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Editorial to the special section—Technology acceptance models: What we know and what we (still) do not know

Introduction

The rapid technological advancements and the digitalization in almost all areas of our lives, including education, have turned the attention of researchers to the factors that explain a person's technology acceptance. This attention resulted in several theoretical models that describe both the behavioral intention and the use of technologies, such as the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT). Over the last three decades, the body of empirical research on these models has increased, yet abounded in contradictory findings, in particular on the generalizability and comparability of these models (Nistor, 2014; Scherer, Siddiq, & Tondeur, 2019). Some reasons for the divergent findings may lie in the cultural specificity of the factors hypothesized to explain technology acceptance and adoption, the validity of measures used to represent them and the specificity to certain technologies (Marangunić & Granić, 2015; Scherer & Teo, 2019). Given the enormous influence TAMs have and will have on the design and distribution of almost any technology in education, including learning analytics tools and collaborative environments, it is critical to bring to attention the current issues and challenges surrounding them in order to identify future needs and research directions. These goals lie in the heart of this special section—it highlights persistent findings on technology acceptance across samples, domains, technologies, countries and other contexts, identifies commonalities in and differences between TAMs and reviews the contributions of these models to teaching and learning. Specifically, the authors present empirical studies and theoretical reviews in order to (a) classify and extend the set of constructs and models of technology acceptance, (b) classify and extend samples of students and teachers, (c) explain contrary findings and (d) review overarching issues in TAMs and research (see Table 1).

Contributions of the articles

Classifying and extending the set of constructs and models

The first set of papers presents several empirical studies and one review is aimed at organizing the constructs and extending the models describing technology acceptance. In the extant literature, some core variables were identified that explain variation in the usage of intentions and technology use. In the TAM, these variables are perceived usefulness, perceived ease of use and attitudes toward technology (Scherer *et al.*, 2019). In later versions of this model, external variables were added to further explain the variation in perceived usefulness and ease of use (Marangunić & Granić, 2015). These extensions describe technology acceptance as a complex process that is influenced not only by individual attitudes and perceptions but also by contextual and situational features, such as the facilitating conditions, subjective norms and technological complexity (Abdullah & Ward, 2016). However, labeled and organized differently, these variables are also contained in the UTAUT and are assumed to explain usage intentions directly (Venkatesh, Thong, & Xu, 2016).

Categorizing the list of explanatory variables, Kemp, Palmer, and Strelan (2019) distinguished between the primary categories of attitude and effect, social factors, usefulness and visibility, perceived behavioral control, instructional attributes, cognitive engagement and social attributes. This framework provides a taxonomy of technology acceptance constructs that supports the

Table 1: Overview of the articles presented in this special section

Article	Study type	Model	Sample(s)	Technology	Key contribution(s)
Organizing and extending the set of constructs and models of technology acceptance					
Kemp *et al.* (2019)	Theoretical review	TAM, UTAUT, & others	Higher education students and teachers	Educational technology in general	• Developing a taxonomy of constructs and measures of technology acceptance variables
Eraslan Yalcin and Kutlu (2019)	Primary study	TAM	University students	Learning management system	• Extending the TAM by user interface design as an external variable • Identifying student subsamples based on technology experience
Sánchez-Prieto *et al.* (2019)	Primary study	TAM	Pre-service teachers	Mobile devices	• Extending the TAM by emotional attachment and resistant to change as external variables
Lemay *et al.* (2019)	Primary study	TAM	College students	Social media	• Extending the TAM by political engagement and beliefs as external variables • Illustrating the situated nature of technology acceptance
Extending and classifying student and teacher samples					
Garone *et al.* (2019)	Primary study	UTAUT	University teachers	Learning management system	• Identifying teacher subsamples based on their technology acceptance through data mining • Extending the UTAUT by social influence policy as an external variable
Martín-García *et al.* (2019)	Primary study	TAM	University teachers	Blended learning technology in general	• Identifying teacher subsamples based on their technology acceptance through data mining
Ursavaş *et al.* (2019)	Primary study	TAM	Pre- and in-service teachers	Information and communication technology	• Examining the role of SN in the TAM • Differentiating between pre- and in-service teachers and testing for measurement invariance
Yuen *et al.* (2019)	Primary study	TAM, UTAUT, & others	Secondary school students	Learning management system	• Examining growth and stability of technology beliefs and usage over time • Students' satisfaction with the system and their learning as outcome variables

Table 1: Continued

Article	*Study type*	*Model*	*Sample(s)*	*Technology*	*Key contribution(s)*
Explaining contrary findings in technology acceptance research					
Liu *et al.* (2019)	Primary study	TAM	College teachers	Educational technology in language teaching	• Differentiating between student- and teacher-centered technology use • Identifying possible moderators of the intention-usage relation (TPACK, FC, and experience)
Nistor *et al.* (2019)	Primary study	TAM, UTAUT, & others	University students	Learning management system	• Extending technology acceptance models by attitude strength • Indirect effects of attitude strength on usage intentions via expectancies
Overarching perspectives on technology acceptance models and research					
Granić and Marangunić (2019)	Systematic review	TAM	Student and teacher samples	Educational technology in general	• Providing empirical evidence for the predictive validity within the TAM • Supporting the dominance of the TAM in educational technology research

Abbreviations: FC = facilitating conditions, SN = subjective norms, TAM = technology acceptance model, TPACK = technological pedagogical content knowledge (framework), UTAUT = unified theory of acceptance and use of technology.

development of assessments and ultimately the crafting of validity arguments of their underlying constructs. Eraslan Yalcin and Kutlu (2019) extended the list of external variables in the TAM by a measure of the interface design of a learning management system (LMS). Collecting the data from university students with different technology experiences, the authors showed that the interface design—a design feature that determines the complexity of an LMS—explained variation in both perceived usefulness and ease of use over and above subjective norms and computer self-efficacy. Sánchez-Prieto, Huang, Olmos-Migueláñez, García-Peñalvo, and Teo (2019) studied preservice teachers' acceptance of mobile devices and extended the external variables in the TAM by the emotional attachment to mobile devices and the resistance to change. Performing structural equation modeling, the authors found that the resistance to change explained variation in almost all relevant TAM variables, while emotional attachment only explained variation in the perceived ease of use. Finally, Lemay, Doleck, and Bazelais (2019) connected college students' social media to use their political beliefs and engagement and emphasizing the situated nature of technology acceptance.

