British Journal of Educational Technology Vol 00 No 00 2018 00–00
doi:10.1111/bjet.12609

Factors that influence behavioral intention to use mobile-based assessment: A STEM teachers' perspective

Stavros A. Nikou and Anastasios A. Economides

Stavros A. Nikou is a Physics and Computer Science educator and researcher in SMILE (Smart & Mobile Interactive Learning Environments) laboratory at the University of Macedonia, Thessaloniki, Greece. He holds a Ph.D. in Information Systems. His research interests include technology enhanced learning, mobile learning and assessment, motivation and digital competences. Anastasios A. Economides is Full Professor on Computer Networks & Telematics Applications and Director of the SMILE (Smart & Mobile Interactive Learning Environments) laboratory at the University of Macedonia, Thessaloniki, Greece. His research interests include personalized and collaborative learning & assessment, user experience and acceptance of smart systems and services and networking techno-economics. He has published over two hundred peer-reviewed papers and received over 3000 citations. He is an IEEE Senior member. Email: economid@uom.gr. Address for correspondence: Dr Stavros Nikou, University of Macedonia, 156 Egnatia street, Thessaloniki 54636, Greece. Tel: 2310891768, Email: snikou@uom.edu.gr and stavrosnikou@sch.gr

Abstract

Teachers' role can be catalytic in the introduction of innovative digital tools in order to create new learning and assessment opportunities. This study explores science technology engineering and mathematics (STEM) teachers' intention to use mobile-based assessments in the teaching practice. The study proposes the teachers' acceptance mobile-based assessment (TAMBA) model which extends the technology acceptance model by introducing individual, social, institutional and instructional design factors. An appropriate questionnaire was developed and answered by 161 STEM teachers from 32 European countries. Their responses were analyzed using structural equation modeling. The proposed TAMBA model explains about 50% of the variance in teachers' intention to adopt mobile-based assessment. Perceived Ease of Use was found to be the most important determinant in teachers' intention to use mobile-based assessment. Facilitating Conditions and Output Quality were the most influential external variables in the model. The study findings revealed that focusing on mobile assessment quality design as well as on institutional support are important factors for STEM teachers in order to accept mobile-based assessments in schools.

Introduction

Mobile-based assessment (MBA), the assessment delivered through wireless technologies and mobile devices, is an emerging trend in the context of Bring Your Own Device movement (Johnson et al., 2016). Recent studies have shown that mobile technologies have a considerable potential in learning and assessment (Sung, Chang, & Liu, 2016). However, effective implementation of any information system depends on user's acceptance (Davis, 1989). Therefore, successful implementation of mobile-based assessment requires investigation of its adoption from both students' and teachers' perspectives (Kim, Kim, Lee, Spector, & DeMeester, 2013). Regarding the students' point of view, there are few studies investigating the acceptance of mobile-based assessment (Nikou & Economides, 2017). The current study aims to investigate the factors that influence science technology engineering and mathematics (STEM) teachers' behavioral intention

© 2018 British Educational Research Association

Practitioner Notes

What is already known about this topic

- Teachers' role can be catalytic in the introduction of innovative digital tools in education in order to create new learning and assessment experiences and opportunities.
- Limited research exists about the factors that influence teachers' acceptance of mobile learning and no study exists that investigates teachers' acceptance of mobile-based assessment.
- Individual factors, such as ICT and mobile self-efficacy, are important determinants towards teachers' acceptance of mobile learning.

What this paper adds

- The model introduces, for the first time in a model about the acceptance of technology-assisted assessment, the variable of Output Quality.
- Perceived Ease of Use is the most influential determinant in teachers' adoption of mobile-based assessments.
- Beyond individual factors, the study suggests that instructional design, institutional and social factors are also important determinants towards teachers' adoption of mobile-based assessment.

Implications for practice and/or policy

- Instructional designers and mobile developers should take into their consideration the affordances offered by mobile devices and provide teachers with quality, effective and easily administered mobile-based assessments.
- Education institutions can better support teachers to integrate mobile-based assessments in the curriculum, by providing the necessary infrastructure and appropriate attitude development.
- Teacher training programs should provide teachers with the appropriate knowledge and skills necessary to use mobile assessment practices into their teaching.

to use (BIU) mobile-based assessment. The study introduces instructional design, individual, institutional and social factors as external variables into the technology acceptance model (TAM) in order to ultimately facilitate MBA adoption from both a bottom-up and/or top-down approach (Chiu, 2017).

Literature review

Mobile-based assessment

There are many successful mobile-based assessment implementations reported in the related literature: classroom polling (Stowell, 2015), assessments blended into learning management systems (Bogdanovic, Barac, Jovanic, Popovic, & Radenkovic, 2013), formative assessments (Hwang & Chang, 2011), peer-and self-assessments (Chen, 2010), performance-based assessments (Campbell & Main, 2014), competency-based assessments (Coulby, Hennessey, Davie, & Fuller, 2010) and ubiquitous and context-aware authentic assessments (Chu, Hwang, Tsai, & Tseng, 2010). Mobile technologies offer unique affordances in assessment (Nikou & Economides, 2013). They provide new and enhanced assessment opportunities, eg, authentic assessment experiences and user-generated content (Cochrane & Narayan, 2017), offering the potential to assess competences related to real-world tasks and higher-level 21st century skills such as

© 2018 British Educational Research Association

problem-solving, creativity and collaboration (Farrell & Rushby, 2016). They offer numerous administration benefits, eg, mobile assessments are digital documents that can be easily used anytime and anywhere, reproduced, modified or processed (UNESCO-IITE, 2012). They enable positive student experiences with increased learning interest and improved learning outcome (Wu et al., 2012). Also, they can effectively support teachers into their everyday teaching practices improving their ongoing professional development (West, 2012).

