Is the Technology Acceptance Model just old wine in new wineskins? Exploring issues for further model development.

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For about three decades, the Technology Acceptance Model (TAM) has been a crucial source of information for understanding the factors and processes that influence the integration of technology. The TAM has been extensively studied in various educational settings, involving students and teachers across different academic levels and specific technologies. The diverse range of applications has generated a vast body of evidence affirming the model's relevance in education. However, despite its success, the research on the TAM still has some unresolved issues and limitations. In this commentary, I address these existing concerns and describe further areas for improvement, including the model itself, the measurement of TAM constructs, and existing gaps and conflicting findings in the current body of evidence. By shedding light on these issues, I hope to guide future research endeavours that build upon and refine the TAM.

Keywords

Technology acceptance, educational measurement, technology usage, intentions-use link, path model, heterogeneity

Citation

Practitioner Notes

1. Technology acceptance encompasses a multifaceted process that goes beyond the mere provision of digital tools and resources.
2. The Technology Acceptance Model (TAM) is a flexible framework that delineates the factors and mechanisms influencing the adoption and intentions to use technology in educational settings.
3. The TAM holds the potential to describe and elucidate the integration of current and upcoming technologies, including generative artificial intelligence.
4. Future research on the TAM should prioritize the generation of longitudinal and causal evidence to substantiate the hypothesized relations within the model.
5. Future research on the TAM should explore model extensions that incorporate relevant constructs, utilize fine-grained measures, and investigate heterogeneity within the context of technology acceptance.

Introduction

The adoption of digital tools and resources for teaching and learning has been a significant area of interest for educational researchers, with a multitude of theoretical models and empirical evidence describing the underlying processes. However, one model has stood out and maintained its dominance in this research arena for over three decades (Granić, 2022). This model is referred to as the "Technology Acceptance Model (TAM)".

The TAM was developed by Fred D. Davis, Jr. in 1985 and proposes a framework of direct and indirect effects that explain technology usage or intentions to use technology (Davis, 1986). These effects establish connections between external variables, technology acceptance, and acceptance outcomes, as depicted in Figure 1. Specifically, the model suggests that the extent to which individuals use technology, whether for instructional purposes or in other contexts unrelated to teaching and learning, is primarily influenced by their intentions to use technology (BI). However, it is important to note that this relationship between acceptance outcomes is not deterministic, as individuals who intend to use technology do not necessarily translate those intentions into actual usage in all circumstances. Some variations of the TAM only include either usage or intentions as outcomes (Granić & Marangunić, 2019).

The primary objective of empirical studies employing the TAM is to elucidate the variation in technology usage or usage intentions among students or teachers. Building on the Fishbein's Theory of Reasoned Action (Fishbein & Ajzen, 1975), the TAM posits various factors and processes that connect these variables. Specifically, the model suggests that a person's attitudes towards technology (ATT) and their perception of its usefulness (PU) directly influence their intentions to use technology. Additionally, the individual's perception of how easy it is to use technology for a specific purpose (PEOU) indirectly affects their behavioural intentions through their attitudes and perceived usefulness. These three acceptance variables serve as the core components of the TAM, representing an individual's beliefs and user motivation in relation to technology (Scherer & Teo, 2019). In other words, they capture the cognitive and affective responses that individuals have towards technology (Davis, 1986).

The TAM includes a set of "external variables", which are exogenous factors that encompass the conditions, complexities, and additional beliefs associated with technology usage (e.g., King & He, 2006; Schepers & Wetzels, 2007; Teo, 2014). These external variables are diverse, often encompassing students or teachers' perceptions of subjective norms (SN), the facilitating conditions at school (FC), their self-efficacy in technology use (Granić & Marangunić, 2019; Scherer et al., 2019). TAM variants may also integrate additional variables, such as technology complexity (e.g., Teo, 2009b), or specify distinct forms of self-efficacy, such as teachers' self-efficacy in their Technological Pedagogical and Content Knowledge (e.g., Joo et al., 2018). Kemp et al. (2019) synthesised these variables into several categories, illustrating their diversity. These categories include but are not limited to: attitudes, effect, and motivation, social factors, instructional attributes, perceived behaviour control, cognitive engagement, and system attributes.

