ANEXO E: BREAK THE WALLS! SECOND-ORDER BARRIERS AND THE ACCEPTANCE OF MLEARNING BY FIRST-YEAR PRE-SERVICE TEACHERS.

Sánchez-Prieto, J.C., Hernández-García, A., García-Peñalvo, F.J., Chaparro-Peláez, J., Olmos-Migueláñez, S. (En revisión) Break the walls! Second-order barriers and the acceptance of mLearning by first-year pre-service teachers.

Break the Walls! Second-Order Barriers and the Acceptance of mLearning by First-Year Pre-Service Teachers

José Carlos Sánchez-Prieto[a] (Corresponding Author)
josecarlos.sp@usal.es

Ángel Hernández-García[b]
angel.hernandez@upm.es

Julián Chaparro-Peláez[b]
julian.chaparro@upm.es

Francisco J. García-Peñalvo[a]
fgarcia@usal.es

Susana Olmos-Migueláñez[a]
solmos@usal.es

[a]GRIAL Research Group, Educational Research Institute, University of Salamanca, Paseo de Canalejas 169, Salamanca, Spain
[b]Departamento de Ingeniería de Organización, Administración de Empresas y Estadística. ETSI de Telecomunicación, Universidad Politécnica de Madrid. Av. Complutense 30, 28040 Madrid, Spain.

ABSTRACT

Despite their many advantages, teachers' adoption of mobile technologies as didactic tools is still limited. Their adoption is conditioned by first-order and second-order barriers. The former, are associated with the availability of resources, and may be solved with the provision of adequate technology, training and support; the latter refer to internal barriers as a consequence of instructors' reflection about their own teaching practice and are harder to overcome.

The training of teaching professionals plays an important role on the formation of these barriers, but prior research mainly focuses on pre-service teachers in their last years of training, where some of those barriers have already been formed, and mostly investigates computer-based learning, omitting a central aspect of current pre-service teachers' everyday life: the use of mobile technologies. This research aims to fill that gap by analyzing the influence of second-order barriers on first-year pre-service teachers' intention to use mobile devices in their future teaching practice.

The study identifies the most relevant second-order barriers predicting intention to use mobile devices and empirically tests the proposed model using a sample of 160 first-year Primary Pre-Service teachers. The results of the partial least squares structural equation modeling analysis emphasizes the relevance of most second-order barriers on the intention to use mobile devices in the future teaching practice of pre-service teachers in their early years. Additionally, the study compares traditional reflective modeling of subjective norm with a formative proposal, suggesting that formative formulations are more suitable for this type of research.

Keywords

mLearning; TAM; technology adoption; pre-service teachers; PLS-SEM

1. Introduction

Sánchez-Prieto, J.C., Hernández-García, A., García-Peñalvo, F.J., Chaparro-Peláez, J., Olmos-Migueláñez, S. (En revisión) Break the walls! Second-order barriers and the acceptance of mLearning by first-year pre-service teachers.

The use of information technologies (IT) in education gives access to an ample selection of new teaching methods. Rapid advances in technology make new solutions available for teachers to help students to adapt to the professional needs of a constantly changing world. One of the most notable technology advances are mobile devices. The increasing storage, fast adoption and presence of mobile devices in all aspects of everyday life makes it possible to talk about a post-PC era already (Wei, Valler, Madhyastha, Neamtiu, & Faloutsos, 2017).

Educational uses of mobile devices in formal education, under the name of mobile learning or mLearning, enables customization and flexibility of learning processes (Traxler, 2009). Anywhere and anytime connectivity, integration of multimedia content, personal use and communication facilitate situated and collaborative learning, adapted to the characteristics of students, and free from time and space constraints (Crompton, 2017).

Due to its many advantages, mLearning has gained interest among educators and scholars and its use is increasing in varied educational settings, such as in-company training or museums, with a wide catalogue of learning activities (Liu, Han, & Li, 2010). However, and despite their ubiquity in everyday life, the use of mobile devices in the classroom is not commonplace, and it is definitely quite below the expected rate of adoption (Liu et al., 2010; Moreira, Ferreira, Santos, & Durão, 2017). In addition, in most occasions, either the initiatives fail or they are one-off implementations that lack continuity (Authors, 2016a). These signs point out to the existence of a problem with the adoption of mobile technologies in educational institutions.

One of the reasons that better explain this problem is the reluctance of instructors to incorporate IT to their teaching practice (Kreijns, Vermeulen, Kirschner, Buuren, & Acker, 2013; Sanchez-Mena, Marti-Parreno, & Aldas-Manzano, 2017). Student attitudes or preferences aside, in the end the decision about whether or not using mobile devices in the classroom falls on the educators (Sang, Valcke, Braak, & Tondeur, 2010), because they choose the instructional method they consider the most appropriate to teach their classes (Yang & Huang, 2008), and they have the final word on the frequency, quality and type of technology the students will be using. Consequently, teachers who do not perceive that a technology fulfills their needs, or the students' needs, will resist using these technologies (Teo, Lee, & Chai, 2008), considerably hindering adoption of mobile technologies in education. Thus, teachers' intention to incorporate mobile technologies is a critical aspect for mLearning adoption.

Generally speaking, there are two different groups of factors that prevent instructors from incorporating a given technology in their teaching practice: first-order or external barriers, and second-order or internal barriers (Brickner, 1995). External barriers relate to availability of resources. In order to ensure a successful integration of technologies, educational institutions need to be able to provide teachers and students with the adequate equipment, training, time and technical support (Reid, 2014). If instructors do not perceive that those barriers have been overcome, they can hardly initiate a process of technology integration where they have to solve every problem by themselves before even starting to use IT in the classroom (Ertmer, 1999). Consequently, external barriers have a capital relevance in the technology acceptance process (Brown, Englehardt, & Mathers, 2016; Reid, 2014; Venkatesh, Morris, Davis, & Davis, 2003).

Nonetheless, overcoming these first-order barriers is usually a matter of resources, and even when the resources are available it does not automatically imply that teachers will immediately start using a new system or technology; there is where internal barriers come into play. Second-order barriers refer to how instructors regard their own teaching practices and the specific technology (McLoughlin, Wang, & Beasley, 2008), and therefore they are linked to motivational aspects, teaching styles or social influence.

In this sense, the training an instructor receives during his years as pre-service teacher plays an essential role (Sang et al., 2010) because it is during these years when the individual creates his or her professional identity, leaving the role of expert student to take on the role of a novice teacher (So, Choi, Lim, & Xiong, 2012).

Given that future teachers are currently digital natives who have grown in pervasive technology environments (Baltaci-Goktalay & Ozdilek, 2010; Teo, Yurdakul, & Ursavas, 2016), they are expected to use new technologies in their practice, as they are supposed to be expert users. However, this assumption is not enough (Jones, Ramanau, Cross, & Healing, 2010; Kimmons, Clark, & Lim, 2017; So et al., 2012), because being familiar with the use of mobile devices does not directly translate to using mobile technologies in educational contexts (Corbeil & Valdés-Corbeil, 2007). Furthermore, students carry a series of preconceptions and learning with them when they begin their training as teachers, which shape their idea of good and bad teaching practices (Holt-Reynolds, 1992).