Mobile-based assessment can be implemented either as an embedded educational activity in a wider context of a mobile learning strategy or it can be administered in its own context as an autonomous educational activity. Therefore, MBA acceptance should be studied in its own context, separately from mobile learning adoption in general.

Technology acceptance model

The TAM is a well-established model that addresses the issue of how users accept and use a technology (Davis, 1989). According to the meta-analysis by Šumak, Hericko, and Pušnik (2011), perceived ease of use (PEOU) and perceived usefulness (PU) are the major factors that influence intention to use e-learning technologies. TAM is a valid and robust model (King & He, 2006) and it is the most widely used acceptance model in e-learning acceptance research (Šumak et al., 2011). Moreover, it has already been successfully used to explain and predict adoption of mobile learning from students' (Park, Nam, & Cha, 2012) and teachers' perspectives (Mac Callum, Jeffrey, & Kinshuk, 2014; Sánchez-Prieto, Olmos-Migueláñez, & García-Peñalvo, 2017).

Teachers' acceptance of mobile learning and mobile-based assessment

Teacher beliefs and attitudes are always critical factors that influence the successful integration of new technologies into classrooms (Kim et al., 2013; Miranda & Russell, 2012). Not only are teachers the primary agents that introduce new technologies into the classrooms but they can also influence students' perceptions towards the use of these technologies. Therefore, investigation of the teachers' acceptance of mobile-based assessment is of utmost importance.

Mobile learning and assessment are still new to many schools. Studies reported varying degrees of teachers' willingness to adopt these technologies (Chiu & Churchill, 2016). There are studies that reported positive teachers' perceptions about the use of mobiles into teaching (Baran, 2014; Chiu & Churchill, 2016; Uzunboylu & Özdamli, 2011). There are also studies that reported that teachers either do not support the use of mobiles in the classroom or they acknowledge uncertainty (Gao, Yan, Wei, Liang, & Mo, 2017; Thomas, O'Bannon, & Britt, 2014). Moreover, limited research exists about teachers' acceptance of mobile learning (Cheung & Hew, 2009).

Technology acceptance research, in order to better predict user acceptance, has extended TAM with individual, social and institutional factors (Chiu, 2017; Tarhini, Hone, & Liu, 2015). However, based on our review of the literature, in the context of teachers' acceptance of mobile learning, only individual factors (digital literacy, ICT and mobile anxiety and ICT teaching self-efficacy) have already been tested. These constructs have been found to significantly influence teachers' PEOU and intention to use mobile learning (Mac Callum et al., 2014; Sánchez-Prieto et al., 2017). Self-efficacy is a necessary factor for teacher adoption of new technologies (O'Bannon & Thomas, 2014). Baydas and Yilmaz (2018) proposed a model where teachers' attitudes and cognitive needs have an influence on their behavioral intention while their affective and social needs do not. O'Bannon and Thomas (2014) suggested that teachers' perceptions regarding the beneficial mobile features for school related work depends on the teachers' age. To the best of our knowledge, other factors (eg, social, institutional) that may affect teachers' acceptance of mobile learning have not been investigated. Furthermore, no study exists that examines teachers' acceptance of mobile-based assessment.

© 2018 British Educational Research Association

The present study

In order to fill in the gap in existing research, this study proposes and tests the teachers' acceptance mobile-based assessment (TAMBA) model based on the TAM. The proposed model incorporates the well-established constructs of PU and PEOU of the TAM, and introduces the following extra constructs: mobile self-efficacy (MSE) (individual construct), social influence (SI) (social construct), facilitating conditions (FC) (institutional construct) and output quality (OQ) (instructional design construct).

Previous studies in different contexts, including mobile learning, found the following relationships regarding these constructs. SI, defined as the "degree to which an individual perceives that important others believe he or she should use the new system," positively affects PU and Intention to Use (Liu, Li, & Carlsson, 2010; Park et al., 2012; Venkatesh, Morris, Davis, & Davis, 2003). FC, defined as "the degree to which users believe that the necessary infrastructures exist to support the use of a technological system," positively affects PU and Intention to Use (El-Gayar, Moran, & Hawkes, 2011; Liu et al. 2010; Venkatesh et al., 2003; West, 2012). The current study introduces for the first time in the context of technology-based assessments the construct of OQ. OQ is defined as "the degree to which an individual believes that the system performs his or her job tasks well" (Venkatesh & Davis, 2000). In our study about MBA, perceptions of OQ can be considered administration benefits (eg, ease to reuse, modify and grade the mobile assessment) and also enhanced assessment opportunities (eg, authentic assessments, user-generated context) that MBA can offer. Previous general technology acceptance research has shown that OQ has a positive effect on PU (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000).

