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Mobile-Based Assessment: Integrating acceptance and motivational factors into a combined model of Self-Determination Theory and Technology Acceptance

Stavros A. Nikou*, Anastasios A. Economides

Interdepartmental Programme of Postgraduate Studies in Information Systems, University of Macedonia, Egnatia Street 156, 546 36, Thessaloniki, Greece

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ABSTRACT

Mobile-Based Assessment (MBA) is an alternative or complementary to paper- or computer-based assessment delivery mode. Its successful implementation depends on users' acceptance. However, no study exists exploring the factors that influence students' acceptance of mobile-based assessment. Furthermore, research that combines acceptance with motivational factors is limited. The current study builds on the theoretical framework of the Self-Determination Theory (SDT) of Motivation and the Technology Acceptance Model (TAM) and proposes the Mobile Based Assessment - Motivational and Acceptance Model (MBA-MAM), a combined model that explains and predicts Behavioral Intention to Use Mobile-based Assessment. One-hundred and forty students (N = 140) from a European senior-level secondary school participated in mobile-assisted assessment activities and self-reported their perceptions about MBA afterwards. Structured equation modeling used to analyze quantitative survey data. The study confirmed the proposed model, explaining and predicting students' intention to use MBA in terms of both acceptance and motivational (autonomy, competence and relatedness) factors. The study provides a better understanding towards the development of mobile-based assessments by relating acceptance and motivational factors into an integrated model. Implications are discussed within the wider context of mobile learning acceptance research.

1. Introduction

With the rapid growth of mobile technologies and the widespread adoption of BYOD policies, Mobile-Based Assessment (MBA) has started to emerge as another delivery mode of assessment - alternative and/or complementary to paper- or computer-based testing (Johnson et al., 2016). MBA offers a number of benefits such as easier administration, time and location independence, ubiquity and context awareness, adaptivity, personalization and social interactivity (Nikou & Economides, 2013).However, despite the important learning opportunities that MBA may provide, its successful development depends on user acceptance. The current study investigates acceptance and motivational factors that influence the acceptance of Mobile-Based Assessment.

The study is based on the Self-Determination Theory (SDT) of Motivation (Deci & Ryan, 2002) and the Technology Acceptance Model (TAM) (Davis, 1989) and has two research objectives.

The first objective is to build a model about the acceptance of mobile-based assessment. While many studies exist about mobile learning acceptance (Liu, Han, & Li, 2010; Park, Nam, & Cha, 2012), no study exists to investigate the acceptance of mobile-based assessment. The current study explores students' acceptance of mobile-based assessment introducing the following external variables: *educational content* with *feedback*, students' *mobile device-self efficacy, interactivity* and *collaboration* during the assessment process, and the *ubiquity* features of mobile device. The study examines the impact of these factors on the behavioral intention to use MBA.

The second objective is to introduce motivational variables into technology acceptance. Researchers argue that in order to achieve a more inclusive approach to technology acceptance in educational contexts, there is a need to introduce motivational variables into the technology acceptance models (Pedrotti & Nistor, 2016). The current study introduces into TAM, the SDT motivational variables of *autonomy*, *competence* and *relatedness* and examines their impact

* Corresponding author.
E-mail addresses: stavrosnikou@sch.gr (S.A. Nikou), economid@uom.gr (A.A. Economides).

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on *perceived ease of use* and *perceived usefulness*, predicting *behavioral intention to use*. While studies exist that relate SDT with information technology (Chen & Jang, 2010; Lee, Lee, & Hwang, 2015) and e-learning acceptance (Sørebø, Halvari, Gulli, & Kristiansen, 2009), to the best of our knowledge, no study exists to investigate mobile-based acceptance based on both TAM and SDT. Our study is aiming to propose a combined model of both acceptance and motivational factors towards the prediction of students' behavioral intention to use mobile-based assessment.

The study is organized as follows: the next section provides a brief literature review about the Technology Acceptance Model, Self-Determination Theory of Motivation and a combined view of Technology Acceptance and Self-Determination for e-learning and mobile learning and assessment, providing the rationale for modeling MBA acceptance based on SDT and TAM. Next, the study presents the proposed conceptual model with the hypotheses to be tested. Following that, the sections of methodology (participants, instruments and procedure) and the data analysis and results follow. Discussions and conclusions for the impact in education follow next along with the study limitations and future work.

2. Literature review

2.1. Technology acceptance model

A critical factor for the successful implementation of any information system is its user acceptance. Technology Acceptance Model (TAM) (Davis, 1989) is a well-established model that is based on the psychological interaction of a user with technology and it addresses the issue of how users accept and use information technology. TAM utilizes the constructs of Perceived Usefulness (PU), Perceived Ease of Use (PEOU) and Attitudes Towards Usage (ATU) to explain and predict technology system adoption (Davis, 1989). According to Davis (1989), Perceived Usefulness (PU) is defined as the degree to which a person believes that using a particular system will enhance his/her job performance. Perceived Ease of Use (PEOU) is defined as the degree to which a person believes that using the system would be free of effort. In TAM, Behavioral Intention to Use a system (BIU) is influenced by Attitude Towards Use (ATU), as well as the direct and indirect effects of Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Acceptance research (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989) suggests that perceived ease of use and perceived usefulness are the two key determinants that influence the attitudes of users toward using e-learning technology. Beyond these two constructs, a meta-analysis review by Sumak, Hericko and Pušnik (2011) highlights the large number of external variables that have been added since the early days of TAM, significantly affecting e-learning acceptance. These variables may be related to user characteristics, supporting technology, facilitating conditions, subjective norms etc. However, some researchers (van der Heijden, 2004) argue that the predicting power of TAM is limited to productivity-oriented (or utilitarian) systems, with the influence of intrinsic motivation (conceptualized as perceived enjoyment) to be usually underestimated. In pleasure- (or hedonic) oriented systems, perceived enjoyment dominates over perceived usefulness (Ha, Yoon, & Choi, 2007). Furthermore, as previous research suggests, motivation is a significant factor in affecting users' acceptance of technologies (Davis et al., 1989). Previous studies highlight the importance of investigating the impact of motivational factors on the intention to use e-learning systems (Fagan, Neill, & Wooldridge, 2008; Huang, 2015; Pedrotti & Nistor, 2016). In the context of knowledge-acquisition-oriented (or educational) systems, further research is needed in order to understand the motivating factors towards intention to use technology.

