

Technology acceptance model in educational context: A systematic literature review

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Abstract

A respectable amount of work dealing with Technology Acceptance Model (TAM) clearly indicates a popularity of TAM in the field of technology acceptance in general. Nevertheless, there is still a gap in existing knowledge regarding representative academic literature that underlie research on TAM in educational context. The main objective of this systematic literature review is to provide an overview of the current state of research efforts on TAM application in the field of learning and teaching for a variety of learning domains, learning technologies and types of users. Through systematic search by the use of EBSCO Discovery Service, the review has identified 71 relevant studies ranged between 2003 and 2018. The main findings indicate that TAM and its many different versions represent a credible model for facilitating assessment of diverse learning technologies. TAM's core variables, perceived ease of use and perceived usefulness, have been proven to be antecedent factors affecting acceptance of learning with technology. The paper identifies some gaps in current work and suggests areas for further investigation. The results of this systematic review provide a better understanding of TAM acceptance studies in educational context and create a firm foundation for advancing knowledge in the field.

Introduction

An area of great interest in incorporating new technologies is the field of learning and teaching. Educational settings involve a wide range of potential users of information and communication technology (ICT) which should support the process of knowledge transfer and acquisition. In

Practitioner Notes

What is already known about this topic

- Technology acceptance research in teaching and learning context has become an attractive trend.
- A number of reviews and meta-analysis focused on specific topics related to technology acceptance in education have been conducted.
- The Technology Acceptance Model (TAM) is the key model in understanding predictors of human behaviour towards potential acceptance or rejection of the technology.

What this paper adds

- The state of current research on Technology Acceptance Model application in educational context lacks comprehensive reviews addressing variety of learning domains, learning technologies and types of users.
- The paper presents systematic review of relevant academic literature on Technology Acceptance Model (TAM) in the field of learning and teaching.
- The paper provides empirical evidence on the predictive validity of the models based on TAM presented in selected literature.
- The findings revealed that TAM, along with its many different versions called TAM++, is a leading scientific paradigm and credible model for facilitating assessment of diverse technological deployments in educational context.
- TAM's core variables, perceived ease of use and perceived usefulness, have been proven to be antecedent factors that have affected acceptance of learning with technology.

Implications for practice and/or policy

- The systematic review adds to the body of knowledge and creates a firm foundation for advancing knowledge in the field.
- By following the most common research objectives and/or by filling current gaps in applied research methods, chosen sample groups and types of result analysis, an own study could be conducted.
- Future research may well focus on identifying additional external factors that could further explain acceptance and usage of various learning technologies.

such context, we could question why users decide on the one hand to adopt and accept or, on the other hand, to reject particular technology. Recently, technology acceptance research in teaching and learning contexts has become an attractive trend (Al-Emran, Mezhyuev & Kamaludin, 2018; Imtiaz & Maarop, 2014; Teo, 2011), and necessity for meaningful inclusion of technology in educational settings has been emphasized (Scherer, Siddiq, & Tondeur, 2019). However, although the potential of ICT for enhancing the learning and teaching process is intuitively compelling (Davis, 2011), the issue of learning technology acceptance or rejection could be essential. Since the field of research on educational technology in general is mature enough to exist as its own study object *cf.* (Hrastinski & Keller, 2007), an identification and assessment of published studies in the current state of the field is needed.

A respectable amount of work dealing with the Technology Acceptance Model (TAM) (Davis, 1989), from its first appearance 30 years ago until the present when this review is written, clearly indicates a popularity of TAM in the research field of technology acceptance. Originated in the psychological Theory of Reasoned Action (TRA), TAM has evolved to become the key model in

understanding predictors of human behaviour towards potential acceptance or rejection of the technology. The strength of the Model is confirmed by numerous studies emphasizing its broad applicability to a diverse set of technologies and users (Venkatesh, Morris, Davis, & Davis, 2003).

TAM and TAM++

At the very beginning of technology entering users' everyday life, there was a growing necessity for comprehending reasons why the technology is accepted or rejected. First theories attempting to explain and predict those decisions were grounded in the field of Psychology. The TRA (Ajzen & Fishbein, 1980) represents the origin of TAM, emerging along with the Theory of Planned Behavior (Ajzen, 1985). To develop a reliable model which could predict actual use of any specific technology, Fred Davis adapted the TRA and proposed the TAM (Davis, 1986). He considered that the actual use of a system is essentially a behaviour and therefore the TRA would be suitable model for explanation and prediction of that behaviour. TAM suggested that the user's motivation can be explained by three factors: *perceived ease of use*, *perceived usefulness* and *attitude towards using*.

Davis hypothesized that the *attitude* of a user towards the system was a major determinant of whether the user will actually use or reject the system. He defined *perceived usefulness* as the degree to which the person believes that using the particular system would enhance her/his job performance, whereas the *perceived ease of use* was defined as the degree to which the person believes that using the particular system would be free of effort (Davis, 1986). Finally, both beliefs were hypothesized to be directly influenced by the *system design characteristics* (represented by X_1 , X_2 and X_3), see Figure 1.

