MTT platform improves my teaching performance"), PEU (five items, e.g., "It is easy for me to become skilled at using the MTT platform"), and BI (four items, e.g., "I intend to use mobile technology to perform teaching-related activities and to communicate with my students"). All the measurement items used in the questionnaire adopted a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Results

Measurement assessment

To assess the reliability and validity of the measures, we adopted a two-step structural equation modeling approach for the data analysis (Anderson & Gerbing, 1988). First, the measurement model was evaluated by using confirmatory factor analysis (CFA) accompanied by LISREL 8.54. Jöreskog and Sörbom (1993) suggested using the value of $\chi^2/d.f.$ as a goodness-of-fit index and recommended that $\chi^2/d.f.$ between 2 and 3 is indicative of a "good" or "acceptable" data-model fit. In the education field, researchers have used the $\chi^2/d.f.$ as the fit index for the proposed model. For example, Zhu et al. (2020) proposed an empirical model of self-directed learning in MOOCs ($\chi^2/d.f. = 2.86$), while Huang and Teo (2020) provided an extended technology acceptance model on Chinese teachers' intentions to use technology ($\chi^2/d.f. = 1.94$). In the current study, the result of $\chi^2/d.f.$ is 1.48, showing an acceptable goodness-of-fit index for our proposed model. Other goodness-of-fit indices were also obtained, including Normed Fit Index (NFI) = 0.97; Non-Normed Fit Index (NNFI) = 0.99; Comparative Fit Index (CFI) = 0.99; Incremental Fit Index (IFI) = 0.99; Goodness of Fit Index (GFI) = 0.89; Root Mean Square Error of Approximation (RMSEA) = 0.04; and Root Mean Square Residual (RMR) = 0.02. Taken together, the CFA results suggested that our proposed model has a satisfactory fit to the data.

The construct reliability was measured by the Cronbach's alpha coefficients and the composite reliability (CR). As seen in Table 3, the Cronbach's alpha coefficients, ranging from 0.84 to 0.90, which are all above the threshold of 0.7 (Nunnally, 1967), show an acceptable range of internal consistency for the used items. Next, the CR measures how consistently individuals respond to the items within a construct. The values of CR (ranging from 0.84 to 0.90) all exceeded the threshold of 0.7 (Hair et al., 1998), indicating high internal consistency of the measurement items.

Convergent validity is obtained by the close relationship of two measures with the same construct. It is statistically achieved under two criteria recommended by Fornell and Larcker (1981). First, all item factor loadings should be significant and should exceed 0.7. Second, composite reliability and average variance extracted (AVE) for each construct must exceed the recommended threshold of 0.8 and 0.5, respectively. AVE is used to measure the percentage of total variance observed in the items accounted for by each construct (Fornell & Larcker, 1981). As shown in Table 3, standardized CFA loadings for all constructs were significant at the 0.001 level (the lowest *t* value is 14.22) and exceeded 0.7. In addition, our CRs (ranging from 0.82 to 0.96) and AVEs (ranging from 0.64 to 0.72) all exceeded 0.5. Hence, the convergent validity was assured. Discriminant validity is established if the square root of the AVE for each construct is greater than its correlations to all other constructs (Fornell & Larcker, 1981). In this study, the square roots of AVE for all constructs, ranging from 0.80 to 0.85 (Table 4), were larger than other correlations. Therefore, it can be concluded that the instrument had proper discriminant validity.

Last, the potential common method bias was examined. If the fit of a one-dimensional model is worse than that of the measurement model, this suggests that the common method variance does not appear to be a serious threat (Podsakoff et al., 2003). The results show that the fit of the one-dimensional model is worse than that of the measurement model. As such, the issue of common method bias is of less concern in this study.