2.2. Self-determination theory (SDT) of motivation

Self-Determination Theory (SDT) of motivation (Ryan & Deci, 2000a, 2000b) is a contemporary macro-theory of motivation assuming that humans have a natural tendency to be intrinsically motivated integrating external regulations into self-regulations towards personal psychological growth, social integration and well-being (Deci & Ryan, 2002). The theory distinguishes between two basic types of motivations: extrinsic and intrinsic (Deci & Ryan, 1985). Extrinsic motivation is the type of motivation that is built upon external rewards or punishments - further categorized into external regulation, introjected regulation, identified regulation and integrated regulation. Intrinsic motivation is the type of motivation that leads to a behavior that is inherently interesting and pleasant. When people are intrinsically motivated they engage in activities for the inherent satisfaction, enjoyment or challenge. SDT argues that intrinsic motivation is supported when the three basic and universal human psychological needs of autonomy, competency and relatedness are satisfied (Deci & Ryan, 1985). Autonomy refers to the desire of people to regulate and self-control their own behavior. Relatedness refers to the desire of people to feel connected and associated with others. Competence refers to the desire of being effective and sufficient when performing an activity. There is a large body of research supporting the SDT postulate that autonomy, competence and relatedness are necessary conditions for the maintenance of intrinsic motivation (Niemiec & Ryan, 2009). Literature describes also intrinsic motivation as autonomous motivation (versus controlled or external motivation) leading to a self-determined behavior.

The current study uses the SDT motivation framework. SDT has been already successfully applied to education (Deci, Vallerand, Pelletier, & Ryan, 1991; Naeghel, Keer, Vansteenkiste, Haerens, & Aelterman, 2016; Niemiec & Ryan, 2009) and on-line learning (Hartnett, 2015; Sørebø et al., 2009). Furthermore, a study by Lee et al. (2015) confirmed the significant relationship across Self-Determination Theory and Technology Acceptance.

2.3. Technology acceptance from the perspective of the Self-Determination Theory of Motivation

Since the early days of TAM, Davis et al. (1989) highlighted the importance of motivation and self-determination towards user's decision to adopt an e-learning system. They showed that perceived enjoyment is an example of intrinsic motivation while perceived usefulness is an example of extrinsic motivation for intention to use information services. Venkatesh (2000) conceptualized intrinsic motivation as computer playfulness that influences perceived ease of use and system acceptance. Lee, Cheung, and Chen (2005) integrated a motivational perspective into the technology acceptance model, capturing both extrinsic (perceived usefulness and ease of use) and intrinsic (perceived enjoyment) motivators for explaining students' intention to use an Internet-based learning medium. An intrinsic motivation perspective was also added to TAM by Zhang, Zhao, and Tan (2008). Drawing on SDT, Chen and Jang (2010) proposed and tested a model for online learner motivation supporting the SDT's main postulate that human motivation is a rather multidimensional construct consisting of intrinsic motivation, external, introjected, and identified regulations, and amotivation.

In the context of e-learning in the workplace, Roca and Gagne (2008), extended TAM with perceived autonomy support, perceived competence and perceived relatedness. All these SDT constructs were found to influence perceived usefulness, perceived playfulness and perceived ease of use. Sorebo et al. (2009) showed that the basic SDT psychological needs and intrinsic motivation can

be useful for predicting teachers' intention to continue use e-learning. Intrinsic motivation affected employees' intention to use e-learning in the workplace more strongly than extrinsic motivation did (Yoo, Han, & Huang, 2012). In a study about utilizing games as a motivator to encourage users' participation in human computation, Pe-Than, Goh, and Lee (2014) found that perceived needs for autonomy, competence, and relatedness influence perceived enjoyment. Lee et al. (2015) confirmed the significant relation between the Self-Determination Theory of Motivation and the Unified Theory of Acceptance and Use of Technology (UTAUT) Model, a successor of TAM. Students' intrinsic motivation found to play a more significant role than their extrinsic motivation in influencing behavioral intention to use cloud services (Huang, 2016). Autonomous motivation found to significantly influence students' decision to use Massive Open Online Courses (MOOCs) (Zhou, 2016). Table 1 summarizes the before mentioned studies that simultaneously investigate SDT and TAM in e-learning contexts.

While there are studies considering motivational dimensions into e-learning acceptance, to the best of our knowledge, no such study exists in the context of mobile-based learning and assessment.

2.4. Mobile learning and assessment acceptance from the perspective of the Self-Determination Theory of Motivation

According to a definition by UNESCO, "mobile learning involves the use of mobile technology, either alone or in combination with other information and communication technology (ICT), to enable learning anytime and anywhere" (p.6, West & Vosloo, 2013). Mobile-based assessment is the assessment that is delivered with the facilitation of mobile devices. The utilization of mobile devices in education provides numerous benefits: it facilitates personalized learning and assessment, supports situated and context-aware learning, supports different assessment practices (classroom polling, formative and summative assessment, peer-assessment, authentic assessment, competence-based) enhances seamless learning, bridges formal and informal learning and assessment, and improves communication and collaboration among members of the learning communities (Nikou & Economides, 2013; West & Vosloo, 2013).

Many studies exist about mobile learning acceptance (Liu, Han, et al., 2010). Perceived ease of use and perceived usefulness have been found to have a significant influence in mobile learning acceptance (Park et al., 2012). Furthermore, many external variables have been added so far to predict and explain behavioral intention to use mobile learning: performance expectancy, effort expectancy, social influence, perceived playfulness (Wang, Wu, & Wang, 2009), facilitating conditions (Iqbal & Qureshi, 2012), quality of service and personal innovativeness (Abu-Al-Aish & Love, 2013), ICT literacy and anxiety (Mac Callum, Jeffrey, & Kinshuk, 2014), social influence (Briz-Ponce, Pereira, Carvalho, Juanes-Méndez, & García-Peñalvo, 2016).

Based on a model of self-determination theory in online learning proposed by Chen and Jang (2010), online learning environments, including m-learning, require and support at the same time the following features: flexibility and choice, employment of technical skills and social interactions. These features are perfectly aligned to the basic constructs of SDT respectively: autonomy, competence and relatedness. Furthermore, the pedagogical framework of mobile learning proposed by Burden and Kearney (2016) highlights three distinctive features of m-learning: personalization, collaboration and authenticity. Connections with SDT are also emerging. The personalization feature has implications for autonomous learning. The collaboration feature captures the relatedness construct of the SDT. The authenticity feature, considered as the effectiveness of learning actions in authentic environments, connects to the SDT construct of competence. Therefore, Self-Determination Theory of motivation may provide an appropriate theoretical framework to study mobile-based learning. It also is an appropriate framework used to investigate the factors influencing intentions to use mobile devices for learning and assessment.

Since, to the best of our knowledge, no such research exists, the current study is aiming at filling this gap in the literature. The study focuses on the acceptance of mobile-based assessment. Even, MBA can be considered as part of a wider mobile learning strategy, its acceptance could be studied separate from other mobile learning activities. Previous studies provide inconsistent results for students' perceptions about MBA acceptance. There are studies reporting positive students' attitudes about mobile-assisted assessment practices (Bogdanovic, Barac, Jovanic, Popovic, & Radenkovic, 2013; Chen, 2010). However, there are also studies reporting students' concerns about usability issues (Huff, 2015), security aspects (Thamadharan & Maarop, 2015) and even psychological limitations associated with the use of mobile devices for

Table 1
Studies combining TAM and SDT.