Even though some prior research has investigated the process of technology acceptance among teachers during their training period (Baydas & Goktas, 2017; Teo, Milutinović, & Zhou, 2016), most of these studies focus on instructors in their latest training stages (e.g. Baydas & Yilmaz, 2018; Parkman, Litz & Gromik, 2018), from a perspective that considers the final results when teachers are about to complete their academic training, and only pay limited attention to the effect of the second-order variables (e.g. Baturay, Gökçearslan, & Ke, 2017, treat them as an unidimensional variable associated with attitudes toward acceptance of computer assisted-education). Because of the changes in pre-service teachers' conceptions about teaching during their whole training years, that approach fails to explain which variables determine their future intention to use a certain technology, such as mobile technologies, during the earlier stages of training.

Identifying and understanding these variables is necessary in order to define educational and academic training processes that fit the needs and characteristics of students when they start assuming teaching roles. Therefore, this study investigates the variables that predict the intention to use mobile technologies in the future practice of pre-service teachers. Specifically, the study aims to give answer to the following research questions:

> RQ 1. Which variables related with the second-order barriers can help predicting the intention to use mobile technologies by pre-service teachers during their first years of training?
>
> RQ 2. What is the relative importance of each of these variables in explaining pre-service teachers' intention to use mobile technologies?

By answering these two questions, this research aims to gain understanding about the relative importance of second-order barriers in the adoption of mobile technologies for educational purposes among pre-service teachers in the earlier years of their training. In order to answer both research questions, the study proposes the development and validation of a theoretical model that takes into account behavioral, psycho-social and technology-related elements. The results of the research may provide further insight on the technology adoption process of pre-service teachers, and help guiding the curriculum design of higher education institutions that aim to promote the use of mobile devices in the future teaching practice of their students.

In order to answer the research questions, the remainder of this study is structured as follows. Section 2 presents the literature review and methodology of the study, details the research variables and model, and formulates the research hypotheses; Section 3 details the data analysis

and results; finally, Section 4 highlights the main implications for teaching practice derived from the results.

2. Literature review and model development

2.1. TAM variables

The Technology Acceptance Model (TAM) (Davis, 1989) is one of the most widely accepted theories for the study of technology adoption in educational contexts (Cano-Giner, Fernandez, & Diaz-Boladeras, 2015). TAM, elaborated upon the ideas of the Theory of Reasoned Action (Fishbein & Ajzen, 1975), proposes that there are two main variables explaining the acceptance and use of a new information system or technology: perceived usefulness (PU) and perceived ease of use (PEU).

One of the key factors behind a teacher's decision to incorporate IT to the teaching-learning process is the perception that such change is going to have a positive effect on his or her practice and that it will significantly and effectively improve learning (Mac Callum, Jeffrey, & Kinshuk, 2014). The assessment of teachers about the perceived usefulness of a technology is one of the main determinants of its future use (Venkatesh & Davis, 2000).

Additionally, the use of a new technology or device usually involves additional workload for instructors (Thorsteinsson & Niculescu, 2013), and this workload increases if the use of the technology is difficult or confusing. Hence, perceiving that the use of mobile devices to develop and perform educational tasks is not easy will most likely discourage teachers from using them.

In earlier stages of adoption of a given technology, perceived ease of use becomes an internal barrier that may condition not just the behavioral intention to use a technology (BI), but also its perceived usefulness (Venkatesh & Bala, 2008). More specifically, pre-service teachers are familiar with the use of mobile devices in everyday activities, but they still lack experience with using them as educational resources (Maher, 2018), and therefore they are in an early adoption stage.

Therefore, we posit that:

- ***H1*** *Perceived usefulness positively predicts pre-service teachers' intention to use mobile devices in their future practice.*
- ***H2*** *Perceived ease of use positively predicts pre-service teachers' intention to use mobile devices in their future practice.*
- ***H3*** *Pre-service teachers' perceived ease of use of mobile devices in their future practice positively predicts perceived usefulness.*

2.2. Perceived enjoyment

As mentioned before, motivational factors of utilitarian nature determine the decision of using a given technology. However, aside from extrinsic motivational factors, there are also intrinsic motivational factors that may influence technology acceptance. These factors refer to the enjoyment of using of mobile devices, regardless of the effect of their use on performance (Davis, Bagozzi, & Warshaw, 1992), and positively affect the intention to use ICTs in education, especially when instructors incorporate the technology to learning activities and tasks that are inherently interesting (Roca & Gagné, 2008).

Current pre-service teachers are digital natives who regularly use mobile devices for leisure and entertainment (Barnes, Marateo, & Ferris, 2007; So et al., 2012). Hence, they might be more inclined to use mobile technologies in their future practice because they perceive that the use of these devices adds an element of playfulness to the teaching-learning process when they use them as students (Zacharis, 2012). Nevertheless, when considering the use of mobile technologies from an instructor's perspective, one may ask if students still believe that enjoyment by itself is enough or, on the contrary, there might be additional variables affecting the adoption of mobile technologies by pre-service teachers.

The association of using mobile technologies with perceived enjoyment may cause a decrease in the perception of the cognitive effort, as users are enjoying the experience (Agarwal & Karahanna, 2000). Thus, perceived enjoyment may lead to the (false) perception that the learning curve to use the technology in a professional context is lower than it actually is (Venkatesh, 2000). Furthermore, if instructors consider that the use of the technology inducing the enjoyment does not have an impact in their performance that justifies the effort, they might feel inclined to discard the use of the technology because they are immerse in a social environment that mainly values instructional results. The cognitive dissonance arising from this conflict between utilitarian and hedonic elements may lead the individual to overestimate the usefulness of the system or technology, and concluding that having fun with its use equals usefulness (Agarwal & Karahanna, 2000).

Pre-service teachers are just beginning their academic training, and therefore they lack both the professional experience and a solid theoretical foundation about their teaching role that might contextualize and make the benefits of using mLearning in the classroom evident. Hence, it is highly likely that this mediating effect of perceived usefulness and perceived ease of use in the relation between perceived enjoyment and behavioral intention might occur.

Finally, mobile devices are mixed technologies (Gerow, Ayyagari, Thatcher, & Roth, 2013); that is, they combine characteristics from utilitarian and hedonic systems, and therefore their use may pursue both utilitarian and hedonic goals, by improving the efficacy of learning processes and enhancing enjoyment along the learning process, respectively (Sun & Zhang, 2006). Consequently, the intention to use mobile devices from the perspective of a teaching role is not only directly determined by a willingness to increase the effectiveness of teaching, but also by the objective of enriching the learning experience through higher enjoyment in the classroom (Gerow et al., 2013). Therefore, we posit that:

H4 *Perceived ease of use mediates the relation between perceived enjoyment and pre-service teachers' intention to use mobile devices in their future teaching practice.*

H5 *Perceived usefulness mediates the relation between perceived enjoyment and pre-service teachers' intention to use mobile devices in their future teaching practice.*

H6 *Perceived enjoyment positively predicts pre-service teachers' intention to use mobile devices in their future practice.*

2.3. Compatibility

Instructional methods also might influence the potential use of mobile technologies (Kiraz & Ozdemir, 2006). In contexts where the teacher uses a traditional learning model, mobile devices will most likely be just a lecture companion or a tool to take notes, whereas within constructivist models the instructor may unleash the full potential of mLearning for mobility and interactivity and develop innovative learning activities (Maher, 2018).