During later experimental stages, the Model was refined to include other variables and at the same time modifying the relationships that were initially formulated. Similarly, other researchers have applied and proposed several additions to TAM. New factors with significant influence on the core variables of the Model are continuously revealed. Over time TAM has evolved to become the key model in understanding predictors of human behaviour towards potential acceptance or rejection of the technology. The strength of the Model and its many different versions (so-called "TAM++") is confirmed by numerous studies emphasizing its broad applicability to various technologies and contexts, for instance acceptance of Internet (Lee, Xiong, & Hu, 2012), digital

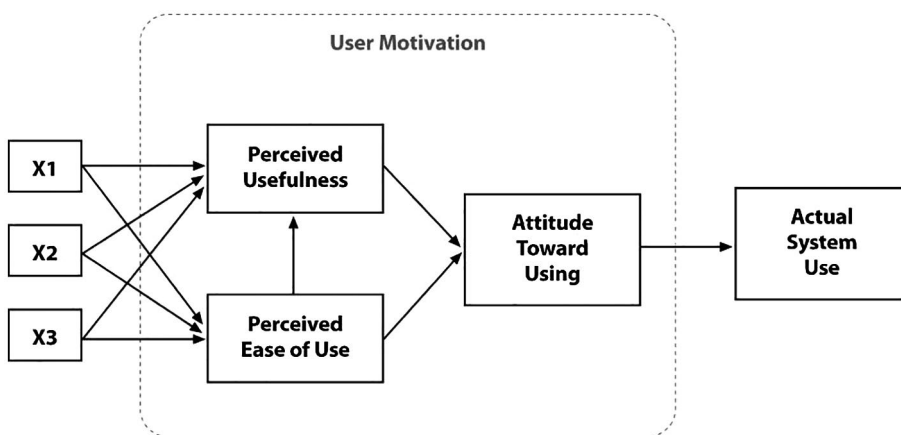


Figure 1: Technology acceptance model (Davis, 1986)

libraries (Hong, Thong, & Tam, 2002), electronic mail (Serenko, 2008), online learning (Farahat, 2012) and electronic commerce (Pavlou, 2003), Internet banking (Nasri & Charfeddine, 2012), wireless Internet (Lu, Yu, Liu, & Yao, 2003), hedonic information systems (Van der Heijden, 2004) along with others. Here, the term TAM++ is applied to those studies that extend/modify the original model by simply adding one or two constructs to TAM, *cf.* (Benbasat & Barki, 2007).

A number of extensive TAM literature reviews have been conducted like the ones presented in Lee, Kozar, and Larsen (2003) and Marangunić and Granić (2015). Furthermore, several literature reviews and meta-analysis have addressed TAM and/or TAM++ in different application domains, for example the review of consumers' acceptance of *e-shopping* (Ingham, Cadieux, & Mekki Berrada, 2015), the meta-analysis of *e-health applications* acceptance (Chauhan & Mahadeo, 2017), the meta-analysis of factors affecting *e-business* adoption (Šumak, Heričko, Budimac, & Pušnik, 2017), the systematic review exploring factors influencing acceptance of *technology for aging* (Peek *et al.*, 2014), the review of technology acceptance in *social media* (Wirtz & Goettel, 2016) as well as the review of TAM studies for *wireless Internet* (Lu *et al.*, 2003).

Current state of TAM application in education

It has been shown that over the years, TAM has emerged as a leading scientific paradigm for investigating acceptance of learning technology by students, teachers and other stakeholders (Davis, 2011). TAM is the most common ground theory in e-learning acceptance literature, *cf.* (Abdullah & Ward, 2016; Šumak, Heričko & Pušnik, 2011; Weerasinghe & Hindagolla, 2017). The intentions of a user towards using an e-learning technology was mainly explained using or extending the TAM research model with other relevant constructs. While, eg, Park, Lee, and Cheong (2008) and Farahat (2012) have tested application of the original TAM in educational area, Gong, Xu, and Yu (2004), Zhang, Zhao, and Tan (2008) and Cheung and Vogel (2013) have used the extended TAM model.

Different acceptance studies in the area have been exploring TAM's applicability for different learning technologies, like mobile learning (Sánchez Prieto, Olmos Migueláñez, & García-Peñalvo, 2016.), Personal Learning Environments (PLEs) (del Barrio-García, Arquero, & Romero-Frías, 2015), Learning Management Systems (LMSs) in general (Alharbi & Drew, 2014) as well as open-source LMS Moodle (Sánchez & Hueros, 2010) and commercial LMS Blackboard (Ibrahim *et al.*, 2017) in particular.

In addition, some theoretical research that summarize empirical research, specifically reviews and meta-analysis, have focused on specific topics in the field of education, eg, the meta-analysis dealing with TAM in prediction of teachers' adoption of technology (Scherer *et al.*, 2019), the quantitative meta-analysis in the context of e-learning adoption (Abdullah & Ward, 2016), the systematic literature review of TAM in the m-learning environment (Al-Emran, *et al.*, 2018) as well as the meta-analysis of the causal effect sizes between common TAM-related relationships (Šumak *et al.*, 2011).

In the light of the aforementioned considerations, it is clear that the state of current research on TAM application in educational domain is not in its infancy. However, the field still lacks comprehensive research study addressing existing approaches and applications that underlie research on TAM and its different versions in educational contexts for a variety of learning domains, learning technologies and types of users. As stated by Webster and Watson (2002, p. xiii), "an effective review creates a firm foundation for advancing knowledge" and therefore the need to uncover what is already known in the body of knowledge should not be underestimated (Levy & Ellis, 2006).