Study	Context	Findings
Davis et al. (1989)	Computers in the workplace	Perceived usefulness (extrinsic motivation) and enjoyment (intrinsic motivation) positively affect intentions to use
Lee et al. (2005)	Qboard online knowledge sharing system	Autonomy, competence and relatedness influence performance expectancy and perceived enjoyment
Zhang et al. (2008)	Web-based learning system	Intrinsic motivation, conceptualized as enjoyment influences intention to use
Roca & Gagne (2008)	e-learning in the workplace	SDT constructs influence perceived usefulness, perceived playfulness and perceived ease of use
Sorebo et al. (2009)	Teachers use e-learning technology	Basic psychological needs and intrinsic motivation predict e-learning continuance intentions
Chen and Jang (2010)	Online certificate programs	SDT constructs predicts motivation/self-determination
Yoo et al. (2012)	e-learning in the workplace	Intrinsic motivators (effort expectancy, attitudes, and anxiety) affected employees' intention to use e-learning in the workplace
Pe-Than et al. (2014)	Human Computation Games	Perceived needs for autonomy, competence, and relatedness influence perceived enjoyment
Lee et al. (2015)	Web-based threaded discussion board	Satisfaction of basic psychological needs influence performance expectancy and perceived enjoyment
Huang (2016)	Team messaging services	Intrinsic motivation influences attitude toward use and behavioral intention to use
Zhou (2016)	MOOCs	Autonomous motivation predicts intention to use

assessment purposes (Wang et al., 2009). Hence, it is important to investigate the factors that impact students' intention to use mobile-based assessment in its own separate context. The current study investigates intention to use mobile-based assessment from both a technology acceptance and a motivation perspective as well.

3. Conceptual framework and hypotheses

Based on the Self-Determination Theory of Motivation (SDT) (Deci & Ryan, 1985) and the original Technology Acceptance Model (TAM) (Davis, 1989), the current study is aiming at providing a combined model of SDT and TAM in order to explain and predict Behavioral Intention to Use (BIU) Mobile-Based Assessment. For that purpose, we have developed the following hypotheses.

3.1. Perceived Ubiquity Value (PUV)

Ubiquitous learning is a new educational paradigm where context-aware mobile technologies are able to sense the situation of the learner and provide "anytime" and "anywhere" adaptive personalized learning (Hwang, Tsai, & Yang, 2008). Ubiquitous learning can support a wide range of context-aware, active, authentic, cooperative, adaptive, and personalized learning activities (Huang, Chiu, Liu, & Chen, 2011). The current study introduces the construct of Perceived Ubiquity Value (PUV) as the users' perception of the value of the ubiquity of the mobile devices when these devices are being used in mobile-based assessments. The seamless and ubiquitous "24/7" access to learning resources across different contexts offered by mobile devices fosters self-perceived autonomy (Milrad et al., 2013, pp. 95–108). Based on previous research about meaningful ubiquitous learning (Huang et al., 2011), we define PUV to have three dimensions: active, authentic and personalized.

The active and personalized learning provided in authentic contexts supports learning autonomy. Therefore, we hypothesize that:

H1. Perceived Ubiquity Value (PUV) has a positive effect on perceived Autonomy (AUT).

3.2. Content (C)

Previous studies have highlighted the importance of Content (C) in e-learning and user satisfaction (Shee & Wang, 2008). Terzis and Economides (2011) proposed that the construct of Content is a significant factor towards the acceptance of computer-based testing. Content relates to the course content itself and the assessment questions also. When the content of both the course and assessment questions is optimally challenging, reasonable, appropriate and easily understood, students have a sense of learning autonomy and competence. We hypothesize that Content may directly affect perceived autonomy and perceived competence:

H2a. Content (C) has a positive effect on perceived Autonomy (AUT).

H2b. Content (C) has a positive effect on perceived Competence (COMP).

3.3. Perceived feedback (F)

Feedback, being cognitive, emotional or conative (Economides, 2009), has a strong impact on learners' self-efficacy (Wang & Wu, 2008) and learning achievement (Hattie & Timperley, 2007). Emotional feedback has a strong influence on behavioral intention to use computer-based testing (Terzis, Moridis, & Economides, 2012). Cognitive feedback provided through classroom response systems has a significant effect on students' learning outcomes (Hunsu, Adesope, & Bayly, 2016). Previous research has shown that the provision of timely and immediate feedback enhances student perceived autonomy (Narciss et al., 2014). Appropriate feedback is one of the most effective ways to support students' feelings of efficacy and perceived competence (Hartnett, 2015). Meaningful positive feedback enhances the feeling of competence (Hagger, Koch, & Chatzisarantis, 2015) and increases intrinsic motivation (Burgers, Eden, van Engelenburg, & Buningh, 2015; Mumm & Mutlu, 2011). The current study introduces perceived feedback as a construct in technology acceptance in the context of mobile-based assessment. We hypothesize that:

H3a. Perceived Feedback (F) has a positive effect on perceived Autonomy (AUT).

H3b. Perceived Feedback (F) has a positive effect on perceived Competence (COMP).

3.4. Mobile Self-Efficacy (MSE)

Computer Self-Efficacy, defined as "an individual's perceptions of his or her ability to use computers in the accomplishment of a task" (Compeau & Higgins, 1995, p. 191) has been identified to play a significant role in the adoption of computer-based testing and assessment (Lu, Hu, Gao, & Kinshuk, 2016; Terzis & Economides, 2011). Shih (2006) identified computer self-efficacy as a strong and positive antecedent of competence. Similarly, we define Mobile Self-Efficacy (MSE) as an individual's perceptions of his or her ability to use mobile devices to accomplish particular tasks. Relevant studies have shown that when students have more experience with mobile technology, they perceive mobile learning as easier to use requiring less effort (Chen, Chen, & Yen, 2011; Wang et al., 2009). Therefore we argue that students with higher level of mobile-self efficacy, feel more competent in using mobile devices in assessment activities. We hypothesize that:

H4. Mobile Self-Efficacy (MSE) has a positive effect on perceived Competence (COMP).

3.5. Perceived Interactivity (INT)

Interactivity refers to those features of e-learning systems to facilitate the interactions among students, between students and instructors and among students, instructors and the e-leaning content. Interactivity plays an important role in online learning because it encourages active participation, assists in knowledge acquisition and develops critical thinking, problem solving and reflection (Muirhead & Juwah, 2004). The interactivity among students (online discussions and content sharing) and between instructors and students (feedback provided by teachers), as a result of using mobile devices for learning and assessment, facilitates the development of a community atmosphere (Muirhead, 2004) promoting perceived relatedness. Therefore we hypothesize that:

H5. Perceived Interactivity (INT) has a positive effect on perceived Relatedness (REL).

3.6. Perceived Collaboration (COL)

Collaboration in learning can be conceptualized as the process of

sharing knowledge and experiences among peers in order to learn together. Collaborative learning provides many benefits such as student engagement, satisfaction and higher-order learning (Prince, 2004). Mobile technologies promote collaboration among learners by using mobile-based cloud services, standalone messaging applications or messaging services embedded in learning management systems. Collaboration in learning enhances the feeling of relatedness among students. We hypothesize that:

H6. Collaboration (COL) has a positive effect on perceived Relatedness (REL).