In the TAM, external variables are posited to have a direct relationship with perceived usefulness and ease of use, but only an indirect connection with acceptance outcomes through the acceptance variables. Although not consistently addressed in many studies, external variables extend beyond technological design features and are assumed to be correlated rather than independent of each other (Scherer et al., 2019).

In summary, the TAM serves as a model illustrating the process of technology acceptance and proposes direct and indirect effects of external and acceptance variables on acceptance outcomes.

Figure 1

A path model describing technology acceptance.
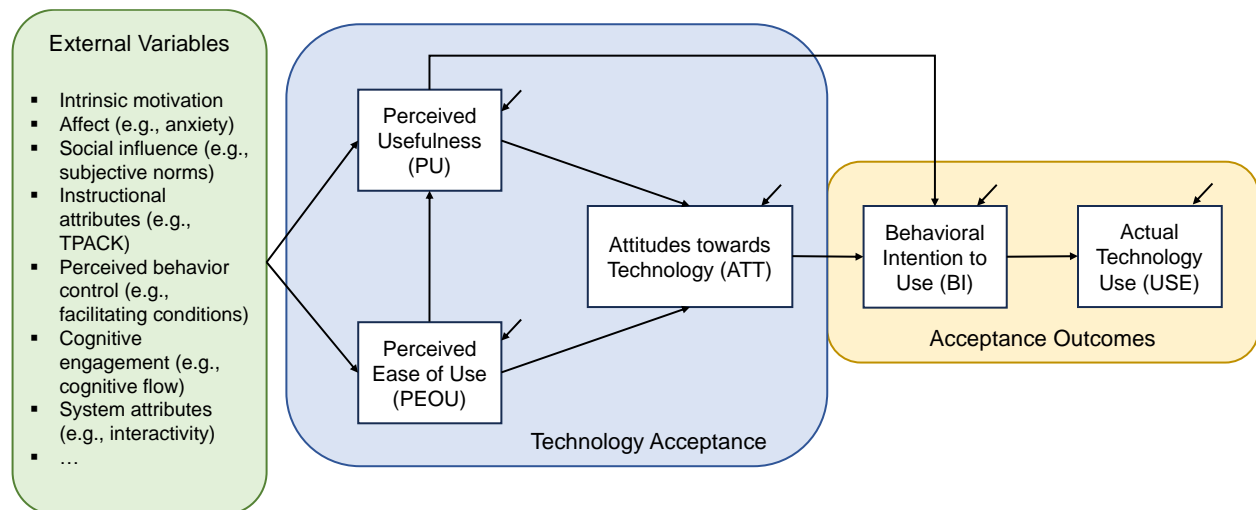
Note. The arrows at the endogenous variables represent the respective residual variances. The curved double arrow of the exogenous variables represents their variances. External variables may also covary. TPACK = Technological and Pedagogical Content Knowledge.

Despite the numerous applications and extensions of the TAM, several unresolved issues and questions continue to remain, while certain findings exhibit varying degrees of consistency within the existing body of research. In this commentary, I aim to underscore these unresolved issues, questions, and findings, concentrating specifically on the TAM in educational settings. The focus will be on three main aspects: (a) the setup of the TAM as a conceptual model representing a theory of technology acceptance, (b) the measurement of TAM constructs, particularly the acceptance and acceptance outcome variables, and (c) the diversity of findings from TAM studies. My objective is to emphasise several potential avenues for future TAM studies.

The Model's Setup

As depicted earlier (see Figure 1), the TAM comprises constructs that largely fall into categories of acceptance outcomes (BI and USE), technology acceptance (PEOU, PU, and ATT), and external variables. The TAM proposes a sequential linkage between these groups, with external variables influencing technology acceptance, which in turn affects acceptance outcomes (Davis, 1986). This proposition is largely based on a specific selection of TAM constructs and assumes linear relationships without interactions.