Inline with previous research, our model about teachers' acceptance of mobile-based assessment proposes the following hypotheses:

H1: Perceived Usefulness (PU) has a positive effect on Behavioral Intention to Use (BIU).

H2a: Perceived Ease of Use (PEOU) has a positive effect on Perceived Usefulness (PU).

H2b: Perceived Ease of Use (PEOU) has a positive effect on Behavioral Intention to Use (BIU).

H3: Social Influence (SI) has a positive effect on Perceived Usefulness (PU).

H4: Output Quality (OQ) has a positive effect on Perceived Usefulness (PU).

H5. Mobile Self-Efficacy (MSE) has a positive effect on Perceived Ease of Use (PEU).

H6: Facilitating Conditions (FC) have a positive effect on Perceived Ease of Use (PEOU).

Previous research on learning technologies adoption, suggested that social, institutional and individual factors may facilitate a top–down adoption approach (eg, educational policy oblige teachers to use the technology) while instructional design factors facilitate a bottom-up approach (eg, teachers voluntarily use the technology) (Chiu, 2017). Therefore, the study findings will provide suggestions on how to amplify the adoption of mobile-based assessments from teachers with a top–down and/or a bottom-up approach.

Methodology

Participants and procedure

A total of 215 STEM teachers were randomly contacted to participate in the survey. A total of 161 teachers completed the survey (response rate 74.8%). The participants were from 32 different European countries, as Table 1 shows. The basic inclusion criteria for our study were the participants' teaching major to be related to STEM subjects. All participating teachers were active members of science education communities with experience in technology-supported approaches to science and mathematics education and high engagement in science education EU funded projects. Teachers were contacted either through their personal emails or through education

© 2018 British Educational Research Association

Table 1: *Countries of the participating teachers (n = 161)*

Country	f	Country	f	Country	f	Country	f
Austria	2	Finland	4	Israel	2	Portugal	9
Belgium	4	France	4	Italy	9	Romania	10
Bulgaria	7	FYROM	2	Latvia	2	Slovakia	3
Croatia	3	Germany	3	Lithuania	3	Slovenia	3
Cyprus	8	Greece	14	Malta	2	Spain	12
Czech Reb.	5	Hungary	5	Netherlands	3	Sweden	4
Denmark	2	Iceland	3	Norway	3	Turkey	7
Estonia	3	Ireland	4	Poland	10	UK	6

related social media channels. Teachers were informed in advance about the research procedure and were asked to fill-in an online survey. Participation was voluntarily and all the data collected anonymously.

Demographical information for the sample group is presented in Table 2. There were 73 males (45.3%) and 88 females (54.6%). Almost half of the teachers (52.17%) were in the age range of 35–50. The majority of the teachers (66.45%) had a quite extensive science teaching experience (more than 10 years). The participating teachers taught the following subjects: Mathematics (11%), Physics (14%), Chemistry (9%), Biology (10%), ICT (11%), Technology (3%) and their combinations. For example, Physics and Chemistry (15%), Physics, Maths and ICT (25%), other (2%). Only 31.67% of the participants had already used mobiles in their classes and 18% of them had used mobile devices for assessment purposes (mostly as clickers for classroom polling).

Table 2: *Demographical information of the sample group (n = 161)*

	f	%
Gender		
Male	73	45.30
Female	88	54.60
Age range (in years)		
20–35	42	26.08
35–50	84	52.17
50–65	35	21.70
School		
Primary	45	27.9
Secondary	116	72.10
Teaching experience (in years)		
Less than 5		
5–10	54	33.54
10–20	89	55.27
Over 20	18	11.18
Used mobiles in courses		
Yes	51	31.67
No	110	68.33
Mobiles experience period (in years)		
0–2	15	9.32
2–5	32	19.87
5 or more	114	70.81

© 2018 British Educational Research Association

Instruments

In order to develop the instrument for our research about the acceptance of mobile-based assessment, we have adapted some items of the constructs from previously validated instruments. For PU, PEOU, BIU, SI, FC, we have adopted items from Venkatesh et al. (2003). For MSE, an individual's perceptions of his or her ability to use mobile devices to accomplish particular tasks, we adapted items from Compeau and Higgins (1995), properly modified for the context of mobile-based assessment. For the OQ, based on items from Venkatesh and Davis (2000), we developed four items properly modified and adapted to reflect enhanced assessment opportunities and administration benefits of mobile-based assessments. Cronbach's a for all constructs were above 0.70, ensuring the internal consistency of the instrument.

Our measurement instrument consists of 7 constructs making a total of 25 items. The questionnaire was developed and distributed in English. All items were measured on a 7-point Likert-type scale with 1 corresponding to "strongly disagree" and 7 to "strongly agree." The questionnaire used is shown in Figure S1 in Appendix (as Supporting Information).