Table 3 Reliability and validity tests

Items	Standardized loading	*t*-value	Cronbach's α	CR	AVE
GM01	0.76	12.33	0.86	0.86	0.68
GM02	0.90	15.63			
GM03	0.80	13.34			
HS01	0.71	11.19	0.84	0.85	0.66
HS02	0.84	14.01			
HS03	0.87	14.72			
SE01	0.79	13.60	0.90	0.90	0.70
SE02	0.88	15.74			
SE03	0.86	15.45			
SE04	0.82	14.35			
SN01	0.89	15.70	0.85	0.86	0.67
SN02	0.87	14.24			
SN03	0.68	10.71			
PU01	0.89	16.08	0.87	0.88	0.71
PU02	0.87	15.53			
PU03	0.77	12.98			
PEU03	0.75	12.39	0.84	0.84	0.64
PEU04	0.77	12.83			
PEU05	0.88	15.72			
BI01	0.87	15.50	0.89	0.89	0.72
BI02	0.86	15.22			
BI03	0.82	14.27			

GM growth mindset, *HS* help seeking, *SE* self-efficacy, *SN* subjective norms, *PEU* perceived ease of use, *PU* perceived usefulness, *BI* behavioral intention, *CR* composite reliability, *AVE* Average variance extracted

Table 4 Descriptive statistics, variance explained, and correlations (n=214)

Constructs	Means	S.D	GM	HS	SE	SN	PU	PEU	BI
GM	4.13	0.71	**0.82**						
HS	4.23	0.58	0.24	**0.81**					
SE	4.25	0.57	0.39	0.44	**0.84**				
SN	4.06	0.68	0.30	0.34	0.57	**0.82**			
PU	4.12	0.69	0.30	0.36	0.58	0.52	**0.84**		
PEU	4.22	0.60	0.39	0.42	0.67	0.48	0.75	**0.80**	
BI	4.29	0.55	0.42	0.45	0.66	0.50	0.72	0.72	**0.85**

S.D. standard deviation

On-diagonals are square roots of AVE (**boldface**)

Results of the structural model

With an adequate measurement model, the proposed hypotheses were then tested. According to Anderson and Gerbing's (1988) suggestion, path analysis was employed to assess the relations among the latent factors. The result shows that model fit was acceptable ($\chi^2/d.f. = 277.74/188 = 1.48 < 2$) and the other goodness of fit indices were: NFI = 0.97, NNFI = 0.99, CFI = 0.99, IFI = 0.99, GFI = 0.89, AGFI = 0.86, RMSEA = 0.04, and RMR = 0.02. The results demonstrate that the proposed model is valid and exhibited an excellent fit to the data; a structural model could thus be developed.

Out of six hypotheses, four were supported. Table 5 lists the results of the structural model, including the standardized path coefficients and the associated *t*-values of the paths. First, in terms of the effects of individual factors on teachers' intention to adopt MTT, hypotheses 1 to 3 were supported. Teachers' growth mindset (GM) and self-efficacy (SE) were two important factors impacting their intentions to use an online teaching platform ($\beta = 0.13$, $p < .05$, H1 was supported; $\beta = 0.19$, $p < .05$, H3 was supported), followed by help seeking (HS) ($\beta = 0.19$, $p < .05$, H2 was supported). Next, contrary to our expectations, social influence (i.e., subjective norms) failed to statistically impact teachers' willingness to use MTT platform ($\beta = -0.03$, $p > .05$, H4 was not supported). Finally, in terms of technology acceptance factors, although perceived usefulness (PU) of MTT had the strongest effect on teachers' intentions to use the online teaching platform ($\beta = 0.47$, $p < .01$, H5 was supported), perceived ease of use (PEU) did not show a significant influence on their behavioral intentions ($\beta = 0.19$, $p > .05$, H6 was not supported). In sum, the proposed framework accounted for 79% of the variance explained in MTT behavioral intention, and most of the hypotheses were supported. This shows that the research provides a satisfactory theoretical explanation for the teachers' acceptance model of the MTT platform. Figure 3 illustrated the result of the structural model.
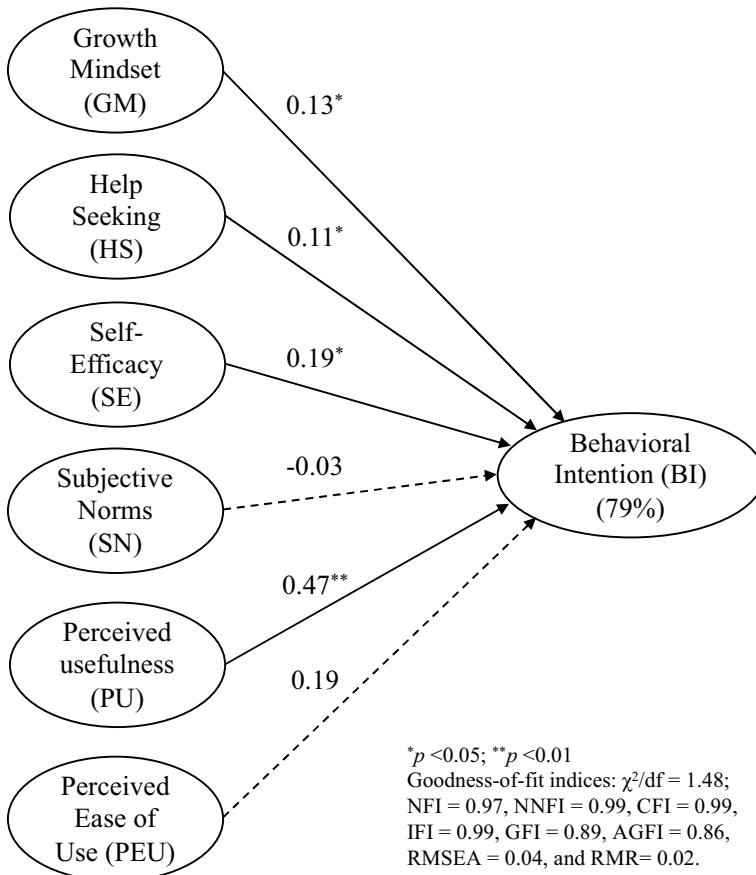
Discussion