Accordingly, the incompatibility between new instructional practices associated to the technology and the teachers' preferred way of work arises as another important internal barrier. The use of a tool that is not compatible with the preferred teaching approach leads the instructor to question his or her own professional model and discourages further use of the technology (Ritchie & Wiburg, 1994; Valtonen, Pontinen, Kukkonen, Dillon, Väisänen, & Hacklin, 2011). Conversely, if teachers feel that a technology may help them work in a way consistent with the way they like to teach, it is more likely that successful adoption will happen (Karahanna, Agarwal, & Angst, 2006). Therefore, compatibility with the preferred work style determines both the extent to which using mobile technologies is perceived as beneficial to improve the quality of teaching and the intention to use them.

Even though pre-service teachers still lack actual professional experience when they begin their training, they do have an idea of what teaching is and what they consider good practices, ideas built upon observational learning that might condition their adoption of mobile technologies. Hence, we posit that:

H7 *Compatibility between mobile technologies and the preferred work style predicts pre-service teachers' intention to use mobile devices in their future practice.*

H8 *Compatibility between mobile technologies and the preferred work style predicts pre-service teachers' perceived usefulness of using mobile devices in their future practice.*

2.3. Subjective norm

Finally, a certain teaching model is being created and assimilated through an evolutionary process that occurs during the whole life of the instructor. The model is not static, and many different elements may influence its development, such as the knowledge acquired, professional practice and experience, and influences from the environment (Beijaard, Meijer, & Verloop, 2004; Day, Kington, Stobart, & Sammons, 2006; Lasky, 2005). That is, despite instructors having the last word regarding the use of a technology for educational purposes in their classroom, social pressure also influences this decision (Teo, 2015). In other words, teachers are aware that their peers and superiors have a series of expectations about how they should practice teaching.

Pre-service teachers that are in the initial stages of academic training are more prone to receive feedback and value it more positively, because they lack the required experience to contrast or contest that information (Lamote & Engels, 2010). For this reason, the perception of pre-service teachers that there is a pressure to use mobile technologies in their teaching practice may determine their intention to use them in order to fulfil these expectations (Teo, 2010; Valtonen et al., 2011).

Therefore, we posit that:

H9 *Subjective norm predicts pre-service teachers' intention to use mobile devices in their future practice.*

Figure 1 depicts the research model, summarizing the different research hypotheses.

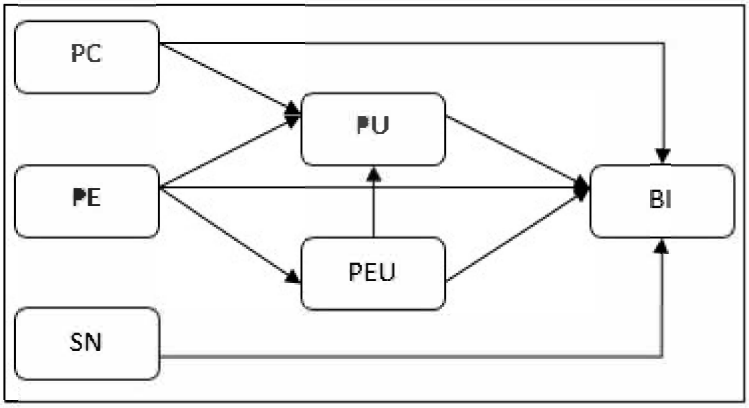

Figure 1. Research Model

3 Method

3.1. Population and sample

An invitation to participate in the study was extended to all first-year students of the Degree in Primary School Teaching at the [*Institution blinded for peer-review*], along three different campuses that are geographically separated by approximately 100 kilometres each. This research design ensures heterogeneity of the sample, as students share the same programme across the three campuses, but not the same instructors –each campus may have developed their own prevailing teaching models and practices, with different levels of social influence. A total of 177 respondents participated voluntarily in the study and completed a questionnaire, for a total of 160 valid questionnaires which is higher than the 147 samples necessary to detect a minimum R-square of 0.10 at a significance level of 5% for a statistical power of 80% (Cohen, 1991). Of these, 73 (45.6%) were enrolled in Campus A, 44 (27.5%) in Campus B, and 43 (26.9%) in Campus C. The mean age of the sample is 19.78 years old (SD=2.69), with the majority of students being female (68.1%). The distribution of the sample is similar to that of total enrolments (49.4% in Campus A, 30% in Campus B, and 20.6% in Campus C).

3.2. Measurement instrument

The questionnaire was delivered on paper and comprised two sections. The first section includes sample demographics–gender, age and campus–and the second section consists of 22 items to measure the study variables using a Likert-7 scale (0=completely disagree; 6=completely agree). Appendix A offers a detailed list of the 22 items.

The measurement instrument was developed from existing literature, and required adaptation of the different items to the context, technology and behavior of the study–use of mobile devices in the future teaching practice of pre-service teachers. Thus, items to measure intention to use, perceived usefulness and perceived ease of use are adapted from TAM3 (Venkatesh & Bala, 2008). Items measuring perceived enjoyment are adapted from a validated scale for the assessment of primary school teachers' intention to use mobile technologies in their future practice ([Authors], 2016b). Compatibility with the preferred work style adapts Moore and Benbasat (1991).

The initial proposal to operationalize subjective norm initially proposed an adaptation of TAM2 (Venkatesh & Davis, 2000). This approach defines subjective norm as "the people who is important for me" and "the people who have influence on my behavior" (*Idem,* p. 27). This

operationalization of the construct is the most frequently used in technology acceptance studies, but the definition is general and unspecific, and does not correspond to the definition of subjective norm in this study. Therefore, the questionnaire includes additional items to measure this latent variable, with a formulation that is closer to Fishbein and Ajzen (1975), Ajzen (1985) and Taylor and Todd (1995). This formulation, adapted from [Authors] (2016c), considers subjective norm as the sum of the influences of different reference groups–in this case, peers and superiors. The differences in both formulations also translate to their representation in the structural model, with the first approach implying a reflective specification and the second approach implying a composite variable, defined formative and caused by non-interchangeable indicators that are independent from one another and that do not need to share the same antecedents and consequences (Hair, Hult, Ringle, & Sarstedt, 2017). The study compares the models resulting from both specifications in order to empirically test the adequacy of both approaches.

3.3. Analysis technique

This study uses Partial Least Squares Structural Equation Modeling (PLS-SEM) and the software SmartPLS 3.2.6 (Ringle, Wende & Becker, 2017) to analyze the data. One of the main goals of PLS-SEM is the prediction of a target variable–in this case pre-service teachers' intention to use mobile technologies in their future teaching practice. PLS-SEM also helps assessing the predictive power of antecedent variables.

The model analysis in PLS-SEM is a two-stage approach. The first step consists on the assessment of the quality of the measurement model in order to confirm the validity and reliability of the different model variables. The second step focuses on evaluating the relationships in the structural model by testing the significance of the relationships, the explained variance of the endogenous variables and the predictive power of the different variables. (Hair et al., 2017)

The use of PLS-SEM makes it possible to analyze subjective norm as a formative construct, which is not only more appropriate to model this variable, according to the definition provided in the research, but also facilitates assessment of the relative weight of each of the sources of influence in the formation of subjective norm.