TAM constructs

While numerous studies have supported the general configuration of the TAM, there is some variation in the selection and definition of the TAM constructs. For instance, some studies include behavioural intentions to use technology as an outcome, while others do not (Granić & Marangunić, 2019; Scherer et al., 2019). Additionally, the set of external variables has been expanded in certain studies to encompass perceptions of technology complexity among students or teachers (e.g., Teo, 2009b). Furthermore, researchers have explored the incorporation of additional external variables such as personality traits (Maican et al., 2019), technology-related anxiety (Abdullah & Ward, 2016), personal innovativeness (Mazman Akar, 2019), cultural orientation (Jan et al., 2022), or self-efficacy in teachers' technological and pedagogical content knowledge (TPACK; Joo et al., 2018). As noted earlier, Kemp et al. (2019) list categories of such variables, largely extending their range.

The potential for theory-driven expansions of the TAM with other relevant variables renders this model highly adaptable, allowing researchers to include novel constructs, test novel hypotheses, and perhaps even enhance the explained variance in the endogenous TAM constructs. While there is potential for expanding the TAM by incorporating additional constructs, it is vital to consider the balance between inclusivity and maintaining distinct and non-overlapping constructs. For instance, TPACK self-efficacy, technological self-efficacy (TSE), and the perceived ease of using technology for teaching and learning (PEOU) all pertain to teachers' belief systems regarding their capabilities and competences in utilising technology (Scherer et al., 2015). Consequently, these constructs may not only exhibit strong positive correlations but may also have overlapping meanings and conceptualisations, potentially obscuring their specific roles and effects within the TAM. Thus, researchers must exercise caution to ensure that new constructs enhance rather than detract from the clarity and specificity of the TAM's underlying theoretical framework.

Relations among the TAM constructs

The TAM connects the respective constructs via direct and indirect effects. Some of these effects may or may not exist (Scherer et al., 2019), as I will also address in a subsequent section. This variability can be attributed to several factors, three of which I will emphasise.

Firstly, the effects within the TAM may be influenced by other variables that stratify student or teacher samples, such as age, gender, experience, or other sample characteristics. As a result, predictors within the TAM may interact with these characteristics, potentially yielding non-linear effects within the model. The recognition of such interactions and the understanding that certain relationships among TAM constructs may vary across sub-samples have informed the development of the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2016) and extensions of the TAM (Bervell & Umar, 2017).

Secondly, it is important to consider the potential interactions among TAM constructs. For example, the influence of subjective norms on perceived usefulness and ease of use may depend on individuals' perception of their competency in using technology (i.e., self-efficacy). Self-beliefs can act as a lens through which external conditions or educational settings are perceived (e.g., Zhao & Qin, 2021). Therefore, I suggest exploring possible interactions among TAM constructs that serve as predictors to gain a deeper understanding of the complex relationships involved. This approach could provide further insights into how these constructs interact and influence technology acceptance and acceptance outcomes.

Thirdly, it is worth noting that TAM constructs can exhibit substantial correlations, and there can be conceptual overlap between certain technology acceptance and external variables. This observation raises questions about their empirical distinctiveness. In a meta-analysis conducted by Scherer et al. (2020), the authors explored the factor structure of TAM constructs including PU, PEOU, ATT, SN, TSE, and FC, and found evidence for a single underlying factor rather than multiple distinct factors. The authors took both a confirmatory and an exploratory approach to factor analysis and tested several assumptions on the number of factors and the structure underlying the TAM variables. In this study, external and acceptance variables were represented by a reflective latent variable that captured the variation and covariance among these TAM constructs (see Figure 2). This reflective latent variable was found to be significantly and positively associated with intentions to use technology (BI) and actual usage (USE) across more than 100 studies involving 37,211 pre- and in-service teachers. However, the link between BI and USE became insignificant, as compared to previous analyses of the same data in which the original TAM setup had been used (Scherer et al., 2019). This example demonstrates how the representation of constructs within the TAM can impact the presence or absence of effects in the model.