Research method

The paper reports a systematic review of published primary studies that underlie research on TAM in educational context. The review employs a concept-centric approach which is focused on a specific topic organizing a framework of review and not on a sample of (mainstream) journals and/or conferences during a limited time period, *cf.* (Webster & Watson, 2002). Namely, such a limitation would have influenced the findings subjectively since on the one hand, research follows trends, and thus, specific research approaches might have been more common during certain period of time, while on the other hand, specific journals might encourage particular research approaches, *cf.* (Hrastinski, 2008).

The aim is to identify, assess and analyse representative academic literature on TAM in educational context with a view:

- to provide a critical overview of the current state of research efforts,
- to present empirical evidence available thus far on the predictive validity of TAM in educational context and
- to define future research perspectives.

A systematic review proposed by Kitchenham (2004) was adopted. Relevant scientific publications were selected following the three-step guideline approach conducted in three phases covering planning, conducting and reporting the review.

Planning the review

Prior to undertaking the review, and as a first step in the planning phase, a preliminary literature assessment was conducted. The preliminary searching string aimed at both (i) checking and identifying existing reviews and meta-analysis related to technology acceptance in education in general and TAM's applicability in particular as well as (ii) assessing the volume of potentially relevant studies. Consequently, after a number of trial searches using various combinations of search terms (keywords) derived from the search objectives, the following string was adopted:

(TAM OR "technology acceptance") AND (education OR learning) AND (review OR meta-)

Since the review's objectives were agreed and decided, the most important steps regarding the development of a review protocol were specified and are depicted in the following.

First, the set of search terms used to search for the primary studies related to TAM in educational context was specified resulting in the following searching string:

(TAM OR "technology acceptance model") AND (education OR learning)

Second, the resources to be searched were identified. Specifically, in order to conduct the search, EBSCO Discovery Service (EDS) which provides full-text searching for leading databases, eBooks and e-journals was used. For the purpose of this review, EDS has provided access to sixteen prominent subject indexes (subscribed electronic information sources) listed in the following:

- Academic Search Complete
- Academic OneFile
- Business Source Complete
- CINAHL with Full Text
- Complementary Index
- Directory of Open Access Journals
- ERIC
- JSTOR Journals

- Library, Information Science & Technology Abstracts
- MasterFILE Premier
- MEDLINE
- Science Citation Index
- ScienceDirect
- Scopus
- Social Sciences Citation Index
- Supplemental Index

Third, taking into account the research objectives, the general criteria that define the time frame for the study along with the type of studies that are relevant were considered. Accordingly, a number of criteria was specified to select appropriate studies for inclusion:

- studies that report on the use of TAM or TAM++,
- studies that describe conducted empirical research and
- studies that engage any kind of learning technology, explicitly any kind of information, communication and related technologies that can be used to support the process of learning, teaching and assessment.

The following exclusion criteria were defined and for that reason studies meeting these criteria were excluded:

- studies not published as peer-reviewed journal articles and conference papers (for example, editorials, book reviews, book chapters, reports, etc.),
- studies that mention “TAM” or “technology acceptance model” but actually TAM was not used as a core model for the conducted research and
- studies that mention “education” or “learning” but the employed models were not validated.

Moreover, only peer-reviewed academic literature was selected to ensure the quality of the studies reviewed. Also, due to a lack of comprehension of other languages, targeted studies had to be written in English. Lastly, to identify all relevant peer-reviewed publications/studies, the search was not limited to a specific time period.

Fourth, in order to minimize bias, two researchers were working autonomously in the selection of relevant literature. In such double-check process, the individual selections were compared and common agreement on the final selection reached.

Conducting the review

For the purpose of this systematic review, the literature search with the specified searching string was conducted in a month period, during December 2018. The search was not limited to a specific time frame. EBSCO Discovery Service was used and the search results were achieved from 16 databases listed in the previous section.

In total, 375 peer-reviewed publications (journal articles and conference papers) written in English that included “TAM” or “technology acceptance model” along with the word “education” or “learning” in the publication title were identified. Since those were the results related to the search of all sixteen databases, duplications had to be removed resulting in 133 academic publications with unique titles. The title, abstract and text of the selected literature were screened to ensure the relevance of the content in terms of the inclusion criteria. In that process five publications were excluded: three due to the language issues (they were written in Spanish, Arabic and Turkish), one because the full text was not accessible and one conference paper since the same research was published also as a journal paper. To minimize bias, each publication was screened

autonomously by two researchers working independently. When in this double-check process disagreement arose, it was discussed until common agreement was reached.

Consequently, the qualified academic literature was retained and unrelated ones were excluded thus leaving for further detailed analysis 128 studies. Full text of the selected literature was subsequently read and summarized. More publications were excluded because they fulfilled some or all of the aforementioned exclusion criteria concluding with a total of 75 primary studies assessed and analysed in this review.

The flow diagram presented in Figure 2 visualizes steps in the conducted academic literature selection process.