This study proposed an integrated model to examine university teachers' intentions to use a mobile technology-enhanced teaching (MTT) platform from three perspectives, namely individual attributes, social influence, and technology acceptance factors. The proposed model was well supported by the high predictive power of teachers' behavioral intention, and most of the hypotheses were supported. Based on the results, this study concludes the following findings. First, teachers' intentions to adopt MTT were determined by three

Table 5 The results of the hypothesis tests

Hypotheses	Paths	ß	*t-value*
H1	GM→BI	0.13*	2.36
H2	HS→BI	0.11*	1.97
H3	SE→BI	0.19*	2.09
H4	SN→BI	−0.03	−0.51
H5	PU→BI	0.47**	2.97
H6	PEU→BI	0.19	1.02

*$p < .05$; **$p < .01$

Growth
Mindset
(GM)

0.13*

Help
Seeking
(HS)

0.11*

Self-
Efficacy
(SE)

0.19*

Subjective
Norms
(SN)

-0.03

Perceived
usefulness
(PU)

0.47**

0.19

Perceived
Ease of
Use (PEU)

Behavioral
Intention (BI)
(79%)

*p <0.05; **p <0.01
Goodness-of-fit indices: χ^2/df = 1.48;
NFI = 0.97, NNFI = 0.99, CFI = 0.99,
IFI = 0.99, GFI = 0.89, AGFI = 0.86,
RMSEA = 0.04, and RMR= 0.02.

Fig. 3 The results of the structural model (N = 214)

individual factors (i.e., growth mindset, help seeking, and self-efficacy). Secondly, with regard to the technology acceptance factors, only perceived usefulness had a positive impact on teachers' behavioral intentions, but not on their perceived ease of use. Lastly, social influence (i.e., subjective norms) failed to significantly influence teachers' behavioral intentions.

The findings show that all three individual attributes play a crucial role in teachers' intentions to use MTT. Consistent with previous research (Chavoshi & Hamidi, 2019; Davis, 1989; Wang & Wang, 2009), this study confirms that individual beliefs are critical in explaining users' intentions to adopt technology. More specifically, regarding the MTT adoption intention of university teachers, growth mindset (Seaton, 2018; Zeng et al., 2019), help seeking (Bai et al., 2019; Butler, 2007), and self-efficacy (Kang & Shin, 2015; Lai et al., 2018; Teo & Zhou, 2014) were identified as essential influential factors. As mentioned earlier, the outbreak of COVID-19 has forced all universities in China to employ online teaching. Some online teaching platforms were released in a hurry (Chen et al., 2020; Demuyakor, 2020), which put teachers in an online teaching dilemma. Therefore, personal attributes have a great influence on teachers' willingness to adopt online teaching platforms. For example, if teachers are confident in their ability (i.e., they have a growth