Data analysis and results

The analysis technique used to predict the factors affecting mobile-based assessment adoption from the teachers' perspective was partial least-squares (PLS) with Smart PLS 2.0 (Ringle, Wende, & Will, 2005). Our sample size exceeds the recommended value of 40, ie, 10 times larger than the number of items for the most complex construct (Chin, 1998).

Instrument validation

Internal consistency, convergent and discriminant validity of the proposed research model need to be verified to ensure its quality. All criteria for convergent validity are satisfied: all factor loadings on their relative construct exceed 0.70, composite reliability of each construct exceed 0.70 and all average variance extracted (AVE) values range from 0.594 to 0.773 (AVE > 0.50) exceeding the variance due to measurement error for that construct (Table 3). Discriminant validity is also supported since the square root of the AVE of a construct is higher than any correlation with another construct (Table 4). Thus, both convergent and discriminant validity for the proposed research model are verified.

Test of the structured model and hypotheses

Figure 1 and Table 5 summarize the structural model and the hypothesis testing results. Figure 1 shows the path coefficient for each path along with its significance (as asterisks, $^{**}p < .05$, $^{***}p < .01$) and the R^2 for each endogenous variable. Table 5 shows the statistical significance of the relations in the model. Table 6 shows path analysis result of the direct, indirect and total effects.

The results from the PLS analysis support all seven hypotheses. The proposed TAMBA model explains and predicts about 50% of the teachers' BIU MBA. This is an acceptable value since it is in the range of 22–68% that is usually found in the mobile learning acceptance research (Baydas & Yilmaz, 2018). Three endogenous variables— PEOU, PU and BIU—were tested. All four exogenous variables—SI, OQ, FC and MSE—had a positive effect on endogenous variables. Considering the direct effects, all standardized path coefficients have values between 0.240 and 0.468. These values are considered to be medium to large (Cohen, 1988).

Two exogenous variables explained 48% of the variance in PEOU. FC had the largest effect on PEOU (0.468), followed by MSE (0.300). Five variables explained 50% of the variance in PU. OQ had the largest effect on PU (0.370), followed by SI (0.240), PEOU (0.225), FC (0.105) and MSE (0.068). Moreover, seven variables explained 50% of the variance in BIU. The aforementioned value is comparable with other TAM related studies about mobile learning adoption (Wang, Wu,

© 2018 British Educational Research Association

Table 3: Descriptive statistics and results for convergent validity for the measurement model (acceptable threshold values in brackets)

Construct items	Mean (SD)	Factor loading (>0.70)	Cronbach's a (>0.70)	Composite reliability (>0.70)	Average variance extracted (>0.50)
Perceived ease of use	5.09 (1.28)		0.851	0.910	0.773
PEOU1		0.811			
PEOU2		0.864			
PEOU3		0.957			
Perceived usefulness	3.95 (1.26)		0.730	0.845	0.647
PU1		0.801			
PU2		0.753			
PU3		0.857			
Social influence	4.95 (1.25)		0.799	0.859	0.604
SI1		0.731			
SI2		0.836			
SI3		0.808			
SI4		0.730			
Facilitating conditions	4.96 (1.18)		0.819	0.880	0.648
FC1		0.813			
FC2		0.802			
FC3		0.822			
FC4		0.783			
Output quality	4.63 (1.20)		0.827	0.884	0.657
OQ1		0.829			
OQ2		0.836			
OQ3		0.784			
OQ4		0.798			
Mobile self-efficacy	3.78 (1.19)		0.774	0.853	0.594
MSE1		0.776			
MSE2		0.737			
MSE3		0.827			
MSE4		0.738			
Behavioral intention to use	4.80 (1.25)		0.724	0.844	0.645
BIU1		0.811			
BIU2		0.812			
BIU3		0.787			

& Wang, 2009). PEOU had the largest effect on BIU (0.540) followed by PU (0.332), FC (0.252), MSE (0.162), OQ (0.123) and SI (0.080). Among the four external variables, FC had the strongest influence on Behavior Intention to Use following by OQ and MSE.

Discussions and conclusions

Teachers' role can be catalytic in the acceptance of mobile learning and assessment (Chiu & Churchill, 2016). While previous studies have focused on teachers' acceptance of mobile learning (Mac Callum et al., 2014; Sánchez-Prieto et al., 2017), the current study provides a step ahead towards the investigation of European STEM teachers' acceptance of mobile-based assessment using individual, social, institutional and instruction design factors and proposes the TAMBA model.

The study provided evidence that PEOU is the most dominant determinant of BIU mobile-based assessment with the PU to follow. PEOU also positively influenced PU. The results are in line with

© 2018 British Educational Research Association

Table 4: Discriminant validity for the measurement model (values in bold: the square root of the AVE for each construct)

	BIU	*FC*	*MSE*	*OQ*	*PEOU*	*PU*	*SI*
BIU	**0.80**						
FC	0.79	**0.81**					
MSE	0.60	0.61	**0.77**				
OQ	0.64	0.74	0.65	**0.81**			
PEOU	0.65	0.65	0.58	0.65	**0.87**		
PU	0.60	0.62	0.57	0.65	0.57	**0.80**	
SI	0.52	0.51	0.65	0.55	0.45	0.54	**0.77**

BIU, behavioral intention to use; PEOU, perceived ease of use; PU, perceived usefulness; SI, social influence; FC, facilitating conditions; OQ, output quality; MSE, mobile self-efficacy.

previous research on technology acceptance (Venkatesh et al., 2003), students' mobile learning and assessment acceptance (Chung, Chen, & Kuo, 2015; Nikou & Economides, 2017) and also teachers' acceptance of mobile-learning (Mac Callum et al., 2014; Sánchez-Prieto et al., 2017). Teachers are more likely to assign mobile-based assessments to their students if they perceive this type of assessment as easy to use and also useful for their teaching.