3.7. Perceived autonomy (AUT)

Research shows that learning autonomy is significantly related to m-learning adoption through perceived behavioral control (Cheon, Lee, Crooks, & Song, 2012). Learning autonomy also has been found to be a predictor of mobile learning acceptance (Liaw & Huang, 2011; Liaw, Huang, & Chen, 2007). Learning tasks that are perceived as autonomy supportive trigger higher intrinsic motivation (Standage, Duda, & Ntoumanis, 2006). According to Roca & Gagné (2008) perceived autonomy support increases both perceived usefulness (i.e. extrinsic motivation) and perceived playfulness (i.e. intrinsic motivation). Sorebo et al. (2009) also highlighted the positive impact of perceived autonomy support on intrinsic motivation. When students feel autonomous in their learning they perceive learning as useful (monitor the quality of their own work) and easy (have control over the learning process with the mobile devices) (Cheon et al., 2012). We hypothesize that:

H7a. Perceived Autonomy (AUT) has a positive effect on Perceived Usefulness (PU).

H7b. Perceived Autonomy (AUT) has a positive effect on Perceived Ease of Use (PEOU).

3.8. Perceived competence (COMP)

Competence refers to the desire of students being effective when they participate in a learning activity. Research has shown that perceived competence has direct effects on pre-service teachers' perceived usefulness of an e-learning course (Teo, Lee, Chai, & Choy, 2009). Also, perceived competence has direct effects on teachers' perceived ease of use and intrinsic motivation towards an e-learning tool (Sorebo et al., 2009). Fostering students' competence has a significant impact on motivation to use e-learning (Chen & Jang, 2010). According to Roca & Gagné (2008), competence support increases students' perceived usefulness and perceived ease of use. Based on the findings of previous research, we hypothesize for mobile-based assessment that:

H8a. Perceived Competence (COMP) has a positive effect on Perceived Usefulness (PU).

H8b. Perceived Competence (COMP) has a positive effect on Perceived Ease of Use (PEOU).

3.9. Perceived relatedness (REL)

Relatedness refers to feeling connected with peers. Research shows that perceived relatedness positively influences perceived playfulness (Roca & Gagné, 2008). Custers et al. (2012) found a positive relation between relatedness and intrinsic motivation. Considering relatedness as a form of social influence (Roca & Gagné, 2008), students who feel related to important people perceive learning as being useful (Venkatesh, 2000). We argue that the feeling of relatedness among classmates increases students' perceived ease of use of the learning activity. We hypothesize, that:

H9a. Perceived Relatedness (REL) has a positive effect on Perceived Usefulness (PU).

H9b. Perceived Relatedness (REL) has a positive effect on Perceived Ease of Use (PEOU).

3.10. Perceived ease of use (PEOU) and perceived usefulness (PU)

Technology acceptance literature (Davis, 1989) employs two basic constructs that strongly affect user behavior in using specific technologies: Perceived Ease of Use (PEOU) and Perceived Usefulness (PU). Users are more likely to use an information system when they feel that it is easy to use and useful. There is a large body of e-learning research supporting the former casual relationships among PEOU, PU and BIU (Sumak et al., 2011). The same holds in the context of mobile learning (Briz-Ponce et al., 2016; Liu, Li, & Carlsson, 2010; Mac Callum et al., 2014; Park et al., 2012) and computer-based assessment acceptance as well (Terzis & Economides, 2011). In-line with previous research, our model about mobile-based assessment proposes the following hypotheses:

H10a. Perceived Ease of Use (PEOU) has a positive effect on Perceived Usefulness (PU).

H10b. Perceived Ease of Use (PEOU) has a positive effect on Behavioral Intention toUse (BIU).

H11. Perceived Usefulness (PU) has a positive effect on Behavioral Intention to Use (BIU).

Based on the previous hypotheses, we have developed the model shown in Fig. 1 to explain and predict the intention to use MBA. The external variables of Content and Feedback are grouped under the category of educational material; the interaction and collaboration are grouped under the method/process category, while mobile-self efficacy is a user profile characteristic and perceived ubiquity is a mobile device feature.

4. Methodology

4.1. Participants

The participants were 140 students drawn from five classes from a senior-level high school in an urban area in Europe. Students were enrolled in an environmental course about biodiversity. All students taught by the same STEM instructor, an experience science teacher. There were 65 males (46%) and 75 females (54%). The average age of students was 16.7 (SD = 1.15). All students had had already used mobile devices either for communication, information searching and entertainment purposes or for self-study (access educational resources, etc). Students participated using smart phones (86%) and tablets (14%). Students were informed in advance about the research procedure; their participation was voluntarily and all the data were collected anonymously. Appropriate parental permissions and school ethical approval for the participation were also requested and approved.

4.2. Procedure

The experimental procedure lasted for one week during spring 2016, in the context of a STEM course about biodiversity. During that period and in order to complement class instruction, students

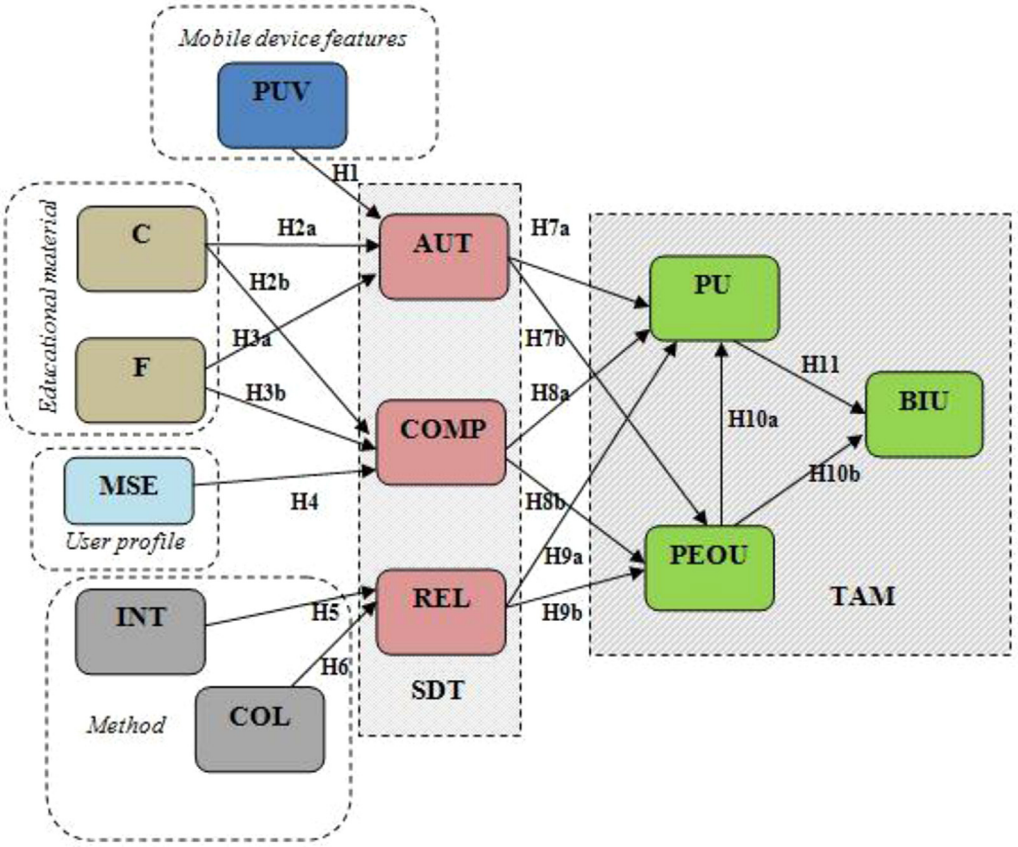

Fig. 1. The research model (MBA-MAM).