mindset) to learn and use online teaching systems, to seek help when encountering difficulties, and to successfully solve problems and implement the platform, then their willingness to adopt this online teaching platform will be greatly enhanced. Therefore, school authorities should provide on-the-job training on the online teaching platforms in advance, or provide timely Q&A technical consultation, so that teachers can operate the system proficiently before formal online teaching, thereby enhancing their confidence. In this way, teachers' willingness to use online teaching technology can be greatly improved, and students' learning efficiency can be enhanced.

Second, our research failed to support the social influence on university teachers' behavioral intentions to adopt the MTT. This finding echoes previous research, that is, subjective norms have no predictive power on teachers' intentions to use technology (Ma et al., 2005; Teo et al., 2016; Yuen & Ma, 2008). From the observations of this study, the following reasons can be drawn. Some teachers are less influenced by supervisors, institutions, or colleagues because they subjectively believe that certain technologies should be used for teaching, and then they will implement them. Teachers who are accustomed to using traditional teaching methods may have no intention or even do not agree with using online teaching systems. In other words, the subjective opinions of university teachers, rather than those of their peers, have a decisive influence on the teaching methods or the technology they will use in the class.

Finally, in terms of technological acceptance factors, while perceived usefulness (PU) appeared to be the most influential factor of teachers' intentions to adopt MTT, perceived ease of use (PEU) failed to exert its influence. This result is inconsistent with prior studies which found that both PU and PEU directly impacted teachers' intentions to adopt mobile technology (Chavoshi & Hamidi, 2019; Hsieh & Tsai, 2017; Teo et al., 2016). In response to this result, we present the following views. Whether the functionality of MTT can improve teachers' work efficiency and teaching performance will also affect students' evaluation of the teaching effectiveness. Therefore, it is not surprising that the perceived usefulness of MTT has become the decisive factor in teachers' willingness to adopt MTT. On the other hand, most of the university teachers had been trained to use the MTT platform after they participated in this study. In this case, the PEU of MTT may not be the main consideration for the university teachers. In terms of practical implications, however, we still recommend collecting the opinions of teachers and students using MTT and improving certain functions. Both of these practices can enhance teachers' willingness to adopt MTT or its advanced version, and improve students' satisfaction with online teaching (which may not be a substitute for face-to-face teaching).

The finding provides some implications for the development of mobile technology-enhanced teaching platforms during the post-COVID-19 era. First, the results showed that three constructs of the individual factor (i.e., growth mindset, help-seeking, and self-efficacy) all have significant impacts on MTT adoption. This has some important implications for teachers' professional development as their willingness to use and their proficiency in using MTT platforms are the keys to continually delivering quality online courses. Therefore, it is suggested that further teacher support systems and training-based systems be provided in the context of online teaching to help teachers dare to try new or different teaching platforms, to improve their self-efficacy, and to be willing to seek help when encountering difficulties. In addition to the individual factor, the results also found that perceived usefulness has the most significant impact on teachers' adoption of MTT; therefore, an upgraded MTT platform with multiple functions which can improve teachers'

teaching performance and efficiency would be essential. For example, featured functions such as quiz-based instant-answer games are suggested to be included in future platform designs. Finally, we conducted this research from the perspective of university teachers; however, this was also the first time for university students to take classes online at home, and many of them only used mobile phones to attend classes. Therefore, researchers can conduct further investigations regarding the effectiveness of the complete online courses from students' perspectives.

Conclusions and limitations

The global education system is facing huge challenges. Due to the COVID-19 pandemic, schools have had to close and completely initiate online teaching. The successful implementation of mobile learning rests on the acceptance of higher education teachers. Therefore, this study aimed to propose a research framework of university teachers' acceptance of mobile technology-enhanced teaching (MTT) platforms, and attempted to identify influential factors by integrating existing theories from the perspectives of individual characteristics, social influence, and technological acceptance factors. Based on structural equation modeling, a total of 214 responses from university teachers were analyzed based on the proposed research questions. The main findings are concluded as follows. First of all, the results show that three individual factors (i.e., growth mindset, help seeking, and self-efficacy) had a great influence on university teachers' acceptance of MTT. Second, the proposed social factor (social norms) was not significant in this study. Third, as one of the technology acceptance factors, perceived usefulness appears to be the most critical determinant of MTT acceptance, while perceived ease of use had no significant impact on the adoption of the MTT platform. Taken together, this present research has special reference value for improving online teaching research and practice during world-wide school closures caused by the pandemic.