Figure 2

A modified version of a TAM in which technology acceptance and external variables are represented by a reflective general factor (gF), proposed by Scherer et al. (2020).
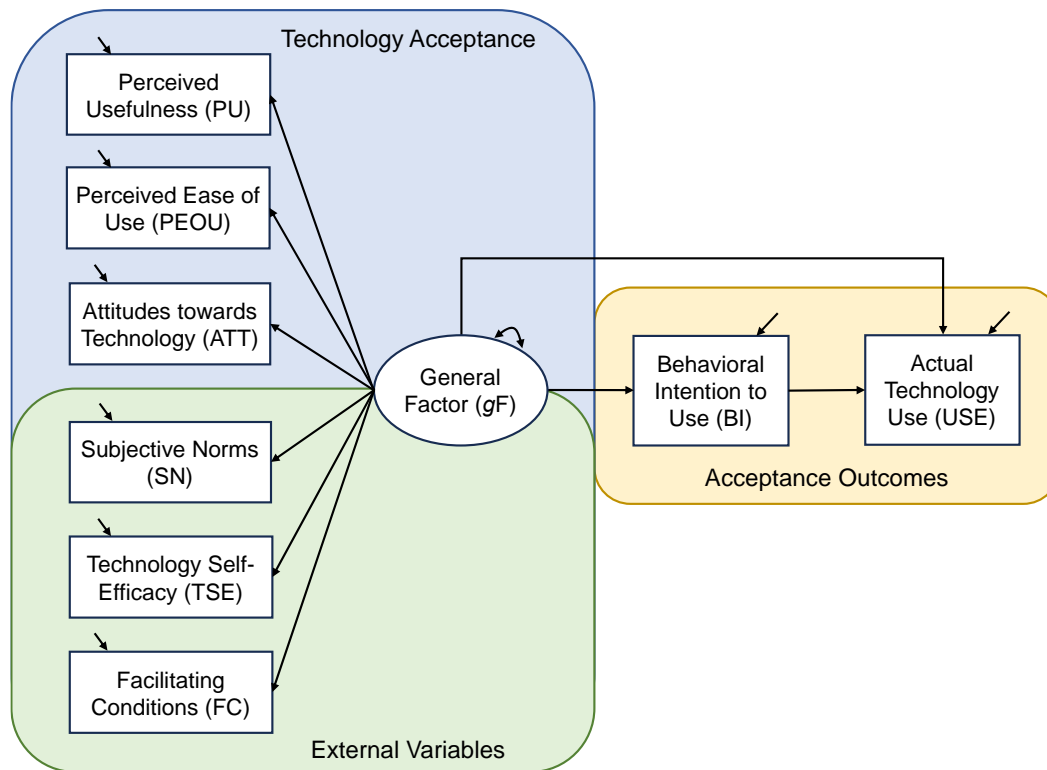
Note. The arrows at the endogenous variables represent the respective residual variances. The curved double arrow of the exogenous variables represents their variances.

The Measurement Perspective

To ensure robust inferences from TAM studies, it is imperative that the assessments of the TAM constructs are based on reliable measures and supported by valid evidence (Davis & Venkatesh, 1996; Scherer & Teo, 2019; Teo, 2011). This necessitates a psychometric evaluation of the TAM measures and a conceptual review of their underlying meaning (AERA et al., 2014; Sireci, 1998). In this section, I advocate for TAM researchers to consider three critical aspects during such evaluations: the limitations of self-report measures, the multidimensional nature of TAM constructs, and the appropriate level of analysis.

Self-reports

In most TAM studies, researchers commonly employ questionnaires to assess the TAM constructs. These questionnaires typically consist of scales composed of multiple items, which ultimately capture respondents' self-reports. However, it is essential for TAM researchers to recognise the limitations associated with these self-reports.

In particular, the TAM incorporates students' or teachers' use of digital technology as a crucial outcome variable. This variable is commonly evaluated through respondents' self-reports, which capture information on usage frequency, purposes, or behavior. However, numerous studies have revealed that self-reports of usage often lack accuracy, for instance, due to respondents' over- or under-reporting, socially desirable responses, retrospective responding, or simply guessing

(Araujo et al., 2017). This bias can potentially result in inconsistent responses, such as instances where respondents claim to have a low frequency of using digital devices in general but admit to using their smartphones almost every hour for checking social media. Furthermore, it can also contribute to dominant response styles, such as respondents consistently reporting a high frequency of digital device use for educational purposes while consistently reporting a lower frequency of use for leisure activities within a school setting.