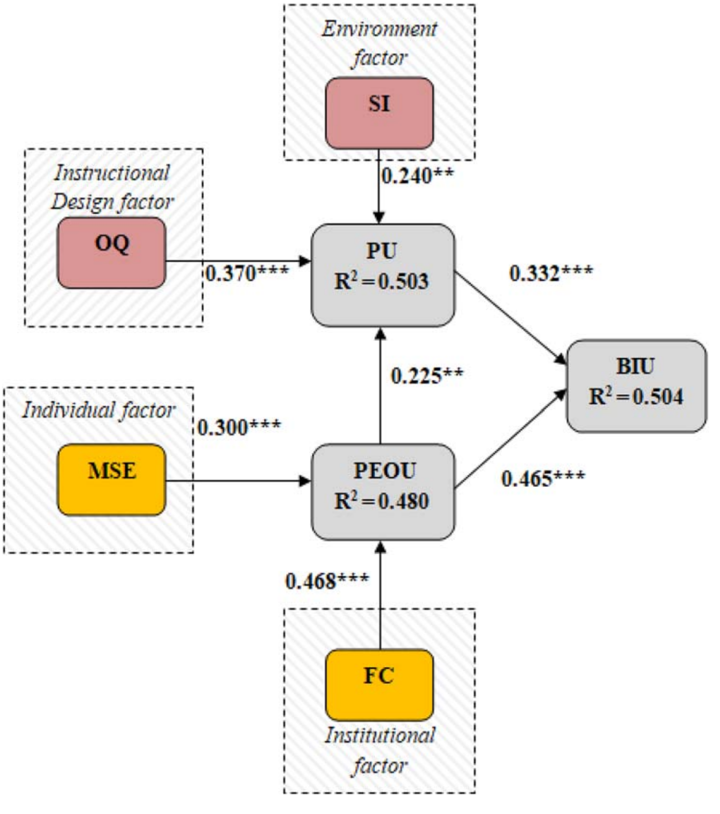

Figure 1: Structured Equation Modeling analysis of the proposed TAMBA model [Colour figure can be viewed at wileyonlinelibrary.com]

© 2018 British Educational Research Association

Table 5: Hypothesis testing results

Hypothesis	*Path*	*Path coefficient*	*t Value*	*Results*
H1	PU → BIU	0.332***	8.289	Support
H2a	PEOU → PU	0.225**	4.907	Support
H2b	PEOU → BIU	0.465***	10.152	Support
H3	SI → PU	0.240**	6.771	Support
H4	OQ→ PU	0.370***	7.660	Support
H5	MSE → PEOU	0.300***	6.608	Support
H6	FC → PEOU	0.468***	9.334	Support

**$p < .05$, ***$p < .01$.

To the best of our knowledge, OQ has been introduced for the first time in the context of technology-based assessment acceptance research. OQ has been attributed to the administration benefits and also to the potential enhanced assessment opportunities that MBA can offer. OQ, as an instructional design factor, had a significant direct positive effect on PU. It also has a strong indirect effect on BIU through PU. The findings are in line with previous general technology acceptance research (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000). Most teachers acknowledge the benefits of using technology-based assessments for students learning and perceive technology-based assessments as useful tools (Chien, Wu, & Hsu, 2014). Based on our results, when a mobile-based assessment is properly designed to enhance assessment opportunities and facilitate at the same time exam administration offering high quality output it is more likely to be considered useful and, therefore, to be adopted by the teachers.

SI, as a social factor, had a positive effect on PU. While SI has already been identified as a significant factor that affects students' PU and students' Intention to Use mobile learning (Park et al., 2012; Wang et al., 2009) and mobile-based assessment (Nikou & Economides, 2017), studies on teachers' acceptance of mobile learning have provided contradictory results. Our findings imply that when teachers know that their school management, colleagues and educational authorities approve of and value the use of mobile devices in assessment, then they perceive it as a useful educational activity. However, other studies suggested that SI does not affect PU of mobile learning (Baydas & Yilmaz, 2018). Also, according to Arpaci (2015), investigation of the impact of SI on Intention to Use should also consider the mediating effect of cultural factors.

Considering the effects on PU, OQ had a greater impact than SI. This result indicates that teachers' needs for useful and better quality mobile enhanced assessments are stronger than their social normative beliefs.