3. Data analysis and results

3.1. Global model assessment

The analysis includes observation of goodness of fit of the overall model as the first part of model assessment in PLS (Henseler, Hubona, & Ray, 2016). In PLS-SEM, it is possible to evaluate the approximate fit of the estimated model by using the standardized root mean square residual (SRMR). The analysis returns a value of 0.062, below the recommended value of 0.08 (Hu & Bentler, 1998), which suggests a good fit. Besides the SRMR for the estimated model, it is also necessary to assess fit of the saturated model, which returns a value of 0.059 and confirms goodness of fit[1].

[1] Hair et al. (2017) provide a note of caution about the use of model fit measures in PLS-SEM, indicating that "too little is known about these measures' behavior across a range of data and model constellations, so more research is needed […] PLS-SEM focuses on prediction rather than on explanatory modeling and therefore requires a different type of validation […] In this context, fit (as put into effect by SRMR, RMStheta, and the exact fit test) offer little value. In fact, their use can even be harmful as researchers may be tempted to sacrifice predictive power to achieve better "fit." […]." (*Idem,* pp. 193–194). As the concept of goodness-of-fit is still under development in PLS-SEM, this study reports SRMR for informative purposes.

3.2. Measurement model assessment

Measurement model assessment includes assessment of measurement instrument reliability and validity, which requires separate analysis of formative and reflective variables. The analysis will consider the formulation of subjective norm as formative composite variable.

The results (Table 1) confirm item reliability, with reflective indicators loadings higher than 0.7 (Nunnally, 1978). The results also confirm convergent validity, with Cronbach's alpha (α), composite reliability (CR) and average variable extracted (AVE) values higher than 0.7, 0.6 and 0.5, respectively (Fornell & Larcker, 1981).

Latent variable	Indicator	Loading	α	CR	AVE
Behavioral intention to use	BI_01	0.920	0.912	0.944	0.850
	BI_02	0.931			
	BI_03	0.915			
Compatibility	PC_01	0.884	0.891	0.932	0.821
	PC_02	0.936			
	PC_03	0.898			
Perceived enjoyment	PE_01	0.841	0.905	0.934	0.779
	PE_02	0.886			
	PE_03	0.905			
	PE_04	0.896			
Perceived ease of use	PEU_01	0.804	0.819	0.881	0.650
	PEU_02	0.798			
	PEU_03	0.881			
	PEU_04	0.735			
Perceived usefulness	PU_01	0.897	0.909	0.937	0.787
	PU_02	0.893			
	PU_03	0.926			
	PU_04	0.830			

Table 1. Item reliability and convergent validity analysis (reflective variables).

Assessment of reliability and validity of the formative construct (Table 2) includes observation of the variance inflation factor (VIF) to discard collinearity issues. VIF values are lower than 3.3 (Diamantopoulos & Siguaw, 2006), confirming that there are no collinearity issues. Furthermore, a bootstrapping with 5000 subsamples returns indicator weights higher than 0.5, and statistically significant, confirming reliability of the formative variable.

Indicator	VIF	Weight	CI	p-value
SN_02	1.380	0.638	0.461-0.791	0.000
SN_03	1.380	0.505	0.322-0.673	0.000

Table 2. Formative measurement model analysis (formative variable).

Discriminant validity assessment includes the use of two different criteria: Fornell-Larcker (Fornell & Larcker, 1981) and the heterotrait-monotrait ratio of correlations, or HTMT (Hair et al., 2017). As shown in Table 3, discriminant validity is confirmed using both criteria–square root of AVE higher than inter-construct correlations and HTMT under 0.85, respectively.

	Fornell-Larcker						HTMT				
	BI	**PC**	**PE**	**PEU**	**PU**	**SN**	**BI**	**PC**	**PE**	**PEU**	**PU**
BI	**0.922**										
PC	0.719	**0.906**					0.796				

PE	0.737	0.632	**0.882**				0.808	0.701			
PEU	0.356	0.377	0.467	**0.806**			0.407	0.433	0.539		
PU	0.746	0.708	0.722	0.386	**0.887**		0.817	0.784	0.792	0.441	
SN	0.702	0.576	0.633	0.255	0.609	-	-	-	-	-	-

Table 3. Discriminant validity analysis

3.3. Structural model assessment

The analysis of the structural model covers the last stage of PLS-SEM analysis. Figure 2 shows the adjusted R^2 values–i.e. variance explained–of the latent variables. The model explains a 62% of perceived usefulness, a 21.3% of perceived ease of use and 70.8% of the variance of pre-service teachers' intention to use mobile devices and technologies in their future teaching practice. Additionally, Stone-Geisser's test returns positive values of Q^2, confirming predictive relevance of the model.

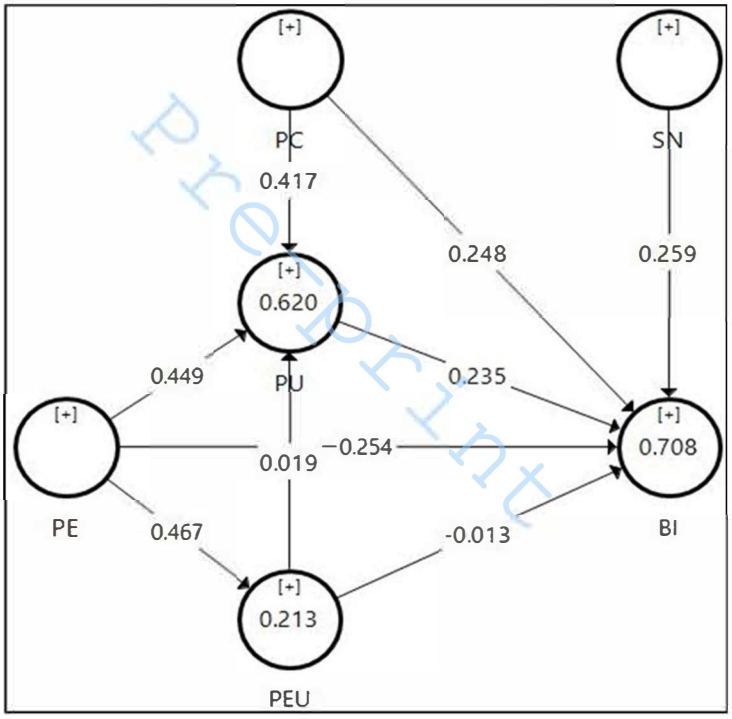

Figure 2. Structural model analysis

Figure 2 also shows the standardized path coefficients. From the figure, perceived enjoyment positively predicts perceived usefulness and perceived ease of use, compatibility predicts perceived usefulness (supporting H7), and all antecedents except perceived ease of use positively predict intention to use mobile technologies by pre-service teachers (supporting H1, H6, H8 and H9, but not H2). Furthermore, perceived ease of use does not predict perceived usefulness (and therefore H3 is not supported). The results of the bootstrapping procedure (Table 4) show the significance of the proposed relations. Table 4 further includes the effect size of the relations and the results of hypothesis testing, with effect sizes between small ($0.02<f^2<0.15$) y and medium ($0.15<f^2<0.35$) for significant relations (Cohen, 1988).