Recent methodological advancements have introduced various approaches to address these forms of response bias, including the use of anchoring vignettes alongside self-reports (e.g., Hopkins & King, 2010), statistical methods to identify inconsistent responding such as mixture modelling (e.g., Jin et al., 2017), and alternative assessments like monitoring students' or teachers' actual technology use with digital devices over a specific time period (e.g., Andrews et al., 2015). From my perspective, TAM researchers should consider adopting some of these approaches to enhance and ensure a more precise representation of technology use as an acceptance outcome.

Multidimensionality

TAM constructs are frequently evaluated using scales consisting of 3-7 items (e.g., Teo, 2009b), and existing research suggests that many of these scales demonstrate satisfactory reliability. Additionally, there is some evidence supporting the validity of the inferences drawn from them. (e.g., Scherer & Teo, 2019). While short-scale assessments offer certain advantages, they may not comprehensively represent the TAM constructs. This is particularly pertinent as TAM constructs are inherently complex, encompassing a student's or teacher's attitudes, beliefs, perceptions, and reported behavior. For instance, consider the case of teachers' self-efficacy in using technology (TSE; see Figure 1). Self-efficacy beliefs are context-dependent (Thommen et al., 2022), and a teacher who exhibits high self-efficacy in using digital resources for creating teaching and learning material may, at the same time, have lower confidence in using a programming language to teach physics. Notably, self-efficacy refers to a person's beliefs about what he or she can do with their skills—hence, it is also person-specific (Bandura, 1997). In the context of technology acceptance, TSE can be seen as a multidimensional construct rather than a unidimensional one, as exemplified by Ulfert-Blank and Schmidt (2022). For instance, in a secondary analysis of the International Computer and Information Literacy Study (ICILS) 2013, Scherer and Siddiq (2015) discovered that the measure of teachers' technology self-efficacy consisted of three distinct factors rather than just one. These factors encompassed confidence in basic technological skills, advanced skills, and the skills required to use technology for instructional purposes. In this case, these three dimensions of TSE exhibited moderate correlations, indicating a conceptual distinction between them. In another secondary analysis of the ICILS 2013 data, Scherer et al. (2015) also observed that teachers' perceptions of the usefulness of technology (PU) were composed of multiple factors, including perceived usefulness in fostering interest and learning, collaboration and communication, and information retrieval, as well as perceiving ICT as causing problems and creating obstacles in teaching and learning.

Within the existing literature, numerous examples demonstrate that assessments of TAM constructs are often multidimensional and consist of multiple aspects. This evidence provides researchers with valuable opportunities to gain a more nuanced understanding of the technology

acceptance processes. However, such evidence should always be interpreted in light of the content, design, and focus of the survey questions that are used to assess the TAM constructs. Capturing respondents' intended reactions on these questions requires carefully designed, clearly written, and construct relevant survey questions.

Analytical levels

An additional aspect regarding the accurate representation of TAM constructs involves selecting the appropriate level of analysis. For instance, In many TAM studies, teachers within a school are asked to rate the extent to which they perceive the conditions in their school as supportive of using technology for teaching and learning (Scherer et al., 2019; Straub, 2009; Teo, 2009b). Although teachers' responses reflect their individual perceptions of these facilitating conditions (FC), they may not necessarily represent the actual conditions within the school. It is possible for two teachers in the same school to perceive these conditions differently, implying that individual teachers' responses may not be representative of the specific school's conditions. However, if multiple teachers within the same school are surveyed, their average ratings of the school conditions can be considered "climate" variables, as described by Marsh et al. (2012). These average ratings can depict the facilitating conditions within the school, particularly when there is consensus among teachers in the same school regarding their ratings.

In the TAM, facilitating conditions are considered external variables that operate at the same analytical level as, for example, technological self-efficacy or subjective norms (see Figure 1). These conditions are specified at the student or teacher level, rather than at the classroom, school, or other aggregate levels, where they represent climate variables. In general, the TAM is designed to capture individual perceptions of several constructs and describe the relations among them. However, if TAM researchers wish to make inferences beyond such individual perceptions, they are advised to carefully select and clarify the level at which facilitating conditions operate, and subsequently determine the meaning assigned to these constructs—whether individual or shared perceptions. Depending on this choice, researchers may consider using multilevel modelling or cluster-robust estimation approaches to test the TAM (Park et al., 2005; Snijders & Bosker, 2012).