MSE, as an individual factor, had a significant direct positive effect on PEOU and an indirect effect on BIU through PEOU. This is in line with previous findings. Research has shown that ICT (Information and Communication Technologies) self-efficacy enhance ICT teachers' adoption (Scherer, Siddiq, & Teo, 2015). Moreover, computer self-efficacy significantly affects the adoption of computer-based testing (Lu, Hu, Gao, & Kinshuk, 2016). Also, basic ICT literacy and specific mobile literacy significantly affect teachers' adoption of mobile learning (Mac Callum et al., 2014). Furthermore, after using mobile devices, STEM teachers reported better attitudes, beliefs and acceptance of mobile technologies in learning, while this was not true for Language and Humanities teachers (Chiu & Churchill, 2016).

FC, as an institutional factor, had a significant direct positive effect on PEOU and an indirect effect on BIU through PEOU. The appropriate technical and administrative infrastructure enhances

© 2018 British Educational Research Association

Table 6: R^2, direct, indirect and total effects

Endogenous variable	Erogenous variable	Direct effect	Indirect effect	Total effect	R^2	Results
Perceived ease of use	Mobile self-efficacy	0.300	–	0.300	0.480	Support***
	Facilitating conditions	0.468	–	0.468		Support***
Perceived usefulness	Social influence	0.240	–	0.240	0.503	Support**
	Output quality	0.370	–	0.370		Support***
	Mobile self-efficacy	–	0.068	0.068		
	Facilitating conditions	–	0.105	0.105		
	Perceived ease of use	0.225	–	0.225		Support**
Behavioral intention to use	Social influence	–	0.080	0.080	0.504	
	Output quality	–	0.123	0.123		
	Mobile self-efficacy	–	0.162	0.162		
	Facilitating conditions	–	0.252	0.252		
	Perceived ease of use	0.465	0.075	0.540		Support***
	Perceived usefulness	0.332	–	0.332		Support***

**$p < .05$, ***$p < .01$.

teachers' perceptions of the Ease of Use. Moreover, given the effects on PEOU, our results show that FC had a greater effect than MSE. The above findings are inline with technology acceptance (Davis, 1989; Venkatesh et al., 2003), teachers' acceptance of mobile learning (Sánchez-Prieto et al., 2017) and students' acceptance of mobile-based assessments (Nikou & Economides, 2017) as well.

Based on our findings, the following suggestions can be made to mobile developers and instructional designers, education administrators (eg, school directors), teacher training institutions and teachers. Mobile developers and instructional designers should employ into mobile-based assessments the appropriate quality characteristics that can positively affect teachers' acceptance. Examples include assessments allowing two-way communication in real time facilitating teacher feedback and peer collaboration, assessments creating new opportunities for student-generated content and personalized assessments adapting to students' contexts and providing teachers with deeper assessment opportunities. Instructional designers and mobile developers should also harness the capabilities offered by mobiles for assessments that are easily delivered anywhere and anytime, easily reused, modified and graded. The aforementioned design characteristics can facilitate the bottom-up adoption process (Chiu, 2017).

Education administration (eg, school policies and principals) should provide teachers with all the resources needed and the proper management, institutional and technical infrastructure and support in order to support and facilitate them into the use of mobiles in assessment practices. Education authorities, school counselors and teacher mentors should encourage teachers to integrate mobile assessment practices in the curriculum. Innovative practices such as mobile-based formative assessments with immediate or adaptive feedback, peer-assessment and ubiquitous context-aware assessments have the potential to facilitate the assessment of the 21st century skills including critical thinking, communication, collaboration and creating content (West, 2012). Even when teachers are not efficacious enough in mobile assessment practices, they are more likely to use mobile-based assessment and also involve their students into this, when the appropriate FC are present.

© 2018 British Educational Research Association

In-service and pre-service teacher education and training institutions should face the challenge of providing teachers the knowledge and skills necessary to use mobile technologies into their teaching and assessment. Teachers should be informed about the affordances offered by mobile technologies in order to advance their own teaching and assessment methodologies. Teacher continuous professional development programs should train teachers into new and innovative assessment methods in order to prepare them to effectively assess 21st century learners. Enhancing teachers' efficacy into using mobiles into their teaching can accelerate the adoption of mobile-based assessment. The support offered by educational administration and teacher training institutions facilitate the top–down adoption process (Chiu, 2017).

Also, there is an issue connecting to STEM education that we would like to discuss. Previous research has shown that effective technology integration into STEM teaching promotes teacher professional development and also has a positive effect on student learning outcomes (Elliot & Mikulas, 2012). Therefore, considering the growing popularity of mobile devices and the spreading of BYOD policies, supporting K-12 STEM teachers to adopt mobile technologies in their classes can be beneficial to the education community (Hu & Garimella, 2014).

One limitation of the current study is that it focuses on STEM teachers. Previous research has shown that Science and Mathematics teachers, compared to Language and Humanities teachers, have more positive attitudes towards mobile devices (Chiu & Churchill, 2016). Therefore, generalization of the study findings to teacher groups with different backgrounds should be made with caution and future studies should include teachers with other backgrounds as well. Another study limitation stems from the fact that the participants of the study are European teachers. There are cultural differences among European countries and these differences should be reflected in future studies (Nistor, Gogus, & Lerche, 2013). Moreover, generalization to non-European contexts should also take into consideration the cultural factors. It would be interesting also to investigate the relation between MBA adoption and other factors eg, gender, age, teaching experience and different assessments types (eg, formative, summative). Moreover, future studies should include other external variables eg, ubiquity, autonomy, security, personalization, enjoyment, satisfaction.