visited with their class instructor, in groups, the city's Botanic garden. They participated in a 2-h learning and assessment activity, using mobile devices and QR-coding technology (Fig. 2) in order to navigate through the Botanic garden, observe the plants and answer a total of twenty multiple-choice type or short-answer type questions delivered to their mobiles. The goal of the self-assessment was to support students to focus on and better learn about the plants' special characteristics and properties. The day after the visit to the Botanic Garden an additional self-assessment with 10 multiple-choice questions was delivered to students' mobile devices (for review) as a homework assignment.

Fig. 2. MBA in the field with QR.

Questions of both assignments were developed by the class instructor. Questions were based on the text-book used in class and they were mostly text-based with image support. Fig. 3 shows a sample question. After the submission of an answer, the mobile application provided students with a simple form of immediate feedback indicating correct/incorrect (e.g. “Correct! You did very well on this question!” or “Please try again! You can answer this question!”), along with a short explanation. The application was written using the Query mobile framework with server backend support. During the assessment activities, students could also exchange messages or files (e.g. photos of the plants), using mobile-based cloud services. After the completion of the two mobile-based self-assessments, students were asked to respond to a questionnaire, reporting their attitudes and perceptions about MBA.

4.3. Instruments

In order to develop the questionnaire used in our research, we adopted items from previously validated instruments. For the perceived autonomy (AUT), competence (COMP) and relatedness (REL) we adopted items from Basic Psychological Need Satisfaction (BPNS) Questionnaire (Baard, Deci, & Ryan, 2004; Deci & Ryan, 2002) and the Intrinsic Motivation Inventory (IMI) Questionnaire (McAuley, Duncan, & Tammen, 1989). BPNS assesses the degree to which people feel satisfaction of the basic SDT psychological needs. IMI assesses participants’ subjective experience related to intrinsic

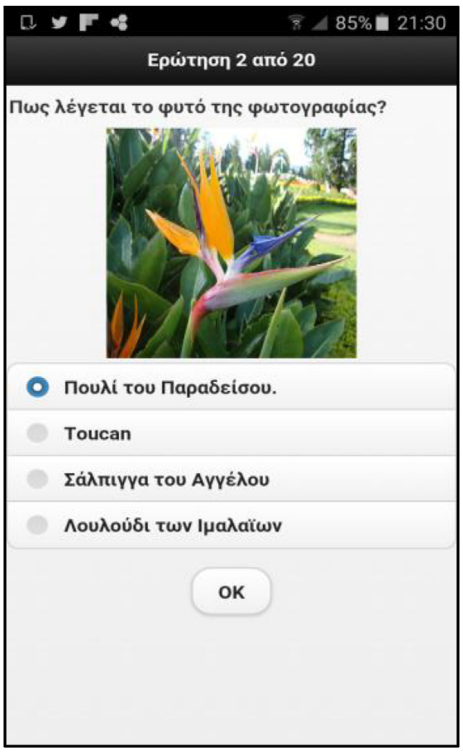

Fig. 3. Sample MBA question.

motivation and self-regulation. A total of 12 question items were used to assess these motivational needs. The three basic needs satisfaction factors had good internal reliabilities (alpha values were 0.81, 0.78 and 0.88 for autonomy, competence and relatedness respectively).

Regarding the TAM variables for Perceived Usefulness (PU), Perceived Ease of Use (PEOU) and Behavioral Intention to Use (BIU), we have adopted items from Venkatesh, Morris, Davis, and Davis (2003). A total of 9 question items were used to assess TAM variables.

For the Mobile device Self-Efficacy (MSE), we adopted items from Compeau, Higgins, and Huff (1999), properly modified for the context of mobile-based assessment. For the perceived Interactivity (INT) we adopted items from Blasco-Arcas, Buil, Hernández-Ortega, and Sese (2013) that refer to the interactions among peers and the interactions between peers and teacher. For perceived Collaboration (COL) we adopted items from So and Brush (2008) and Huang et al. (2011) that refer to the students' collaborative learning experience. For the Content (C) we adopted items from Terzis and Economides (2011). For perceived Feedback (F) we have developed an instrument consisting of four items referring to immediate feedback with knowledge of correct response. The internal consistency of the instrument (Cronbach's a) was 0.85. For the Perceived Ubiquity Value (PUV) of the mobile devices we developed an instrument consisting of four items that refer to the dimensions of activity, authenticity, cooperativeness and adaptivity (Huang et al., 2011). The internal consistency of the instrument (Cronbach's a) was 0.85.

The questionnaire was first developed in English and then translated into the native language of the students. The translation was made by certified translators to ensure linguistic equivalence. Items for all the above constructs were answered on a 7-point scale (1 = *strongly disagree* to 7 = *strongly agree*). The questionnaire used is shown in Table 6 (Appendix).

5. Data analysis and results

Partial Least-Squares (PLS) with Smart PLS 2.0 (Ringle, Wende, & Will, 2005) was used as the analysis technique to predict factors influencing mobile-based assessment adoption. Our sample size exceeds the recommended value of 50 e.g.10 times the largest number of independent variables impacting a depended variable (Chin, 1998).

5.1. Instrument validation

Convergent and discriminant validity of the proposed research model are verified in order to ensure the quality of the model. 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 0.596 to 0.773(AVE > 0.50) exceeding the variance due to measurement error for that construct (Table 2). Discriminant validity is also supported since the square root of the average variance extracted (AVE) of a construct is higher than any correlation with another construct (Table 3).