Path	Path coeff.	CI	f^2	Results
PU→BI	0.235^{**}	0.084-0.386	0.07^{+}	**H1 Supported**

PEU→BI	-0.013^{ns}	-0.109-0.088	0.00	**H2 Not supported**
PEU→PU	0.019^{ns}	-0.080-0.121	0.00	**H3 Not supported**
PE→PU	0.449*	0.343-0.575	0.29††	
PE→PEU	0.467*	0.359-0.575	0.28††	
PE→BI	0.254*	0.124-0.377	0.09†	**H6 Supported**
PC→PU	0.417*	0.283-0.530	0.28††	**H7 Supported**
PC→BI	0.248*	0.129-0.366	0.10†	**H8 Supported**
SN→BI	0.259*	0.135-0.383	0.12†	**H9 Supported**

*p<.001; ** p<.01; ^{ns}non-significant. †small effect; ††medium effect

Table 4. Direct effects

Some of the latent variables, namely compatibility, perceived enjoyment and perceived ease of use, may have both a direct and indirect effect on other endogenous variables–perceived usefulness and behavioral intention. Therefore, it is necessary to analyze these effects in order to have a complete understanding of the model. Table 5 shows the indirect effects and the significance of these effects. From Table 5, compatibility has both a direct and indirect effect on intention to use mobile technologies by pre-service teachers, and perceived enjoyment has an indirect effect on behavioral intention via perceived usefulness.

Relation	Eff. Coeff.	Conf. Interv.
PC → BI	0.098*	0.032 - 0.168
PE → BI	0.102**	0.029 - 0.187
PE → PU	0.009	-0.038 - 0.058
PEU→ BI	0.004	-0.018 - 0.034

**p<.01 *p<.05

Table 5. Indirect effects

So far, the analysis has tested hypotheses including direct relations. The results show that there is no relation between perceived ease of use and behavioral intention, which does not support a mediation of perceived ease of use in the relation between perceived enjoyment and behavioral intention (Hair et al., 2017), therefore rejecting H5. In order to test H4, the *variance accounted for* (VAF) of the moderating effect (Nitzl, Roldan, & Cepeda, 2016) returns a value of 29.35%, confirming a typical partial complementary mediation, and supporting H4.

The observation of total effects (Table 6) shows that the two main predictors of pre-service teachers' intention to use mobile technologies in their future teaching practice are perceived enjoyment and compatibility with the work style, whereas perceived ease of use does not have a significant relation with perceived usefulness or behavioural intention.

Relation	Eff. Coeff.	CI
PC → BI	0.346*	0.226 - 0.455
PC → PU	0.417*	0.283 - 0.530
PE → BI	0.355*	0.240 - 0.2470
PE→ PEU	0.467*	0.359 - 0.575
PE → PU	0.458*	0.347 - 0.588
PEU → BI	-0.009	-0.101 - 0.091

PEU → PU	0.019	-0.080 - 0.121
PU → BI	0.235*	0.084 - 0.386
SN → BI	0.259*	0.135 - 0.383

*p<.001

Table 6. Total effects

Finally, as noted in section 2.2.1, this study aims to compare the research model using the formative formulation of subjective norm (M1) and an alternative model that includes a traditional reflective TAM specification of subjective norm (M2). After confirming the validity of M2–item reliability, convergent and discriminant validity–, the results show important differences between both models. Thus, in M1 the relation between subjective norm and intention to use mobile technologies by pre-service teachers is significant and with a medium effect size, whereas in M2 this relation is not significant (p=0.410). Additionally (Table 7), observation of Q^2 and information criteria confirm that M1 is a more parsimonious and generalizable model (Sharma & Kim, 2012).

	Model 1 (M1)	Model 2 (M2)
Q^2	0.562	0.533
CAIC	1035.676	1054.290
BIC	1023.676	1042.290
HC	1001.759	1020.370

Table 7. Model comparison (M1, formative formulation of subjective norm; M2, reflective formulation of subjective norm)

4. Discussion

This study highlights the pivotal role of internal barriers in the adoption of mobile technologies by pre-service teachers from the very beginning of their academic training, which has important ramifications both for the study of the adoption of mobile technologies and for the design of teacher training programs. In answer to the original research questions RQ1 and RQ2, intention to use mobile technologies in their future practice by first-year pre-service teachers is mostly predicted by perceived enjoyment and compatibility with their work style, followed by social influence and perceived usefulness. The results also suggest that perceived ease of use does is not a relevant predictor of future use of mobile technologies in pre-service teachers in their practice.

4.1. Implications for the research on pre-service teachers' technology acceptance

The research model predicts and explains 70% of the variance of the target variable, emphasizing the importance of considering the impact of second-order or internal barriers in the adoption process. Additionally, the percentage of variance explained is considerably higher than prior research where second-order barriers are far less accounted for (Jeong & Kim, 2017; Sanchez-Mena et al., 2017; Teo, Ursavas, & Bahcekapili, 2012).

The results also show important differences with prior adoption studies. As usual in technology acceptance studies (Camadan, Reisoglu, Ömer, & Mcilroy, 2018; Escobar-Rodriguez & Monge-Lozano, 2012), the findings support the relation between perceived usefulness and behavioral intention, both directly and as mediator on the relationship between perceived enjoyment and behavioral intention, and between compatibility and the intention to use mobile technologies by pre-service teachers. However, the results do not support the effect of perceived ease of use on perceived usefulness or behavioral intention, which contradicts the findings from previous studies

with pre-service teachers in 3D multi-user virtual environments (Fokides, 2017) or computer-assisted learning (Okyere-Kwakye, Md Nor, & Ologbo, 2016; Parkman, Litz & Gromik, 2018).

There are different explanations to this finding. On the one hand, the relation between perceived ease of use and perceived usefulness is moderated by the experience of users with the technology; in this study, users are at an initial adoption stage because they do not have enough experience with mobile technologies *as teaching tools*. Furthermore, the operationalization of the variable adapts the proposal of Venkatesh and Bala (2008) in TAM3. Venkatesh and Bala (2008) state that higher experience with a technology reinforces the relation between perceived ease of use and perceived usefulness, opposing Davis's (1989) views in TAM. Considering this, the results seem to go in line with TAM3, although the wording of the items measuring perceived ease of use do not make an explicit reference to the teaching role, which might be a source of misunderstandings for respondents. Participants are digital natives, experts in the use of mobile technologies in their everyday activities, and therefore they are experienced outside of the educational context. Under this view, the results would be aligned with Davis, Bagozzi and Davis (1989) in that experience reduces the effect of perceived ease of use on perceived usefulness. Therefore, the results suggest that it is necessary to further refine the items measuring perceived ease of use in order to adapt them to contexts where the users are experts in the use of the technology in their daily life but are just giving their first steps in the adoption and use of the technology in a professional context of use.