Among the 75 selected publications, 4 (four) were addressing different reviews and meta-analysis in the field, bringing to a close a total of 71 primary studies included in this review. It is important to point out that the identified theoretical literature was not reporting (systematic) reviews of the literature that aim to investigate TAM in educational context at large. However, those studies were rather focused on particular themes in the field of education, like the meta-analysis aiming to clarify which factors in TAM might predict teachers' adoption of technology (Scherer *et al.*, 2019), the study conducted to systematically review and synthesize TAM studies related to m-learning (Al-Emran *et al.*, 2018), the meta-analysis targeting the identification of the most commonly used external factors of TAM in the context of e-learning adoption (Abdullah & Ward, 2016), as well as the review focusing on TAM applications in the domains of Education and Library and Information Science (Weerasinghe & Hindagolla, 2017).

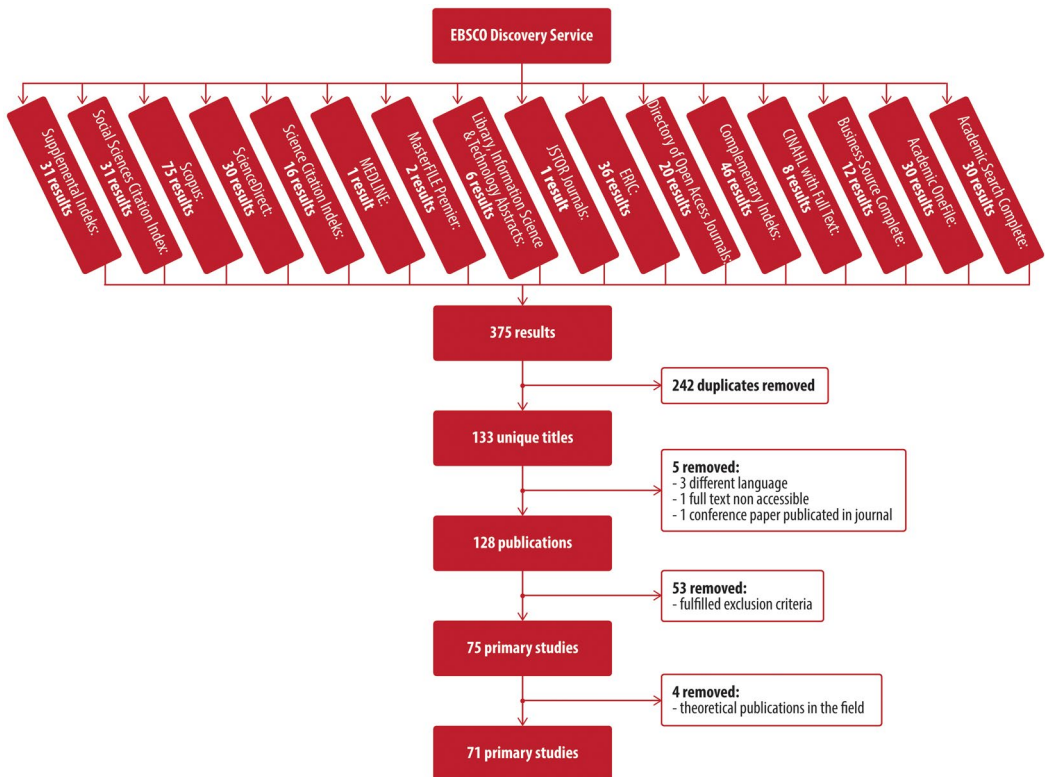


Figure 2: Flow diagram of the publication selection process

Additionally, prior to undertaking the systematic review, the preliminary literature assessment was conducted. Twelve peer-reviewed publications written in English were identified when the same databases have been explored with the preliminary searching string, the string which enabled identification of reviews and/or meta-analysis not only related to TAM but to technology acceptance in education in general. It is important to point out that yet again the search was not limited to a specific time frame. Once the duplications were removed, 5 studies remained.

Subsequently, (i) firstly taking together those five studies along with the four theoretical ones selected through the conducted search of the literature related to TAM in educational context and (ii) secondly removing obvious duplications, six reviews and meta-analysis were selected. Table 1 presents identified theoretical publications available in the literature which provide reviews and meta-analysis focused on specific topics of technology acceptance in education in general as well as TAM application in particular.

Results

Overall review of selected studies

When considering the final selection of a total of 71 primary studies that underlie research on TAM in educational context, a couple of issues have to be emphasized. The first one concerns the history of publishing related to the selected research. Figure 3 depicts the last 16 years of research along with publication frequency of selected academic literature. A clear trend starting in 2003 can be followed until 2018, with a highest peak around the year 2014 and a number of publications between 9 and 13.

The second issue is related to the prevalence of authors all around the globe interested in the research on TAM in the field of learning and teaching, addressing a variety of learning domains, learning technologies and types of users. Figure 4 clearly visualizes different cultures with one common goal—to study users' acceptance of learning technology as well as to understand their behaviour while using any kind of new ICT and related technologies that can be used to support the process of learning, teaching and assessment. A majority of research regarding TAM in educational context comes from Asia, where in countries like Taiwan, Malaysia, South Korea and China various technologies were tested to reveal their potential in enhancing teaching and learning. Europe, North America, Middle East and Africa are following with the same goal and similar research perspectives.

Sample groups of participants and TAM model variations

During the process of the literature review, a few notable facts emerged. The first one is related to different sample groups of participants in the selected studies, with the sample type breakdown presented in Figure 5. In a great majority of analysed research (explicitly 83%), university students were the most commonly chosen sample group pointing to the fact that most empirical data was collected at universities. Only 17% of all sample groups are involving other participants (high school students, faculty members/teachers and employees) which could be considered as a research flaw further discussed in the section related to the limitations.