This study is the first that investigates teachers' acceptance of mobile-based assessment considering individual, institutional, social and instructional design factors. The application of mobile technologies into assessment can be a major driver for change throughout teaching and learning (Farrell & Rushby, 2016) and the teachers' role towards this direction can be a catalyst.

Statement on open data, ethics and conflict of interest

The data can be obtained by request, by contacting the corresponding author.

Participation was voluntarily and all the data collected anonymously. Appropriate permissions and ethical approval for the participation requested and approved.

There is no potential conflict of interest in this study.

References

Arpaci, I. (2015). A comparative study of the effects of cultural differences on the adoption of mobile learning. *British Journal of Educational Technology*, *46*, 699–712.

Baran, E. (2014). A review of research on mobile learning in teacher education. *Educational Technology & Society*, *17*, 17–32.

Baydas, O., & Yilmaz, R. M. (2018). Pre-service teachers' intention to adopt mobile learning: a motivational model. *British Journal of Educational Technology*, *49*, 137–152. doi:10.1111/bjet.12521

Bogdanovic, Z., Barac, D., Jovanic, B., Popovic, S., & Radenkovic, B. (2013). Evaluation of mobile assessment in a learning management system. *British Journal of Educational Technology*, *45*, 231–244.

© 2018 British Educational Research Association

Campbell, A., & Main, S. J. (2014). Performance, assessment and communication in one app: mobile tablet assessment is here to stay. *eCULTURE*, *7*.

Chen, C.-H. (2010). The implementation and evaluation of a mobile self- and peer-assessment system. *Computers & Education*, *55*, 229–236.

Cheung, W. S., & Hew, K. F. (2009). A review of research methodologies used in studies on mobile handheld devices in K-12 and higher education settings. *Australasian Journal of Educational Technology*, *25*, 153–183.

Chien, S.-P., Wu, H.-K., & Hsu, Y.-S. (2014). An investigation of teachers' beliefs and their use of technology-based assessments. *Computers in Human Behavior*, *31*, 198–210.

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In G. A. Marcoulides (Ed.), *Modern business research methods* (pp. 295–336). Mahwah, NJ: Lawrence Erlbaum Associates.

Chiu, T. K. F. (2017). Introducing electronic textbooks as daily-use technology in schools: a top-down adoption process. *British Journal of Educational Technology*, *48*, 524–537.

Chiu, T. K. F., & Churchill, D. (2016). Adoption of mobile devices in teaching: changes in teacher beliefs, attitudes and anxiety. *Interactive Learning Environments*, *24*, 317–327.

Chu, H. C., Hwang, G. J., Tsai, C. C., & Tseng, J. C. R. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science course. *Computers & Education*, *55*, 1618–1627.

Chung, H.-H., Chen, S.-C., & Kuo, M.-H. (2015). A study of EFL college students' acceptance of mobile learning. *Procedia - Social and Behavioral Sciences*, *176*, 333–339.

Cochrane, T., & Narayan, V. (2017). Design considerations for mobile learning. In C. Reigeluth, B. J. Beatty, & R. Myers (Eds), *Instructional-design theories and models* (pp. 385–414). Abingdon, UK: Routledge.

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Compeau, D., & Higgins, C. (1995). Computer self-efficacy: development of a measure and initial test. *MIS Quarterly*, *19*, 189–211.

Coulby, C., Hennessey, S., Davie, N., & Fuller, R. (2010). The use of mobile technology for work-based assessment: the student experience. *British Journal of Educational Technology*, *42*, 251–265.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly*, *13*, 319–340.

Elliot, S., & Mikulas, C. (2012). Improving student learning through teacher technology training: a study of the effectiveness of technology integration training on student achievement. In P. Resta (Eds), *Proceedings of society for information technology & teacher education international conference 2012* (pp. 1759–1766). Chesapeake, VA: AACE.

El-Gayar, O., Moran, M., & Hawkes, M. (2011). Students' acceptance of Tablet PCs and implications for educational institutions. *Educational Technology and Society*, *14*, 58–70.

Farrell, T., & Rushby, N. (2016). Assessment and learning technologies: an overview. *British Journal of Educational Technology*, *47*, 106–120.

Gao, Q., Yan, Z., Wei, C., Liang, Y., & Mo, L. (2017). Three different roles, five different aspects: differences and similarities in viewing school mobile phone policies among teachers, parents, and students. *Computers & Education*, *106*, 13–25.

Hu, H., & Garimella, U. (2014). iPads for STEM teachers: a case study on perceived usefulness, perceived proficiency, intention to adopt and integration in K-12 instruction. *Journal of Educational Technology Development and Exchange (JETDE)*, *7*, 49–66.

Hwang, G. J., & Chang, H. F. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education*, *56*, 1023–1031.