5.2. Test of the structured model and hypotheses

Fig. 4 and Table 4 summarize the structural model and the hypothesis testing results. Fig. 4 shows the path coefficient for each path along with its significance (as asterisks, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$) and the R^2 for each endogenous variable. Table 4 shows the statistical significance of the relations in the model. Perceived Ease of Use has a direct positive effect on Perceived Usefulness (0.176) and on Behavioral Intention to Use (0.331). Perceived Usefulness has a direct positive effect on Behavioral Intention to Use (0.465). Perceived Autonomy (AUT) has a direct positive effect on Perceived Usefulness (0.524) and Perceived Ease of Use (0.195). Perceived Competence (COMP) has a direct positive effect on Perceived Ease of Use (0.238). No significant direct effect of perceived competence on perceived usefulness was found. Perceived Relatedness (REL) has a direct positive effect on Perceived Usefulness (0.205) and Perceived Ease of Use (0.323). Perceived Ubiquity Value (PUV) has a direct positive effect on students' self-perceived Autonomy (0.157). Content (C) was found to relate directly to perceived Autonomy (0.447) and perceived Competence (0.362). Perceived Feedback (F) was found to relate directly to perceived Autonomy (0.418) and perceived Competence (0.301). Mobile-Self Efficacy (MSE) has a direct positive effect on students' perceived Competence (0.350). Perceived Interactivity (INT) has a positive direct effect on students' perceived Relatedness (0.596) and perceived Collaboration (COL) has a direct positive effect on students' perceived Relatedness (0.323).

Thus, the results from the PLS analysis support all hypotheses except the direct effect of perceived Competence on Perceived Usefulness (Hypothesis H8a). Table 5 shows the direct, indirect and total effects. Total effects have all statistical significance.

The model explains 50% of the variance in Behavioral Intention to Use. The total effects of Perceived Ease of Use (0.412), Perceived Usefulness (0.465), perceived Autonomy (0.323), perceived Relatedness (0.227) and Content (0.194) indicate that these constructs are important determinants of the Behavioral Intention to Use. Furthermore, perceived Autonomy (0.225), perceived Competence (0.238), perceived Relatedness (0.323) and perceived Interactivity (0.192) explain 49% of the variance in Perceived Ease of Use with the perceived Relatedness to be the most important factor. Finally, Perceived Ease of Use (0.176), perceived Autonomy (0.558), perceived Relatedness (0.262), Content (0.299) and perceived Feedback (0.274) explain 52% of the variance in Perceived

Table 2
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 Ubiquity Value	5.24 (1.06)		0.811	0.875	0.637
PUV1		0.780			
PUV2		0.821			
PUV3		0.817			
PUV4		0.774			
Content	4.95 (1.24)		0.803	0.883	0.717
C1		0.851			
C2		0.884			
C3		0.803			
Mobile Self-Efficacy	4.66 (1.39)		0.850	0.897	0.688
MSE1		0.886			
MSE2		0.776			
MSE3		0.834			
MSE4		0.818			
Perceived Feedback	4.62 (1.11)		0.777	0.856	0.599
F1		0.739			
F2		0.873			
F3		0.733			
F4		0.742			
Perceived Interactivity	5.21 (1.12)		0.791	0.864	0.615
I1		0.822			
I2		0.800			
I3		0.774			
I4		0.738			
Perceived Collabor.	3.78 (1.91)		0.774	0.855	0.596
Col1		0.753			
Col2		0.759			
Col3		0.837			
Col4		0.735			
Perceived Autonomy	4.78 (1.14)		0.792	0.865	0.618
AUT1		0.701			
AUT2		0.767			
AUT3		0.790			
AUT4		0.880			
Perceived Competence	4.84 (1.17)		0.828	0.886	0.660
COMP1		0.844			
COMP2		0.805			
COMP3		0.769			
COMP4		0.830			
Perceived Relatedness	4.62 (1.39)		0.761	0.852	0.600
R1		0.802			
R2		0.861			
R3		0.874			
R4		0.701			
Perceived Usefulness	5.09 (1.28)		0.851	0.910	0.773
PU1		0.813			
PU2		0.862			
PU3		0.956			
Perceived Ease of Use	3.95 (1.26)		0.730	0.846	0.647
PEOU1		0.803			
PEOU2		0.763			
PEOU3		0.854			
Behavioural Intention to Use	4.80 (1.25)		0.724	0.845	0.645
BIU1		0.811			
BIU2		0.812			
BIU3		0.787			

Usefulness with the perceived Autonomy to be the most important factor. No significant direct total effect of perceived competence on perceived usefulness was found. Perceived Ubiquity value (0.157), Content (0.447) and perceived Feedback (0.418) explain 82% of the variance in self-perceived Autonomy. Content (0.362), perceived Feedback (0.301) and Mobile Self-Efficacy explain 86% of the variance in self-perceived Competence. Interactivity (0.596) and Collaboration (0.323) explain 67% of the variance in self-perceived Relatedness.

6. Discussions and conclusions

The current study introduces motivational factors into technology acceptance, in the context of mobile-based assessment, proposing Mobile Based Assessment-Motivational and Acceptance Model (MBA-MAM). While researchers have already recognized the importance of integrating motivational factors into technology acceptance (Fagan et al., 2008; Pedrotti & Nistor, 2016), not many studies exist with few exceptions (Lee et al., 2015; Zhou, 2016). The study employs the constructs of autonomy, competence and relatedness from the Self-Determination Theory of motivation in order to explain and predict factors influencing behavioral intention to use mobile-based assessment. Exploring mobile-based assessment with the lens of the SDT, helps us to optimize autonomous learning motivation (Deci & Ryan, 2016), necessary for the 21st century learners. Assessment contexts that support

Table 3
Discriminant validity for the measurement model (values in bold: the square root of the average variance extracted for each construct).

	AUT	BIU	C	F	COMP	COL	INT	MSE	PEOU	PU	PUV	REL
AUT	0.786											
BIU	0.654	0.803										
C	0.724	0.755	0.847									
F	0.700	0.730	0.703	0.774								
COMP	0.629	0.622	0.561	0.552	0.813							
COL	0.626	0.601	0.589	0.581	0.644	0.772						
INT	0.405	0.584	0.755	0.549	0.704	0.557	0.784					
MSE	0.436	0.749	0.721	0.523	0.528	0.660	0.547	0.829				
PEOU	0.642	0.600	0.604	0.423	0.659	0.664	0.574	0.653	0.805			
PU	0.687	0.657	0.646	0.673	0.655	0.577	0.611	0.604	0.577	0.879		
PUV	0.645	0.638	0.558	0.732	0.698	0.504	0.484	0.695	0.526	0.681	0.798	
REL	0.697	0.706	0.670	0.713	0.742	0.655	0.476	0.544	0.636	0.609	0.657	0.775

PEOU - Perceived Ease of Use, PU - Perceived Usefulness, BIU - Behavioural Intention to Use, MSE - Mobile Self-Efficacy, PUV - Perceived Ubiquity Value, C – Content, F – Perceived Feedback, I – Perceived Interactivity, Col – Perceived Collaboration, AUT – Perceived Autonomy, COM – Perceived Competence, REL - Perceived Relatedness.