Besides, as depicted in Figure 6, all of the assessed and analysed research has used TAM as a framework, ie, as a core model when proposing their own research models. Almost half of the identified publications (specifically 49%) have used the original TAM but with an addition of new external variables, thus trying to enhance predictive validity of the original model. The other half combined various extensions and modifications (as stated by the authors) of the original TAM model aiming at explaining factors affecting learning technology acceptance (38% and 13%, respectively).

Table 1: Identified reviews and meta-analysis on some topics related to technology acceptance in education

Study	Analysis dimension	Studies reviewed	Summary of findings
Scherer, Siddiq, and Tondeur (2019)	To clarify which factors in TAM might predict teachers' technology adoption by combining meta-analysis with structural equation modelling approaches	114 empirical studies	TAM is powerful model that hypothesizes direct and indirect mechanisms leading up to teachers' technology use; yet, the role of certain key constructs and importance of external variables contrast some existing beliefs about the TAM
Al-Emran, Mezhyuev, and Kamaludin (2018)	To systematically review and synthesizes TAM studies related to acceptance of m-learning among students in the published work 2006–2018	87 articles	Most of TAM studies involving m-learning are focused on extending the TAM with external variables; most of the analysed studies carried out in the higher educational settings
Weerasinghe and Hindagolla (2017)	To review literature related to TAM focusing on TAM applications in the domains of Library and Information Science (LIS) and Education	8 articles	TAM is a robust model which has many successful applications in the prediction of user acceptance and adoption of various technologies across diverse research contexts
Abdullah and Ward (2016)	To identify the most commonly used external factors of TAM in the context of e-learning adoption by performing a quantitative meta-analysis covering the last 10 years	107 articles	most commonly used external factors of TAM are self-efficacy, subjective norm, enjoyment, computer anxiety and experience; best predictor of student's perceived ease of use of e-learning systems is self-efficacy; the study proposed a General Extended Technology Acceptance Model for E-Learning (GETAMEL)
Imtiaz and Maarop (2014)	To study popular technology acceptance theories in order to build a firm base for examining the technology acceptance works in education domain; to identify the current research patterns	37 articles	Majority of the acceptance studies in education area are on e-learning barring a few on e-assessment; most of the acceptance studies in education domain use TAM, but they have to be extended with other relevant constructs
Šumak, Heričko, and Pušnik (2011)	To conduct a meta-analysis of the causal effect sizes between common TAM-related relationships; to conduct a systematic literature review of articles mostly published in major journals	42 articles	Perceived ease of use and perceived usefulness tend to be the factors that can influence the attitudes of users towards using an e-learning technology in equal measure for different user types and types of e-learning technology settings



Figure 3: Publication frequency of selected primary studies



Figure 4: Worldwide popularity and number of selected studies

Learning technologies, methods and results analysis

A brief description of all analysed research is presented in Table S1 (enclosed in the Appendix) and Figure 7. Numerous learning technologies were used in revised studies combined with a variety of research methods aiming to understand antecedents of technology usage. Types of data analysis, along with Structural Equation Modelling (SEM) as the most often deployed type,

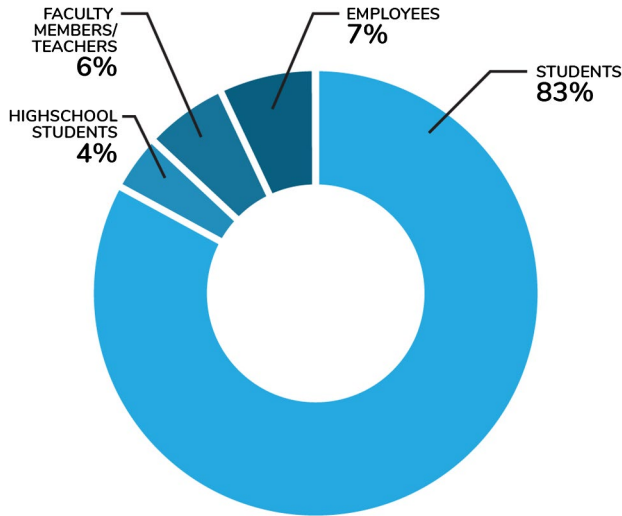


Figure 5: Sample types breakdown

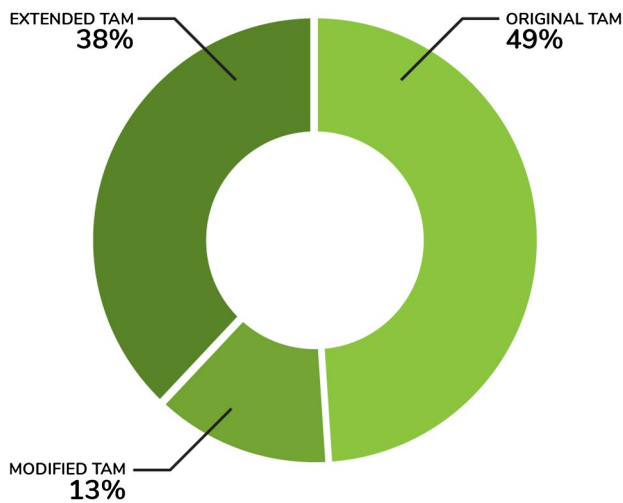


Figure 6: Type of TAM as a framework in analysed studies

clearly indicate research direction. By explaining variable variance as well as path coefficients, authors attempted to enhance predictive validity of their hypothesized models.