Johnson, L., Becker, S. A., Cummins, M., Estrada, V., Freeman, A. & Hall, C. (2016). *NMC horizon report: 2016 higher education edition*. Austin, TX: The New Media Consortium.

Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education*, *29*, 76–85.

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management*, *43*, 740–755.

Liu, Y., Li, H., & Carlsson, C. (2010). Factors driving the adoption of m-learning: an empirical study. *Computers & Education*, *55*, 1211–1219.

© 2018 British Educational Research Association

Lu, H., Hu, Y-P., Gao, J-J., & Kinshuk, (2016). The effects of computer self-efficacy, training satisfaction and test anxiety on attitude and performance in computerized adaptive testing. *Computers & Education*, *100*, 45–55. Retrieved from https://doi.org/10.1016/j.compedu.2016.04.012.

Mac Callum, K., Jeffrey, L., & Kinshuk, (2014). Factors impacting teachers' adoption of mobile learning. *Journal of Information Technology Education Research*, *13*, Retrieved from http://www.jite.org/documents/Vol13/JITEv13ResearchP141-162MacCallum0455.pdf

Miranda, H. P., & Russell, M. (2012). Understanding factors associated with teacher-directed student use of technology in elementary classrooms: a structural equation modeling approach. *British Journal of Educational Technology*, *43*, 652–666.

Nikou, S. A., & Economides, A. A. (2013). Mobile assessment: state of the art. In Z. L. Berge & L. Y. Muilenburg (Eds), *Handbook of mobile learning* (pp. 346–355). Florence, NY: Routledge.

Nikou, S. A., & Economides, A. A. (2017). Mobile-based assessment: investigating the factors that influence behavioral intention to use. *Computers & Education*, *109*, 56–73. Retrieved from https://doi.org/10.1016/j.compedu.2017.02.005

Nistor, N., Gogus, A., & Lerche, T. (2013). Educational technology acceptance across national and professional cultures: a European study. *Education Technology Research Development*, *61*, 33–749.

O'Bannon, B. W., & Thomas, K. (2014). Teacher perceptions of using mobile phones in the classroom: age matters! *Computers & Education*, *74*, 15–25.

Park, S. Y., Nam, M.-W., & Cha, S.-B. (2012). University students' behavioral intention to use mobile learning: evaluating the technology acceptance model. *British Journal of Educational Technology*, *43*, 592–605.

Ringle, C. M., Wende, S., & Will, A. (2005). SmartPLS 2.0 (beta), [computer software]. Retrieved from http://www.smartpls.de

Sánchez-Prieto, J. C., Olmos-Migueláñez, S., & García-Peñalvo, F. J. (2017). MLearning and pre-service teachers: an assessment of the behavioral intention using an expanded TAM model. *Computers in Human Behavior*, *72*, 644–654. Retrieved from https://doi.org/10.1016/j.chb.2016.09.061.

Scherer, R., Siddiq, F., & Teo, T. (2015). Becoming more specific: measuring and modeling teachers' perceived usefulness of ICT in the context of teaching and learning. *Computers & Education*, *88*, 202–214.

Stowell, J. R. (2015). Use of clickers vs. mobile devices for classroom polling. *Computers & Education*, *82*, 329–334.

Šumak, B., Hericko, M., & Pušnik, M. (2011). A meta-analysis of e-learning technology acceptance: the role of user types and e-learning technology types. *Computers in Human Behavior*, *27*, 2067–2077.

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: a meta-analysis and research synthesis. *Computers & Education*, *94*, 252–275.

Tarhini, A., Hone, K., & Liu, X. (2015). A cross-cultural examination of the impact of social, organisational and individual factors on educational technology acceptance between British and Lebanese university students. *British Journal of Educational Technology*, *46*, 739–755. doi:10.1111/bjet.12169

Thomas, K. M., O'bannon, B. W., & Britt, V. G. (2014). Standing in the schoolhouse door: teacher perceptions of mobile phones in the classroom. *Journal of Research on Technology in Education*, *46*, 373–395.

UNESCO IITE, Institute for Information Technologies in Education (2012). *Policy brief: technology enhanced assessment in education*. Moscow: Russian Federation.

Uzunboylu, H., & Özdamli, F. (2011). Teacher perception for m-learning: scale development and teachers' perceptions. *Journal of Computer Assisted Learning*, *27*, 544–556.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, *39*, 273–315.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: four longitudinal field studies. *Management Science*, *46*, 186–204.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Quarterly*, *27*, 425–478.

Wang, Y.-S., Wu, M.-C., & Wang, H.-Y. (2009). Investigating the determinants and age and gender differences in the acceptance of mobile learning. *British Journal of Educational Technology*, *40*, 92–118.

© 2018 British Educational Research Association

West, M. (2012). *Mobile learning for teachers: global themes*. Paris: UNESCO.
Wu, W.-H., Wu, Y.-C. J., Chen, C. Y., Kao, H.-Y., Lin, C.-H., & Huang, S.-H. (2012). Review of trends from mobile learning studies: a meta-analysis. *Computers & Education*, 59, 817–827.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Fig S1. Questionnaire Items used

© 2018 British Educational Research Association