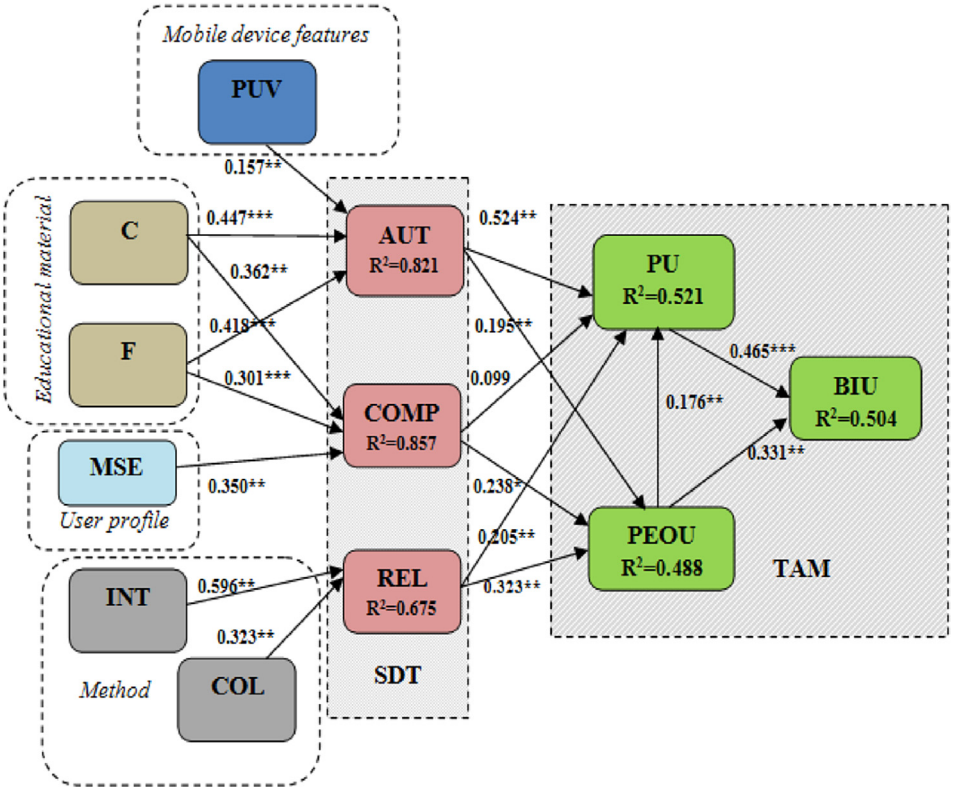

Fig. 4. SEM analysis of the research model.

satisfaction of autonomy, competence, and relatedness improve student involvement and engagement into learning. Furthermore, to the best of our knowledge, the study is one of the first to explicitly focus on students' acceptance of mobile-based assessment (Nikou & Economides, 2014). While many studies exist that explore acceptance of mobile learning (Liu, Han, et al., 2010; Park et al., 2012), there is a gap in the literature about the acceptance of mobile-based assessment. Studies report both positive (Chen, 2010) and negative (Wang et al., 2009; Huff, 2015) students' attitudes for the use of mobile devices for assessment purposes. The study is a step forward towards the understanding of the factors driving mobile-based assessment.

According to the results emerged from the previous analysis, our study suggests that Behavioral Intention to Use Mobile-based Assessment is significantly attributed to Perceived Ease of Use and Perceived Usefulness. When the mobile-based assessment system is perceived as easy and useful, students are willing to use it. These findings are in-line with previous technology acceptance research (Davis, 1989; Venkatesh et al., 2003).

Perceived Autonomy has a significant positive effect on Perceived Usefulness, Perceived Ease of Use and Behavioral Intention to Use. When students feel autonomous into their learning, they perceive learning more useful and easy to use, and also they have a stronger intention to use MBA. Perceived Relatedness has a positive significant effect on Perceived Usefulness, Perceived Ease of Use and Behavioral Intention to Use. When students feel related to their classmates and teacher, they perceive learning and assessment as a useful and an easier task to do and therefore they have a stronger intention to use MBA. Perceived Competence has a direct positive effect on Perceived Ease of Use. Students feeling competent at their learning and assessment tasks, they perceive learning as easy. The results are line with previous research about

Table 4
Hypothesis testing results.

Hypothesis	Path	Path coefficient	Results
H1	Perceived Ubiquity Value → Perceived Autonomy	0.157**	Supported
H2a	Content → Perceived Autonomy	0.447***	Supported
H2b	Content → Perceived Competence	0.362**	Supported
H3a	Perceived Feedback→ Perceived Autonomy	0.418***	Supported
H3b	Perceived Feedback → Perceived Competence	0.301***	Supported
H4	Mobile Self-Efficacy → Perceived Competence	0.350**	Supported
H5	Perceived Interactivity → Perceived Relatedness	0.596**	Supported
H6	Perceived Collaboration → Perceived Relatedness	0.323**	Supported
H7a	Perceived Autonomy → Perceived Usefulness	0.524**	Supported
H7b	Perceived Autonomy → Perceived Ease of Use	0.195**	Supported
H8a	Perceived Competence → Perceived Usefulness	0.099	Not Supported
H8b	Perceived Competence → Perceived Ease of Use	0.238*	Supported
H9a	Perceived Relatedness → Perceived Usefulness	0.205**	Supported
H9b	Perceived Relatedness → Perceived Ease of Use	0.323**	Supported
H10a	Perceived Ease of Use → Perceived Usefulness	0.176**	Supported
H10b	Perceived Ease of Use → Behavioral Intention to Use	0.331**	Supported
H11	Perceived Usefulness → Behavioral Intention to Use	0.465***	Supported

*p < 0.1, **p < 0.05, ***p < 0.01.

Table 5
R^2 and direct, indirect and total effects.

Dependent variables	R^2	Independent variables	Direct effect	Indirect effect	Total effect
Perceived Autonomy	0.821	Perceived Ubiquity Value	0.157	0.000	0.157***
		Content	0.447	0.000	0.447***
		Perceived Feedback	0.418	0.000	0.418***
Perceived Competence	0.857	Content	0.362	0.000	0.362**
		Perceived Feedback	0.301	0.000	0.301***
		Mobile Self-Efficacy	0.360	0.000	0.360**
Perceived Relatedness	0.675	Perceived Interactivity	0.596	0.000	0.596**
		Perceived Collaboration	0.323	0.000	0.323**
Perceived Usefulness	0.521	Perceived Ease of Use	0.176	0.000	0.176**
		Perceived Autonomy	0.524	0.034	0.558**
		Perceived Competence	0.099	0.042	0.141*
		Perceived Relatedness	0.205	0.057	0.262*
		Perceived Ubiquity Value	0.000	0.087	0.087**
		Content	0.000	0.299	0.299**
		Perceived Feedback	0.000	0.274	0.274**
		Mobile Self-Efficacy	0.000	0.048	0.048**
		Perceived Interactivity	0.000	0.155	0.155**
		Perceived Collaboration	0.000	0.084	0.084**
Perceived Ease of use	0.488	Perceived Autonomy	0.195	0.030	0.225**
		Perceived Competence	0.238	0.000	0.238*
		Perceived Relatedness	0.323	0.000	0.323**
		Perceived Ubiquity Value	0.000	0.030	0.030*
		Content	0.000	0.186	0.173*
		Perceived Feedback	0.000	0.151	0.151*
		Mobile Self-Efficacy	0.000	0.080	0.080**
		Perceived Interactivity	0.000	0.192	0.192**
		Perceived Collaboration	0.000	0.104	0.104*
Behavioral Intention to Use	0.504	Perceived Ease of Use	0.331	0.081	0.412*
		Perceived Usefulness	0.465	0.000	0.465***
		Perceived Autonomy	0.000	0.323	0.323**
		Perceived Competence	0.000	0.143	0.143**
		Perceived Relatedness	0.000	0.227	0.227**
		Perceived Ubiquity Value	0.000	0.050	0.050*
		Content	0.000	0.194	0.194*
		Perceived Feedback	0.000	0.173	0.173*
		Mobile Self-Efficacy	0.000	0.049	0.049*
		Perceived Interactivity	0.000	0.135	0.135**
		Perceived Collaboration	0.000	0.072	0.072**