Discussion

Main findings

All collected and analysed results within this systematic review, depicted in the figures presented in the Results section (Figures 3–7) and Table S1, provide interesting outcomes for all readers engaged in the domain of educational technology acceptance. When preparing a research of

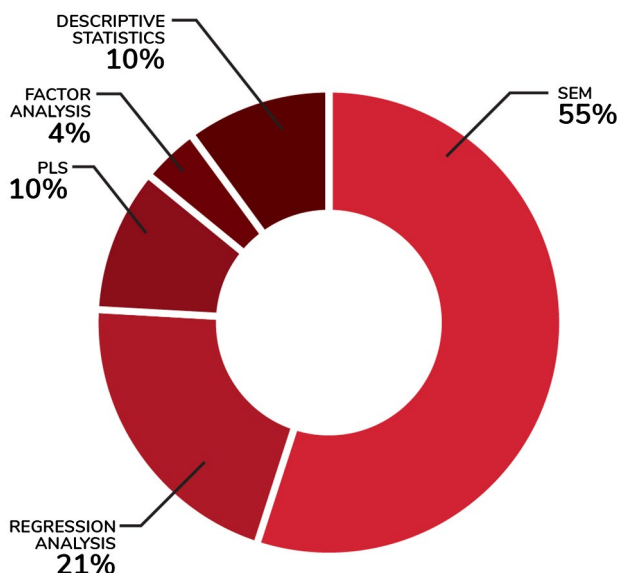


Figure 7: Types of results analysis

their own, a lot can be learned from the presented data, by following the most common research objectives and/or by filling current gaps in applied research methods, chosen sample groups as well as types of result analysis. Even though vast work has been conducted in the last 15 years, there is still great potential for research in this area. Namely, it is always interesting to perceive how education has evolved and improved due to certain technological advancement, even more if the wider context is taken into account. Authors from different countries could be involved in research related to their specific context or even some cross-cultural samples of users might be considered. Moreover, there is still lack of solid experimental methods in the revealed studies. By engaging different research methods on experimental and control groups of users, the achieved results possibly will provide better understanding of a technology impact in the learning and teaching domain. New samples could also be enriched with teaching staff from different educational domains and levels of educations. Those various research directions will also imply different types of result analysis (eg, group testing, structural factor analysis or correlation approach) which can also provide significant contribution in understanding TAM predictive power.

Models presented and validated in the selected primary studies have enabled a better understanding of the acceptance and the use of e-learning environments. The most common objective of all analysed studies was to incorporate new variables or factors into the TAM model. Accordingly, those proposed research models have been built in order to increase TAM predictive validity. For instance, in the context of the research conducted by Esteban-Millat, Martinez-Lopez, Pujol-Jover, Gazquez-Abad, and Alegret (2018), a variable flow referred to the user's intrinsic motivation to adopt virtual learning technologies, hence a student's flow state and extrinsic motivation have been used to explain her/his specific behaviour. Self-efficacy has been a common construct tested as an external variable that has influenced perceived ease of use (Al-Azawei & Lundqvist, 2015; Ibrahim *et al.*, 2017), but it has been also shown that it has a positive effect on the academic achievement of e-learners (Cakır & Solak, 2015). The results of the research conducted by Tarhini, Hone, and Liu (2014) and Jung-Wen and Tseng (2008) have indicated that self-efficacy and perceived ease of use were critical factors for students' behavioural intention to use

e-learning. On the contrary, Juarez Collazo, Wu, Elen, and Clarebout (2014) have found that self-efficacy had no significant effects on perceptions; however, they indicated that self-efficacy might have an effect on perceived usability. Other studies have empirically proved that constructs like subjective norm (Park, 2009), university support and computer self-efficacy (Al-Mushasha, 2013), enjoyment (Chang, Su, & Hajiye, 2017; Zhang *et al.*, 2008), social factors (Setyohadi, Aristian, Sinaga, & Hamid 2017) or perceived content quality (Sulistiyaningsih, Tambotih, & Tanaamah, 2014) are seamlessly connected with the effectiveness of the e-learning system. Also students' attitudes were found to significantly influence their usage of web-based learning technologies. Research findings indicate promising prospects for introducing e-learning based courses (eg, Shah, Iqbal, Janjua, & Amjad, 2013).

A great amount of analysed research has been dealing with specific learning technologies like LMSs, Blended E-Learning Systems, Virtual Learning Environments (VLEs), Video conferencing software or even existing multimedia platforms adapted for learning like YouTube or Vimeo. This fact strongly affirms the credibility of TAM model in facilitating the assessment criteria for diverse technological deployments. Authors have incorporated numerous potential external factors in their studies, aiming to raise predictive validity of TAM and its variables, perceived ease of use and perceived usefulness. Specifically, perceived utility of the engaged learning technology emerged as a good predictor of actual usage (Poellhuber, Fournier, & Roy, 2018; Siegel, Acharya, & Sivo, 2017), learning satisfaction (Al-hawari & Samar, 2010; Nagy, 2018) as well as learning motivation (Hui & Hsiao, 2012). Playfulness (Padilla-Meléndez, Aguila-Obra, & Garrido-Moreno, 2013) and enjoyment (Yi & Hwang, 2003) have also proven to play a significant role in acceptance of various technologies in the educational context. On the other hand, the integration of learning styles theory did not positively influence the model (Al-Azawei, Parslow, & Lundqvist, 2017). From a practical perspective, reviewed research has provided useful insights for educational institutions wishing to adopt and combine various information, communication and related technologies with traditional classroom instruction. Chen, Yang, Tang, Huang, and Yu (2008) have emphasized the feasibility of web-based learning with a high possibility to be used as a learning model.