The Existing Evidence

Despite the extensive body of TAM research, there remains a compelling need for further substantiation of the model. To achieve this, TAM researchers should delve into uncovering and understanding unexpected findings within the TAM, as well as explore the diverse effects that may exist. Furthermore, there is a call for additional evidence to back the causal claims of the TAM, along with a need for insights into the development of the TAM constructs and their interrelationships over time. Such focused investigations will enrich the TAM and ensure its continued relevance in technology acceptance research.

Heterogeneity in the TAM relations

The TAM has found numerous applications in the field of education, yet the evidence regarding the relationships within the model exhibits some degree of variation. While the general framework of the TAM is applicable across many studies, the specific relationships within the model often differ among them. For instance, the TAM posits a positive and significant link between a person's intentions to use technology (BI) and their actual technology usage (USE). The assumption underlying this link is that students or teachers who have the intention to use digital tools and resources for teaching and learning are more likely to do so. However, the evidence supporting this link indicates that the strength of the BI-USE relationship exhibits variability across different research studies and within different educational settings (Scherer et al., 2019). In fact, some TAM studies have found no significant link at all (Nistor, 2014; Scherer et al., 2020). Another finding concerns the role students' and teachers' attitudes (ATT) play. Specifically, some TAM studies found only found an indirect effect of ATT on technology use (USE) via behavioural intentions, while other studies had evidence on an additional direct effect (Scherer et al., 2019). Nistor et al. (2019) questioned the positioning of ATT within technology acceptance models and suggested utilising them as predictors of perceived usefulness (PU), rather than outcomes. One potential explanation for this finding may be statistical, that is, ATT may not explain variation in intentions to use technology beyond PU and PEOU due to its relations to these two variables. However, as others have stated, the role of ATT and the necessity to include it in the TAM are still to be clarified (e.g., Nistor & Heymann, 2010; Teo, 2009a).

This heterogeneity in the evidence might be attributed to several factors, such as variations in the analysis and modelling approaches used by TAM researchers, differences in study designs, or the diverse characteristics of the samples under investigation (Scherer et al., 2019). Some of these potential causes could be directly examined, for instance, by investigating the impact of sample characteristics on the relationships within the TAM (e.g., Teo et al., 2015; Xue et al., 2024). However, other underlying factors may be unobserved or unexplored (Howard et al., 2021). TAM researchers should explore the heterogeneity in the data from TAM studies to identify groups or profiles of students or teachers to whom the TAM may or may not apply. This exploration could yield nuanced insights into the potential differential processes of technology acceptance, offering suggestions for tailored interventions. Furthermore, incorporating an analysis of heterogeneity as part of research syntheses (e.g., meta-analyses, integrative data analyses) may provide valuable insights into the impact of study designs and measurement decisions across TAM studies.