The study also supports the relation between compatibility with the preferred work style and perceived usefulness, and between compatibility and behavioral intention, confirming that pre-service teachers have already formed an idea of the teaching role by observational learning prior to their training. This idea determines their perception about the educational potential of the application of mobile technologies and the benefits they can expect from their use, as well as their plans to use mobile technologies in the future. During their academic teaching training in the University, the initial identity that instructors have created in their minds will experience changes as they gain knowledge in the field of education, get in contact with new instructional models and paradigms, and have their first hands-on experience as teachers during their practice time in educational centers (Stock, Sameshima, & Slingerland, 2016; Trent, 2013). Hence, the findings from this study stress the importance of the analysis of the process by which the professional identity of teachers is created before entering higher education, and how this identity influences-and is influenced by–the use of new technologies in their role as students.

Regarding subjective norm, the results lead to different conclusions depending on the operationalization of the variable. Thus, from the view of Venkatesh and Bala (2008) and the idea of social pressure exerted by generic agents as a starting point, social influence does not seem to influence behavioral intention. However, an explicit formulation of the sources of influence in terms of peers and superiors confirms the relevance of social influence in pre-service teachers' intention to use mobile technologies in their future teaching practice. The results, coupled with better parsimony and generalizability of model M1, suggest that future research on technology acceptance should study subjective norm by clearly differentiating the different sources of social influence, under a lens that is closer to the proposals of Ajzen (1985) or Taylor and Todd (1995) than to Venkatesh and Bala (2008).

4.2. Implications for the teaching practice

The results of the study also have important implications for practice. First, the findings underline the need to develop teaching and learning processes that go beyond a mere transmission of the technical knowledge required to use mobile technologies with educational purposes, focusing

instead on *raising students' awareness about the educational benefits* that the integration of mobile technologies can bring to formal education.

The development of these new processes involves fostering *a curriculum that highlights the benefits of specific teaching and learning scenarios of application of mobile technologies* in educational contexts. This curriculum should also stress the usefulness of mobile technologies for the development of key competences. Additionally, the academic programs should cover *both extrinsic and intrinsic motivational elements*; that is, they also need to emphasize the hedonic aspects of mobile technologies, and how playfulness can improve activities in the classroom, both for students and teachers. In this sense, it would be interesting to explore the use of mobile technologies within gamified learning design as well as in game-based learning.

The study also underscores the fundamental role of the teaching model taught in Higher Education institutions. These academic training years play a critical part in the creation of the professional identity of future teachers, who will assimilate the instructional model promoted or favored by the institution. *If this model is not compatible with the technology*, or makes a limited use of new technologies, *students will most likely not consider their use as positive*. Teaching models are not only taught via contents of academic programs, and the method used by academic trainers has a strong influence on students through observational learning. It is crucial then *not only to observe what* –content, concepts and practices– that pre-service teachers are being taught, *but also how the content is delivered and how they are being taught*. If future teachers have remarkable learning experiences using mobile technologies during their training, they will be more inclined to reuse this kind of instructional approaches once they start their professional practice.

Teacher education programs must also take into consideration the influence of the educational environment over the choice of instructional method. This influence may reinforce learning during the academic training period as pre-service teachers *when what is taught goes in line with the existing practices*. However, if prevailing practices in the educational institution are contrarian to what is being taught, novice teachers might feel inclined to dismiss the delivered instructional contents and instilled beliefs (Darban & Amirkhiz, 2015).

In sum, besides the acquisition of theoretical and technical knowledge about the use of mobile technologies, it is all about the design of academic teaching programs that aim to foster learning, to transmit the utilitarian and hedonic benefits that teachers can obtain from their use, and to promote and facilitate the integration of these technologies with the creation of the professional identity as future teachers of students.

4.3. Contributions, limitations and further research

The adoption of technologies with educational purposes by pre-service teachers has been the focus of prior research, focusing mainly on computer-assisted education. Given the pervasive use of mobile devices in everyday activities but their low adoption rates for educational purposes, this study turns the focus toward the investigation of the influence of second-order barriers on the intention to use mobile devices in the future teaching practice of first-year pre-service teachers. As stated throughout the study, the early years of training of pre-service teachers are critical for the creation and development of their professional identity. Further, regardless of students' attitudes toward the use of mobile technologies for education–even though they are important in closing the adoption process–, the ultimate decision to incorporate them to the teaching practice falls on the instructor. The results of this study thus offer a significant contribution to the field of mLearning adoption.

First, the study provides empirical evidence on the influence of these barriers not only in the late years of training of pre-service teachers, which have usually attracted the interest of researchers, but also during their initial stages. The results of the study suggest that second-order barriers have high predictive power of the acceptance of mLearning by pre-service teachers from the moment they begin their training.

As seen in sections 4.1 and 4.2, this finding has important ramifications for pre-service teachers training programs, especially considering the importance of two under-researched variables in this area –compatibility with existing practices and perceived enjoyment–, compared to more common research variables that were found to be not relevant–e.g. perceived ease of use. The results highlight the need to continue with this line of research, expanding on the constructs included in the model.

Second, the study contributes to research on technology acceptance by providing evidence pointing out to the need to revise the operationalization of this variable in prior studies (Jeong & Kim, 2017; Teo, 2012) in favour of an approach that is closer to the formulation of Taylor and Todd (1995). The findings of this research should be confirmed in future studies.

The research is not exempt from limitations. Due to the nature of the sampling method, open to all students but with voluntary participation, the results may be affected by self-selection bias. In addition, despite the relative heteogeneity of the sample, selected from three different campuses with different instructors, all the students share the same programme and similar cultural characteristics. Therefore, an extension of the study to other institutions and cultural contexts would help ensuring generalizability of results.

Appendix A. Questionnaire items

Behavioral intention		Reference
BI_01	Assuming that I had access to mobile technologies I intend to use them in my teaching practice.	Adapted from Venkatesh and Bala (2008)
BI_02	Given that I had access to mobile technologies I predict that I would use them.	
BI_03	I plan to use mobile technologies in my future teaching practice.	
Perceived usefulness		
PU_01	Using mobile technologies in my lessons increases my productivity.	Adapted from Venkatesh and Bala (2008)
PU_02	Using mobile technologies enhances my efectiveness in my job.	
PU_03	Using mobile technologies in my teaching improves my job performance.	
PU_04	I find mobile technologies to be useful for teaching.	
Perceived ease of use		
PEU_01	Using mobile technologies does not require a lot of my mental effort.	Adapted from Venkatesh and Bala (2008)
PEU_02	I find it easy to get mobile technologies to do what I want them to do.	
PEU_03	My interaction with mobile technologies is clear and understandable.	
PEU_04	I find mobile technologies to be easy to use.	
Perceived enjoyment		

PE_01	The use of mobile devices in my classes adds a fun aspect to my job.	Adapted from Authors (2016b)
PE_02	I am amused by carrying out activities with my students through the use of mobile technologies.	
PE_03	I enjoy using mobile devices in my classes.	
PE_04	The use of mobile devices makes my classes more amusing.	
Compatibility with the preferred work style		
PC_01	Using mobile technologies in my lessons would be compatible with my work style.	Adapted from Moore and Benbasat (1991).
PC_02	Using mobile technologies to teach would be compatible with the way I work.	
PC_03	Using mobile technologies to teach would fit my life style.	
Subjective norm		
SN_01†	People who are important to me think that I should use mobile technologies in my teaching practice.	Adapted from Venkatesh and Davis, (2000)
SN_04†	People who influence my behavior think that I should use mobile technologies in my teaching practice.	
SN_02‡	My classmates think that teachers should use mobile technologies in the classroom	Adapted from Authors (2016b)
SN_03‡	In the schools, teachers are expected to integrate mobile devices in their lessons	

†Reflective, ‡Formative

References

Agarwal, R., & Karahanna, E. (2000). Time Flies When You're Having Fun: Cognitive Absorption and Beliefs about Information Technology Usage. *MIS Quarterly*, *24*(4), 665-694.