Mobile learning or m-learning has been the next best thing which has emerged through demands and mobility of "new learner" generations, widening opportunities for timing, location, accessibility and context of learning. The research results of Almaiah, Jalil, and Man (2016) have revealed that learning content quality, content design quality, interactivity, functionality, user interface design, accessibility, personalization and responsiveness are among antecedents of mobile learning acceptance. Abramson, Dawson, and Stevens (2015) have found that there is a relationship between prior use of e-learning and behavioural intention to use m-learning. The findings of the study conducted by Joo, Lee, and Ham (2014) have highlighted again the mobile user interface as an important factor that affects usefulness and ease of use perceived by learners. Huang and Lin (2007) have stressed the importance of perceived mobility value and Chang, Yan, and Tseng (2012) importance of perceived convenience in predicting individual's acceptance of m-learning.

Overall, findings from numerous revised studies revealed that perceived usefulness was the strongest determinant for the adoption of various technologies in educational context. For the majority of assessed and analysed studies, TAM has been a leading scientific paradigm for investigating acceptance and prediction of use of any kind of learning technology. It has been shown that usefulness and ease of use perceived by learners, increase satisfaction in learning while usefulness and satisfaction in learning create a positive intention to use. Model's core variables, perceived ease of use and perceived usefulness, have been proven many times to be antecedent factors that have affected acceptance of learning with technology.

Gaps in current work and implications for future research

Every empirical research, although meticulously designed and conducted, has its limitations thus opening new paths for a future work. A vast majority of studies presented in this systematic literature review have pointed to some research gaps and accordingly have suggested areas for further investigation. For instance, most of the studies have declared generalizability of results as a major shortcoming. Generalizations to populations other than in presented samples of reviewed studies are discouraged due to specific demographic or cultural context. Analysed data often comes from one or just a few educational institutions on the one hand (Fathema, Shannon, & Ross, 2015; Ibrahim *et al.*, 2017; Lemay, Morin, Bazelaïs, & Doleck, 2018; Ma, Chao, & Cheng, 2013; Schoonenboom, 2014) and/or a sample of participants is too small for valid statistical analysis on the other (Lo, Hong, Lin & Hsu, 2012; Lorenzo, Lezcano, & Sanchez-Alonso, 2013; Sek, Lau, Teoh, Law, & Parumo, 2010; Yeou, 2016). Furthermore, other common limitations have to do with a short period of time in which the research was conducted (Chang *et al.*, 2017; Ibrahim *et al.*, 2017; Lee, Hsieh, & Chen, 2013; Saadé & Bahli, 2005) as well as with a few new variables incorporated in the research model based on TAM (Lo *et al.*, 2012; Saadé, Nebebe, & Tan, 2007; Sek *et al.*, 2010; Shittu, Gambari & Sule, 2013; Wu & Yuan, 2011). In line with presented limitations, future research perspectives encompass new studies covering broader sample of participants, specifically other countries or other constructs (Tarhini, Hone, Liu, & Tarhini, 2017), other organizations (Lee *et al.*, 2013), other systems, subjects and participants with different ages (Chang *et al.*, 2012), other e-learning circumstances or infrastructures (Park, 2009) or wider set of technologies (Saadé & Bahli, 2005). To ensure generalizability of the study findings, Yi and Hwang (2003) has discussed that in a future research, the findings should be validated in other settings beyond the specific conditions such as subject characteristics and technology type. A potential direction for future researchers could be a collection of data from more universities, thus the generalization of the results would be more feasible (Jamil, 2017). Besides an attempt to generalize TAM to other contexts with different student populations, levels of higher education as well as programs should also be considered (Lemay *et al.*, 2018). Tarhini *et al.* (2017) has recommended that e-learning implementation should focus on the social and cultural contexts rather than just the technological solution, while Dumpit and Fernandez (2017) have proposed that other users of social media should also be given attention. Moreover, an incorporation of new external variables into research models may possibly be a great perspective which offers opportunities for future work (Al-Azawei & Lundqvist, 2015; Al-Azawei *et al.*, 2017; Sulistiyarningsih *et al.*, 2014).

To summarize, future studies could be expanded for a larger number of respondents by also including instructors since, aside from students, a wide range of teaching staff is also involved in teaching and learning process (Baharin, Lateh, Nathan, & Nawawi, 2015). Additional, future research may well focus on other features, identifying additional decomposed constructs that might further explain students' motivational perceptions (Cheung & Vogel, 2013), as well as on additional variables that will improve acceptance predictability of e-learning systems (Lee *et al.*, 2013). One severe limitation of recent studies lays in the fact that there are very few measures for actual usage of learning technologies (Abramson *et al.*, 2015; Briz-Ponce & García-Peñalvo, 2014; Esteban-Millat *et al.*, 2018; Liu, Chen, Sun, Wible, & Kuo, 2010; Yeou, 2016). The other limitation concerns the type of conducted studies which are often transversal. In light of these considerations, there is a need for longitudinal research to provide deeper insights into the attitudes towards usage of technology in education (Goh, Hong, & Gunawan, 2014; Lee, Hsieh, & Hsu, 2011; Sek *et al.*, 2010). Last but not least, some of the authors have recommend training on how to effectively use the emerging resources (Park, Nam, & Cha, 2012; Shittu *et al.*, 2013) like digital games as learning tool (Lo *et al.*, 2012) as well as social media in education context (Dumpit & Fernandez, 2017).