Causal and longitudinal evidence

The TAM represents a theory of the processes underlying technology acceptance, with some causal assumptions underlying the relations (Davis, 1986). However, it is important to recognise that these causal assumptions, like any path model, are probabilistic rather than deterministic, indicating to what extent TAM constructs account for variation in others (Kline, 2016). The degree of causality within the TAM greatly depends on the researchers' substantive knowledge of the field and the data-generating process, as emphasised by Bollen and Pearl (2013). To enhance the support for causal inferences, TAM researchers may also consider conducting experimental studies wherein selected TAM constructs are manipulated.
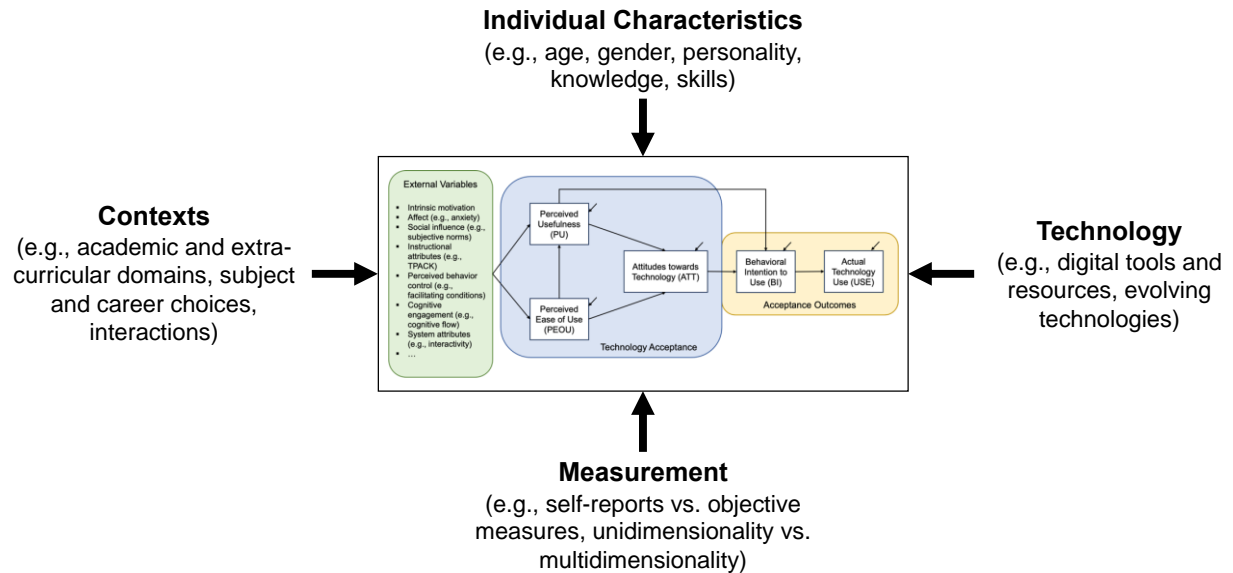
In addition to the necessity for causal evidence on the TAM, there is also a demand for longitudinal evidence (Venkatesh & Davis, 2000). In my review of the existing literature, there is a remarkable scarcity of longitudinal investigations into the development of the TAM constructs and their interactions over time. This represents a missed opportunity, because such evidence could shed light on the possible sequence of effects within the TAM, the changes in TAM constructs within and between persons over time, and the possible cross-lagged effects and predictions. Moreover, longitudinal studies would offer a more comprehensive understanding of the hypothesised, causal processes in the TAM.

Conclusion

From my perspective, the issues raised in this commentary highlight the robustness and applicability of the TAM across a wide range of educational settings. It stands to reason that this model could also provide insights into the adoption of future technologies that have yet to be developed. At the same time, it is crucial to continuously update and further develop the TAM, while also ensuring the replication and synthesis of relevant evidence. In my view, the TAM stands as a dynamic model that integrates contextual, individual, technological, and measurement-related factors, tailoring them to the unique contexts where technology acceptance is examined, and expanding their scope (see Figure 3).

Figure 3

Extending the TAM by incorporating contextual and individual characteristics, refining measurement methodologies, and accounting for diverse technological attributes.

Individual Characteristics
(e.g., age, gender, personality, knowledge, skills)

Contexts
(e.g., academic and extra-curricular domains, subject and career choices, interactions)

Technology
(e.g., digital tools and resources, evolving technologies)

Measurement
(e.g., self-reports vs. objective measures, unidimensionality vs. multidimensionality)

Specifically, I argue that TAM researchers must always consider the specific context in which technology acceptance is being studied. This pertains not only to the specificity of the measures assessing the TAM constructs but also the selection of external variables, which may vary across different contexts. To demonstrate the widespread applicability of TAM findings, it is essential to systematically monitor and synthesise the evidence regarding the relationships among TAM constructs in both curricular and extra-curricular settings, across student and teacher samples, for different digital tools and resources, and with various study designs (see Figure 3). Expanding the individual characteristics encompassed within the TAM and exploring their potential moderating roles is an integral aspect of advancing the model further.

In addition to the contextual, individual, and technological perspectives, the measurement aspect of the TAM is also important (see Figure 3). I argue that researchers should make every effort to accurately represent the TAM constructs by acknowledging their multidimensional nature, representing them at the appropriate analytical level, and recognising the limitations of self-reports. Lastly, to advance the TAM research field, it is crucial to provide explanations for the heterogeneity of findings within the TAM, as well as employ study designs that enable researchers to establish causal inferences and analyse the progression of technology acceptance over time.

Conflict of Interest

Acknowledgement

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