Extending and classifying samples

The second set of papers presents empirical studies of technology acceptance that extended or classified samples of students and teachers. Garone *et al.* (2019) identified subsamples of university teachers on the basis of their LMS acceptance. Their cluster analysis revealed three groups of teachers, each of which indicated different needs for professional development. Similarly, Martín-García, Martínez Abad, and Reyes-González (2019) showed how data mining procedures, such as decision trees and cluster analysis, can be utilized to identify subsamples of university teachers that would have otherwise been unobservable. In contrast, Ursavaş, Yalçın, and Bakır (2019) distinguished between directly observable groups of pre and inservice teachers. The authors highlighted the role of subjective norms in both subsamples and brought to attention that any comparison of technology acceptance measures across subsamples requires the testing of measurement invariance—a testing procedure needed to ensure meaningful group comparisons (eg, Sass & Schmitt, 2013). Finally, Yuen, Cheng, and Chan (2019) extended their study of secondary school students' LMS acceptance by a longitudinal component. This extension allowed them to examine the growth and stability of technology beliefs and usage over time.

Explaining contrary findings in technology acceptance research

The third set of papers presents empirical studies that were aimed at explaining some of the contradictory findings in the technology acceptance research. Liu, Wang, and Koehler (2019) addressed probably one of the most discussed findings, that is, the oftentimes missing link between usage intentions and technology use. Differentiating between student- and teacher-centered usages of educational technology, the authors provided one possible explanation and further extended it by considering technological pedagogical content knowledge, facilitating conditions and experience with technology as moderating factors. Nistor, Stanciu, Lerche, and Kiel (2019) proposed attitude strength as a relevant technology acceptance variable and showed that indirect effects of attitude strength on usage intentions existed via different types of expectancies. The latter explained the missing intention-use link in their study.

Overarching perspectives on technology acceptance models and research

Finally, Granić and Marangunić (2019) took some overarching perspectives on TAMs and research and reviewed the state-of-the-art in education. Their systematic review revealed that the TAM dominated the research on technology acceptance and most empirical studies focused on the original TAM, yet not its extensions by external variables. Moreover, the core variables,

perceived usefulness and ease of use, were consistent predictors of usage intentions or technology use. At the same time, the authors pointed to the lack of testing the generalizability of the TAM across study contexts as a major shortcoming in this research area.

Conclusions and future research directions

Overall, the primary studies and reviews in this special section illustrate both the commonalities and the diversity in studies of technology acceptance. Several empirical findings pervade the current research landscape:

- TAMs, such as the TAM and UTAUT, represent hypotheses about the process, the determinants and outcomes of technology acceptance.
- Technology acceptance outcome variables are mainly represented by students' and teachers' usage intentions and reported use; yet, several other variables are gaining attention (eg, satisfaction with the technology or the learning outcomes).
- In all technology acceptance studies, students' and teachers' perceptions of the usefulness and ease of use, along with their attitudes toward technology are key explanatory variables.
- External variables, such as subjective norms, facilitating conditions, technology features and technology self-efficacy show mainly indirect effects on usage intentions and technology use via perceptions and attitudes.
- The relations among the variables describing technology acceptance seem to be robust across student and teacher samples, types of technology and acceptance models.

At the same time, the papers in this special section highlighted some unknowns and ultimately pointed to future directions in technology acceptance research:

- Cultural comparisons of the relations among technology acceptance variables are hardly conducted and their prerequisites (ie, measurement and structural invariance) are rarely examined. Testing the latter is critically important to interpret possible cultural differences or similarities meaningfully.
- Measures of technology acceptance variables are largely based on self-reports. This represents a possible threat to the validity of their interpretation. Consequently, improving these measures by, for instance, including objective measures of technology use, administering performance assessments of digital competences rather than assessments of competence beliefs (ie, self-efficacy or self-concept) and combining different types of data (eg, observational data, log file data obtained from technologies such as LMS and self-reports) should become a key goal for future technology acceptance research.
- Some of the papers pointed to extending TAMs by further variables. In addition to the extensions proposed in these papers, the perspective of trust in and trustworthiness of technology has hardly been taken. Besides, only now, some researchers integrate variables of teachers' professional knowledge into the existing acceptance models (eg, Hsu, 2016). We realize that even more perspectives could be taken and we encourage researchers in the field to explore possible extensions of these models in order to improve their prediction of usage intentions and technology use.
- The stability and changes of technology acceptance variables and their relations, along with the invariance of the corresponding measures over time requires further research. In this context, intervention studies with pretest–posttest experimental designs could shed light on whether some of these variables are malleable.
- Finally, the search for variables explaining between study variation in technology acceptance variables and their relations (eg, the missing intention-use link) continues.

The scope and diversity of the papers in this special section are innovative and forward-looking by providing a clear and sound rationale for continuing research in technology acceptance. Moving on, the editors encourage all authors and readers to recognize and exploit the immense possibilities in research disciplines in which technology acceptance is less often associated, with an aim to deepen its impact and extend its influence on the study of phenomena hitherto unreported in the literature.

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