Limitations of the conducted review and directions of our future work

Even though the conducted systematic review attempted to deliver important recapitulation of education technology acceptance and to provide a critical overview of the current state of research efforts, there are a few limitations which have to be underlined. Firstly, some concerns about the specified searching string can be raised. We could argue that the specific search terms in the publication title did not completely encompass all potential contributing research studies, since there are some peer-reviewed publications in which these keywords may not appear in the title but they do still appear in the content. Nevertheless, due to the enormous work around the world by researchers in the field of technology acceptance, the review could not be exhaustive but could only cover representative academic literature. Secondly, the potential specification of other criteria, namely search terms, along with a selection of other databases, perhaps would have yielded more publications. Thirdly, we started with the assumption that all extensions/modifications of the original TAM model would be embraced under the common term “TAM++” (Benbasat & Barki, 2007; Davis, 2007). Yet, during the analysis of the final literature selection, we realized that “TAM++” is not an established term in the literature and proceeded with differentiating publications by the presented research model based on the original TAM or on its modification or extension (as declared by the authors of identified publications), offered in Table S1. In line with the identified gaps in current work as well as the limitations of the review itself, our future work will follow new research directions:

- conduct a broader search for academic literature which will adopt a few different search strings also including specific learning technology as an explicit search term,
- orientation towards discovering and analysing new TAM extensions/modifications defined in the literature, for example MTAM—mobile technologies or STAM—social network platforms,
- carry out a study to address some of the identified gaps in current work which underlies research on TAM in educational contexts, specifically involving cross-cultural samples of users.

Conclusion

We are living in an era of advanced technology which impacts our lives in different ways. Educational setting has been recognized as a domain with good potential for incorporation of new technologies. It involves a wide range of users of learning technology which should support the process of knowledge transfer and acquisition. Hence, technology acceptance research in the field of learning and teaching has become an attractive trend. TAM and its many different versions are worldwide acknowledged as solid frameworks for planning and conducting empirical research in the field of education. The presented work systematically reviews academic literature dealing with TAM in educational context bringing a total of 71 primary studies published between 2003 and 2018. Identified, assessed and analysed studies offer a wide range of tested learning technologies with different research methods based on TAM thus trying to shed more light on this important topic. The main findings are discussed and a summary of identified gaps in current work along with future research perspectives is presented. A majority of authors attempt to prove TAM to be a strong model for predicting acceptance and usage of various kinds of learning technologies. New extensions/modifications of the Model are proposed to encompass various factors affecting decision to adopt and accept or instead to reject particular technology in the learning and teaching process.

A short summary of the main findings of this review are:

- The number of published studies that underlie research on TAM in educational context has progressively increased, starting from the 2003 and reaching the highest peak around the year 2014.

- The majority of research comes from Asia, in particular Taiwan, Malaysia, South Korea and China, followed by Europe, North America, Middle East and Africa.
- Most empirical data has been collected at universities with university students as the most commonly chosen sample group (83%). Target groups like high school students, academics/teachers and employees are potential groups in future.
- Nearly half of the identified studies (49%) have used the original TAM but with an addition of new external variables. The other half combined various extensions (38%) and modifications (13%), accordingly adding new factors to the Model.
- The Structural Equation Modelling (SEM) has been the most often used type of data analysis (55%), followed by regression analysis (21%), partial least squares (PLS) (10%), descriptive statistics (10%) and factor analysis (4%).
- The main purpose of research models based on TAM or TAM++ has been to increase the predictive validity of TAM in educational domain.
- The main findings revealed that TAM is a leading scientific paradigm and credible model for facilitating assessment of diverse technological deployments in educational context.
- In general, TAM's core variables, perceived ease of use and perceived usefulness, have been proven to be antecedent factors that have affected acceptance of learning with technology.
- In particular, perceived usefulness has been the strongest determinant for the adoption of various learning technologies. Besides, usefulness and ease of use perceived by learners increase satisfaction in learning, while usefulness and satisfaction in learning create a positive intention to use.
- Most of the studies have declared generalizability of results as a major shortcoming. Other common limitations are related to rather short period of time in which the research was conducted as well as to a few new variables incorporated in the research model. Here, there is a potential field for further research.

This review offers critical overview of the current state of research efforts on TAM acceptance studies in learning and teaching domain thus adding to the body of knowledge. To the authors' knowledge, this is the first systematic literature review specific to TAM and its different versions in educational contexts for a variety of learning domains, learning technologies and types of users.

Statements on open data, ethics and conflict of interest

The data of the systematic review consist of articles published in journals and conferences. Many of these are freely available online, others can be accessed for a fee or through subscription.

No ethics review was required to undertake this literature review. The study did not involve human research participants.

The authors declare no conflicts of interest.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.