*p < 0.1, **p < 0.05, ***p < 0.01.

the impact of autonomy and relatedness on technology acceptance (Chen & Jang, 2010; Cheon et al., 2012; Roca & Gagné, 2008; Sørebø et al., 2009; Venkatesh, 2000). Also, according to Niemiec and Ryan (2009) when classroom environment supports the SDT basic psychological needs, students are more engaged. However, Perceived Competence was not found to significantly relate to Perceived Usefulness and Behavioral Intention to Use. The result is contradictory to previous research (Chen & Jang, 2010; Sørebø et al., 2009). Low level of students' perceived competence and skills does not affect students' intention to use MBA; it may be the case that low competence level may be an opportunity for more practice through the assessment in order to improve either content

knowledge or mobile device skills. This implies stronger intention to use MBA. However, more research is needed to justify this contradictory result.

Perceived Autonomy is attributed to Perceived Ubiquity Value, Content and Feedback. Perceived Competence is attributed to Content, Feedback and Mobile Self Efficacy. Perceived Relatedness is attributed to Interactivity and Collaboration. These findings are in line with previous SDT research (Deci & Ryan, 2016). Ubiquity, context-sensitivity, technology support, time and location independence (PUV), meaningful feedback (F), relevant and optimally challenging educational content and tasks (C), self-efficacy (MSE), communication and interactions among peers and between peers and teacher (COL, INT) are all determinants of the basic psychological needs of autonomy, relatedness and competence (Hartnett, 2015; Niemiec & Ryan, 2009).

Overall, our results are in line with previous basic research that integrates self-determination into technology acceptance, confirming that there is a relation between motivation and technology acceptance. Also, our proposed model, confirms TAM in the context of mobile-based assessment. The study's main contribution is the proposed integrated model of SDT and TAM to explain and predict students' intention to use mobile-based assessment. However, more research is needed towards the direction of exploring motivation and acceptance of mobile-learning and acceptance. Different educational contexts with larger sample sizes need to be employed.

A deeper understanding of the factors driving mobile-based assessment will help education stakeholders to better design assessments used on mobile devices. Taking into consideration both acceptance and motivational factors, more motivating and engaging assessment can be designed and implemented. Students would like to use mobiles devices for educational activities (Economides & Grousopoulou, 2010) if administrators and teachers properly guide and support them. Mobile devices, appropriately used, may provide, in our era of testing and pressure, an autonomy supportive learning environment (Deci & Ryan, 2016) that ultimately can promote learning.

APPENDIX

Table 6
Questionnaire Items used.

Constructs	Items	Descriptions	Sources
Mobile Self-Efficacy	MSE1	I can complete a job or task using a mobile-device.	Compeau,Higgins & Huff (1999)
	MSE2	I could complete a job or task using a mobile device if someone showed how to do it first.	
	MSE3	I was fully able to use a mobile device before I began using MBA.	
	MSE4	I can navigate easily through the Web using a mobile device to find any information I need.	
Perceived Ubiquity Value	PUV1	The MBA supports me to be more active in my learning.	Self-developed
	PUV2	The MBA can be used for real world tasks in authentic learning environments.	
	PUV3	The MBA can be used anywhere and anytime.	
	PUV4	The MBA can offer personalized learning.	
Perceived Feedback	F1	Feedback during MBA was useful.	Self-developed
	F2	Feedback during MBA was relevant.	
	F3	Feedback during MBA supported my learning.	
	F4	Feedback during MBA helped me to be more engaged.	
Content	C1	MBA's questions were clear and understandable.	Terzis and Economides (2011)
	C2	MBA's questions were relative with the course's syllabus.	
	C3	MBA's questions were useful for my course.	
Perceived Interactivity	I1	The MBA facilitates my interaction with peers and teacher.	Blasco-Arcas et al. (2013)
	I2	The MBA gives me the opportunity to interact with peers and teacher.	
	I3	The MBA facilitates the dialog with peers and teacher.	
	I4	The MBA allows the exchange of information with peers.	
Perceived Collaboration	COL1	During the MBA, I felt part of a learning community.	So and Brush (2008); Huang et al. (2011)
	COL2	During the MBA, I was able to develop my collaboration skills.	
	COL3	During the MBA, I can share experiences or knowledge with my peers.	
	COL4	Overall, I am satisfied with my collaborative learning experience during the MBA.	
Basic Needs Satisfaction (SDT)			
Perceived Autonomy	AUT1	I feel a sense of choice and freedom while participating in the MBA.	McAuley et al. (1989); Baard et al. (2004)
	AUT2	I feel pressured during the MBA.	
	AUT3	The MBA provides me with interesting options and choices.	
	AUT4	There is not much opportunity for me to decide for myself how to do the MBA.	
Perceived Competence	COMP1	I think I am pretty good at the MBA.	McAuley et al. (1989); Baard et al. (2004)
	COMP2	I think I did pretty well at the MBA, compared to other students.	
	COMP3	After working at the MBA for a while, I felt pretty competent.	
	COMP4	The MBA was an activity that I couldn't do very well.	
Perceived Relatedness	REL1	I have the opportunity to be close to others when I participate in the MBA.	McAuley et al. (1989); Baard et al. (2004)
	REL2	I feel close to others when I participate in the MBA.	
	REL3	I feel connected with my classmates when I participate in the MBA.	
	REL4	I feel really distant to my classmates when I participate in the MBA.	
Technology Acceptance Model (TAM)			
Perceived Ease of Use	PEOU1	My interaction with the MBA is clear and understandable.	Venkatesh et al. (2003)
	PEOU2	It is easy for me to become skilful at using theMBA.	
	PEOU3	I find the MBA easy to use.	
Perceived Usefulness	PU1	Using the MBA enhances my effectiveness.	Venkatesh et al. (2003)
	PU2	The MBA is useful for my study.	
	PU3	Using theMBA increases my productivity.	
Behavioural Intention to Use	BIU1	I indent to use MBA in the future.	Venkatesh et al. (2003)
	BIU2	I plan to use MBA in the future.	
	BIU3	I predict I would use MBA in the future.	

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