Some limitations of this study are as follows. First, in order to collect first-hand data, this research survey was conducted in China. More comparison studies involving different cultures are suggested for future research to increase the generalizability of the results. Second, the research setting of the current study is DingTalk, the very first mobile technology-enhanced teaching platform adopted in China. Other types of mobile teaching systems are suggested for testing the generalizability of the findings. Third, the antecedents of MTT adoptions are limited to three perspectives (i.e., individual, social, and technology acceptance factors). Future studies may include other variables (e.g., affective attributes of MTT use) to increase the explanatory power and generalizability of the model. Regarding the different prior experiences of technology-enhanced teaching on the intention of adoption, it is suggested that further research be conducted using an experimental design to compare the effects on users with and without experience.

Appendix

See Table 6.

Table 6 List of measurement items

Measurement items for each construct	Sources
Growth mindset (GM)	Adapted from Bai et al. (2019) and Dweck (2006)
GM01 I can learn a lot from my mistakes when using the mobile technology-enhanced teaching (MTT) platform	
GM02 I like to challenge myself when using the MTT platform	
GM03 I can improve using the MTT platform by putting in more effort	
Help seeking (HS)	Adapted from Bai et al. (2019)
HS01 I will ask the instructor to clarify procedures if I don't understand well	
HS02 When I can't understand the material in the program, I will ask peers for help	
HS03 I try to identify people whom I can ask for help if necessary	
HS04[a] Even if I had trouble learning the use of the MTT platform, I did not seek help from others (reversed item)	
Self-efficacy (SE)	Adapted from Kao and Tsai (2009)
SE01 I am confident that I have adequate ability to operate the MTT platform	
SE02 I am confident that I can integrate the functions of the MTT platform with my teaching plan	
SE03 I am confident that I can use the MTT platform even if there is no one around to show me how to use it	
SE04 I am confident that I can integrate the benefits of the MTT platform into my teaching activities	
Subjective norms (SN)	Adapted from Fishbein and Ajzen (1975)
SN01 The authorities of my institution agreed to the use of the MTT platform in my teaching	
SN02 The authorities of my institution support the use of the MTT platform in my online courses	
SN03 My colleagues think I should use the MTT platform in my program	
SN04[a] My colleagues will appreciate my adoption of the MTT platform for online teaching	
SN05[a] People around me have a positive view on my use of the MTT platform	

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Table 6 (continued)

Measurement items for each construct		Sources
Perceived usefulness (PU)		Adapted from Davis (1989)
PU01	Using the MTT platform improves my teaching performance	
PU02	Using the MTT platform increases my work efficiency as a teacher	
PU03	Using the MTT platform gives me greater control over my work	
PU04[a]	For me, using the MTT platform can help the professional development in my teaching	
Perceived ease of use (PEU)		Adapted from Davis (1989)
PEU01[a]	I can easily use the MTT platform for my online courses	
PEU02[a]	I can easily use the MTT platform to communicate with students	
PEU03	It is easy for me to become skilled at using the MTT platform	
PEU04	It is easy for me to integrate the functions of the MTT platform with my teaching plan	
PEU05	It is easy for me to complete teaching activities more efficiently by using the MTT platform	
Behavioral Intention (BI)		Adapted from Wang and Wang (2009)
BI01	I intend to use the MTT platform to perform teaching-related activities	
BI02	I intend to increase my use of the MTT platform in the future	
BI03	I would be glad to use the MTT platform for professional development in the future	
BI04[a]	I would like to recommend that others use the MTT platform	

[a]Removed items. Seven items were removed due to a low factor loading (less than 0.7) (Nunnally, 1967)

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval "All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

Informed consent Informed consent was obtained from all individual participants included in the study.

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