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In: J. Kuhl, & J. Beckmann (Eds.), *Action Control: From Cognition to Behavior* (pp. 11-39). Berlin, Heidelberg: Springer Berlin Heidelberg.

Baltaci-Goktalay, S., & Ozdilek, Z. (2010). Pre-service teachers' perceptions about web 2.0 technologies. *Procedia - Social and Behavioral Sciences*, *2*(2), 4737-4741.

Barnes, K., Marateo, R.C., & Ferris, S.P. (2007). Teaching and learning with the net generation. *Innovate: Journal of Online Education*, *3*(4), 1-10.

Baturay, M. H., Gökçearslan, Ş., & Ke, F. (2017). The relationship among pre-service teachers' computer competence, attitude towards computer-assisted education, and intention of technology acceptance. *International Journal of Technology Enhanced Learning*, *9*(1), 1–13.

Baydas, O., & Goktas, Y. (2017). A model for preservice teachers' intentions to use ICT in future lessons. *Interactive Learning Environments*, *25*(7), 930-945.

Baydas, O., & Yilmaz, R. M. (2018). Pre-service teachers' intention to adopt mobile learning: A motivational model. *British Journal of Educational Technology*, 49(1), 137–152.

Beijaard, D., Meijer, P.C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and Teacher Education*, *20*(2), 107-128.

Camadan, F., Reisoglu, I., Ömer, F.U., & Mcilroy, D. (2018). How teachers' personality affect on their behavioral intention to use tablet PC. *International Journal of Information and Learning Technology*, *35*(1), 12-28.

Cano-Giner, J.L., Fernandez, V., & Diaz-Boladeras, M. (2015). Do We Know Enough About the Factors of the TAM Model to Predict the Information System's Acceptance?. In: R. Zhang, Z. Zhang, K. Liu, & J. Zhang (Eds.), *LISS 2013: Proceedings of 3rd International Conference on Logistics, Informatics and Service Science* (pp. 75-79). Berlin, Heidelberg: Springer Berlin Heidelberg.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Erlbaum.

Cohen, J. (1991). A power primer. *Psychological Bulletin*, *112*, 155-519.

Corbeil, J.R., & Valdés-Corbeil, M.E. (2007). Are you Ready for Mobile learning? *Educause Quarterly*, *30*(2), 51-60.

Crompton, H. (2017). Moving toward a mobile learning landscape: presenting a mlearning integration framework. *Interactive Tech & Smart Ed*, *14*(2), 97-109.

Davis, F.D., Bagozzi, R.P., & Warshaw, P.R. (1992). Extrinsic and Intrinsic Motivation to Use Computers in the Workplace1. *Journal of Applied Social Psychology*, *22*(14), 1111-1132.

Day, C., Kington, A., Stobart, G., & Sammons, P. (2006). The personal and professional selves of teachers: stable and unstable identities. *British Educational Research Journal*, *32*(4), 601-616.

Diamantopoulos, A., & Siguaw, J.A. (2006). Formative Versus Reflective Indicators in Organizational Measure Development: A Comparison and Empirical Illustration. *British Journal of Management*, *17*(4), 263-282.

Escobar-Rodriguez, T., & Monge-Lozano, P. (2012). The acceptance of Moodle technology by business administration students. *Computers and Education*, *58*(4), 1085-1093.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: an introduction to theory and research*. Reading, Massachusets: Addison-Wesley Pub. Co.

Fokides, E. (2017). Pre-Service Teachers' Intention to Use MUVEs as Practitioners--A Structural Equation Modeling Approach. *Journal of Information Technology Education: Research*, *16*(0), 47-68.

Fornell, C., & Larcker, D.F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39-50.

Gerow, J.E., Ayyagari, R., Thatcher, J.B., & Roth, P.L. (2013). Can we have fun @ work? The role of intrinsic motivation for utilitarian systems. *European Journal of Information Systems*, *22*(3), 360-380.

Hair, J.F., Hult, G.T.M., Ringle, C.M., & Sarstedt, M. (2017). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Thousand Oaks, California: Sage.

Henseler, J., Hubona, G., & Ray, P.Λ. (2016). Using PLS path modeling in new technology research: Updated guidelines. *Industrial Management & Data Systems*, *116*(1), 2-20.

Holt-Reynolds, D. (1992). Personal History-Based Beliefs as Relevant Prior Knowledge in Course Work. *American Educational Research Journal*, *29*(2), 325-349.

Hu, L., & Bentler, P.M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods*, *3*(4), 424-453.

Jeong, H.I., & Kim, Y. (2017). The acceptance of computer technology by teachers in early childhood education. *Interactive Learning Environments*, *25*(4), 496-512.

Jones, C., Ramanau, R., Cross, S., & Healing, G. (2010). Net generation or Digital Natives: Is there a distinct new generation entering university? *Computers & Education*, *54*(3), 722-732.

Karahanna, E., Agarwal, R., & Angst, C.M. (2006). Reconceptualizing compatibility beliefs in technology acceptance research. *MIS Quarterly*, *30*(4), 781-804.

Kimmons R., Clark B., & Lim M. (2017). Understanding web activity patterns among teachers, students and teacher candidates. *Journal of Computer Assisted Learning*, *33*(6), 588-596.

Kiraz, E., & Ozdemir, D. (2006). The Relationship between Educational Ideologies and Technology Acceptance in Pre-service Teachers. *Journal of Educational Technology & Society*, *9*(2), 152-165.

Kreijns, K., Vermeulen, M., Kirschner, P.A., Buuren, H.v., & Acker, F.V. (2013). Adopting the Integrative Model of Behaviour Prediction to explain teachers' willingness to use ICT: a perspective for research on teachers' ICT usage in pedagogical practices. *Technology, Pedagogy and Education*, *22*(1), 55-71.

Lamote, C., & Engels, N. (2010). The development of student teachers' professional identity. *European Journal of Teacher Education*, *33*(1), 3-18.

Lasky, S. (2005). A sociocultural approach to understanding teacher identity, agency and professional vulnerability in a context of secondary school reform. *Teaching and Teacher Education*, 21(8), 899-916.

Liu, Y., Han, S., & Li, H. (2010). Understanding the factors driving m-learning adoption: a literature review. *Campus-Wide Info Systems*, *27*(4), 210-226.

Darban, M. & Amirkhiz, H. (2015). Herd Behavior in Technology Adoption: The Role of Adopter and Adopted Characteristics. *System Sciences (HICSS), 2015 48th Hawaii International Conference on*, 3591-3600.

Mac Callum, K., Jeffrey, L., & Kinshuk, K. (2014). Factors Impacting Teachers' Adoption of Mobile Learning. *Journal of Information Technology Education: Research*, *13*(1), 141-162.

Maher, D. (2018). Supporting Pre-Service Teachers' Understanding and Use of Mobile Devices. In: *Teacher Training and Professional Development: Concepts, Methodologies, Tools, and Applications* (pp. 676-693).

Moore, G.C., & Benbasat, I. (1991). Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research*, *2*(3), 192-222.

Moreira, F., Ferreira, M.J., Santos, C.P., & Durão, N. (2017). Evolution and use of mobile devices in higher education: A case study in Portuguese Higher Education Institutions between 2009/2010 and 2014/2015. *Telematics and Informatics*, *34*(6), 838-852.

Nitzl, C., Roldan, J.L., & Cepeda, G. (2016). Mediation analysis in partial least squares path modeling: Helping researchers discuss more sophisticated models. *Industr Mngmnt & Data Systems*, *116*(9), 1849-1864.

Nunnally, J.C. (1978). *Psychometric theory*. New York: McGraw-Hill.

Sánchez-Prieto, J.C., Hernández-García, A., García-Peñalvo, F.J., Chaparro-Peláez, J., Olmos-Migueláñez, S. (En revisión) Break the walls! Second-order barriers and the acceptance of mLearning by first-year pre-service teachers.

Okyere-Kwakye, E., Md Nor, K., & Ologbo, A.C. (2016). Technology Acceptance: Examining the Intentions of Ghanaian Teachers to Use Computer for Teaching. *African Journal of Library, Archives & Information Science*, *26*(2), 117-130.

Parkman, S., Litz, D. & Gromik, N. (2018). Examining pre-service teachers' acceptance of technology-rich learning environments: A UAE case study. *Education and Information Technologies*, *23*(3), 1253–1275.

Ritchie, D., & Wiburg, K. (1994). *Educational Variables Influencing Technology Integration*. *J.Technol.Teach.Educ.*, 2(2), 143-153.

Roca, J.C., & Gagné, M. (2008). Understanding e-learning continuance intention in the workplace: A self-determination theory perspective. *Computers in Human Behavior*, *24*(4), 1585-1604.

Sanchez-Mena, A., Marti-Parreno, J., & Aldas-Manzano, J. (2017). The Effect of Age on Teachers' Intention to Use Educational Video Games: A TAM Approach. *Electronic Journal of E-Learning*, *15*(4), 355-365.

Authors (2016a) [details removed for peer review]

Authors (2016b) [details removed for peer review]

Authors (2016c) [details removed for peer review]

Sang, G., Valcke, M., Braak, J.v., & Tondeur, J. (2010). Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviors with educational technology. *Computers & Education*, 54(1), 103-112.

Sharma, P.N., & Kim, K.H. (2012). Model selection in information systems research using partial least squares based structural equation modeling. In: *Proceedings of the International Conference on Information Systems* (pp. 1-13).

So, H., Choi, H., Lim, W.Y., & Xiong, Y. (2012). Little experience with ICT: Are they really the Net Generation student-teachers? *Computers & Education*, *59*(4), 1234-1245.

Stock, R.V., Sameshima, P., & Slingerland, D. (2016). Constructing Pre-Service Teacher Identities Through Processes of Parallax. *Learning Landscapes*, *9*(2), 489-512.

Sun, H., & Zhang, P. (2006). Causal Relationships between Perceived Enjoyment and Perceived Ease of Use: An Alternative Approach. *Journal of Association for Information Systems*, *7*(9), 618-645.

Taylor, S., & Todd, P.A. (1995). Understanding Information Technology Usage: A Test of Competing Models. *Information Systems Research*, *6*(2), 144-176.

Teo, T. (2010). Examining the influence of subjective norm and facilitating conditions on the intention to use technology among pre-service teachers: A structural equation modeling of an extended technology acceptance model. *Asia Pacific Education Review*, *11*(2), 253-262.

Teo, T., Lee, C.B., & Chai, C.S. (2008). Understanding pre-service teachers' computer attitudes: applying and extending the technology acceptance model. *Journal of Computer Assisted Learning*, *24*(2), 128-143.

Sánchez-Prieto, J.C., Hernández-García, A., García-Peñalvo, F.J., Chaparro-Peláez, J., Olmos-Migueláñez, S. (En revisión) Break the walls! Second-order barriers and the acceptance of mLearning by first-year pre-service teachers.

Teo, T. (2015). Comparing pre-service and in-service teachers' acceptance of technology: Assessment of measurement invariance and latent mean differences. *Computers & Education*, *83*, 22-31.

Teo, T. (2012). Examining the intention to use technology among pre-service teachers: an integration of the Technology Acceptance Model and Theory of Planned Behavior. *Interactive Learning Environments*, *20*(1), 3-18.

Teo, T., Milutinović, V., & Zhou, M. (2016). Modelling Serbian pre-service teachers' attitudes towards computer use: A SEM and MIMIC approach. *Computers & Education*, *94*, 77-88.

Teo, T., Ursavas, O.F., & Bahcekapili, E. (2012). An Assessment of Pre-Service Teachers' Technology Acceptance in Turkey: A Structural Equation Modeling Approach. *Asia-Pacific Education Researcher*, *21*(1), 191-202.

Teo, T., Yurdakul, I.K., & Ursavas, O.F. (2016). Exploring the digital natives among pre-service teachers in Turkey: a cross-cultural validation of the Digital Native Assessment Scale. *Interactive Learning Environments*, *24*(6), 1231-1244.

Thorsteinsson, G., & Niculescu, A. (2013). Examining Teachers' Mindset and Responsibilities in Using ICT. *Studies in Informatics and Control*, *22*(3), 315-322.

Traxler, J. (2009). Current state of mobile learning. In: M. Ally (Ed.), *Mobile learning: Transforming the Delivery of Education and Training* (pp. 9-25). Edmonton: AU Press.

Trent, J. (2013). From learner to teacher: practice, language, and identity in a teaching practicum. *Asia-Pacific Journal of Teacher Education*, *41*(4), 426-440.

Valtonen, T., Pontinen, S., Kukkonen, J., Dillon, P., Väisänen, P., & Hacklin, S. (2011). Confronting the technological pedagogical knowledge of Finnish Net Generation student teachers. Technology, *Pedagogy and Education*, *20*(1), 3-18.

Venkatesh, V., & Davis, F.D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*(2), 186-204.

Venkatesh, V. (2000). Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model. *Information Systems Research*, *11*(4), 342-365.

Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences*, *39*(2), 273-315.

Wei, X., Valler, N.C., Madhyastha, H.V., Neamtiu, I., & Faloutsos, M. (2017). Characterizing the behavior of handheld devices and its implications. *Computer Networks*, *114*, 1-12.

Yang, S.C., & Huang, Y. (2008). A study of high school English teachers' behavior, concerns and beliefs in integrating information technology into English instruction. *Computers in Human Behavior*, *24*(3), 1085-1103.

Zacharis, N.Z. (2012). Predicting college students' acceptance of podcasting as a learning tool. *Interactive Technology and Smart Education*, *9*(3), 171-183.