Using Technology Adoption Theories to Maximize the Uptake of E-learning in Medical Education

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Abstract

Introduction While the use of e-learning tools in medical education is guided by robust literature on their design and evaluation, there is sparse literature on strategies that maximize their adoption among trainees.

Methods In this scoping review, we searched Web of Science for studies on technology adoption theories as applied to education, using a final censoring date of August 1, 2021.

Results Based on our findings, we identified three representative theories: (1) technology acceptance model, (2) technology adoption life cycle, and (3) domestication theory.

Discussion We describe these theories in detail, examine their prior applications, and propose specific uses within medical e-learning.

Keywords Technology · E-learning · Virtual learning · Flipped classroom

Introduction

The past decades have seen an expansion of e-learning in medical training, defined as internet-assisted learning that is generally distanced and asynchronous [1] such as computer-based teaching modules [2]. A 2015 survey of Internal Medicine residency program directors found that 72% of programs use at least one form of asynchronous e-learning [3]. E-learning has the advantages of convenience due to remote access and flexibility due to learner-set pace. It may also help bridge the digital divide in medical education by bringing high-quality content to learners in countries or regions where it is not locally available [4]. Its growing use was accelerated by the coronavirus disease-2019 (COVID-19) pandemic, as health educators introduced teleconferencing for lectures, online practice questions, electronic procedural simulation [5], virtual learning platforms [6], and telemedicine training [7] into curricula. One study found that trainees who viewed technology-assisted learning in their program favorably had fewer concerns that their training was

compromised by the pandemic [8]. Other studies conducted during the pandemic found that successful implementation of e-learning requires that educators focus on strategies to maximize learner engagement [9], minimize technical burden [10], and integrate tools conscientiously into existing learning environments [11].

There is a wealth of medical education literature on creating and evaluating e-learning tools such as video-based lectures [12] and computer-based teaching modules [13], as well as on broadly applicable design principles [2, 14, 15]. In contrast, there is little guidance on how to introduce them strategically to trainees to maximize acceptability, which is a missed opportunity as high-quality tools are helpful only if learners embrace them. The optimized uptake of technology-based tools is the subject of technology adoption theories prominent in the fields of sociotechnology and technology management [16, 17]. Although they have been applied to education, they have not been systematically studied for their applicability to medical education.

Methods

We examined well-cited review articles on technology adoption theories in the fields of sociotechnology and technology management [18–20] to generate a comprehensive list of

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Fig. 1 Literature search methodology using the Web of Science Core Collection database, with a final censoring date of August 1, 2021

theories. We searched the Web of Science Core Collection database for these theories as applied to education using the search terms detailed in Fig. 1, with a final censoring date of August 1, 2021. Based on these results, we describe three representative theories in detail and explore their potential applications to e-learning in medical education.

Results

There were 385 publications on technology acceptance models (TAMs) and education, dominated in topic by learning management systems, massive open online courses (MOOCs), and other online courses. Less well-represented were podcasts, mobile learning, and blended learning environments. The versions of the theory most studied were classic TAM and unified theory of acceptance and use of technology (UTAUT) (details below). There were four studies specific to medical education on the topics of video capture technology for competency assessment in nurse practitioner education [21], online training for teaching cervical cancer detection for a broad audience of healthcare providers [22], virtual simulation in nursing education [23], and mobile learning in nursing education [24].

There were 67 publications on the technology adoption life cycle (TALC) and education, dominated in topic by MOOCs, e-textbooks, and blended learning environments. There were two studies based in medical education, one on

the development of virtual communities in nursing education [25] and one on resources for learning anatomy on handheld electronic devices [26].

Although our search terms for the domestication theory and education yielded 32 publications, the vast majority were irrelevant due to the vagueness of the terms “domestication” and “domesticating”; however, one representative study investigated young people’s adoption of technologies in formal and informal education settings [27]. There were eight publications on the Gardner Hype Cycle and education, five on the Concerns-Based Adoption Model and education, and three on the Disruptive Innovation Theory and education.

Based on these results, we identified three representative theories: TAM and TALC due to their relatively high representation in the literature and the domestication theory due to its complementary qualitative derivation against the quantitatively derived TAM. We describe each below, and summarize their principles and potential implementation strategies in Table 1.

Technology Acceptance Models

TAMs postulate that the final acceptability of a technology is a summation of its individual groups of attributes [28]. Originating in 1989 and revised in 2000 as TAM2, its next iteration termed the “unified theory of acceptance and use of technology” (UTAUT) collapsed a large set of attributes into four independent constructs [29], which has found strong

Table 1 Technology adoption theories and their proposed applications to e-learning in medical education

Technology adoption theory	Basic tenet	Criticisms	Proposed application to e-learning in medical education	Practical questions
Technology acceptance model	The final acceptability of a technology is a summation of its individual groups of attributes, which one version of the model divides into those related to (1) performance expectancy, (2) effort expectancy, (3) social influence, and (4) facilitating conditions	Complexity over practicality, especially of later versions	Checklist of essential elements related to learner perception (design and evaluation phases of an e-learning tool)	<ol style="list-style-type: none"> 1. Are learners likely to perceive that the tool would help them excel among their peers? 2. Are learners likely to perceive that the tool would give them immediate or imminent learning advantages? 3. Are learners likely to perceive that the tool is easy to learn? 4. Are learners likely to perceive that the tool is aesthetically pleasing? 5. Are learners likely to perceive that their peers would like them to use the tool? 6. Are learners likely to perceive that they will have ready access to technical support?
Technology adoption life cycle	Potential users react to new technologies on a spectrum of early adopters to late ones, divided into (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. It is relatively easy to recruit innovators and early adopters to use new technologies but difficult to recruit the early majority	Datedness without accounting for accelerated diffusion of ideas in the present highly digitally interconnected world	Targeting learner subsets (disseminating phase)	<ol style="list-style-type: none"> 1. Which learners are innovators that may trial the tool in its first iterations and help address early issues? 2. Which learners are early adopters that may trial the tool in its early iterations and provide feedback? 3. Which learners are the early majority that would require reassurance about the tool? 4. Which learners are late adopters and laggards (and may not require direct engagement)? 5. Did I budget sufficient time to support “crossing the chasm?”
Domestication theory	Individuals adopt technologies into their daily lives and routines based on interconnected stages that include (1) appropriation (or “acquisition”), (2) objectification (or “familiarization”), (3) incorporation, and (4) conversion	Qualitative derivation without quantitatively measurable validation	Deep dive into learner habits (monitoring phase)	<ol style="list-style-type: none"> 1. How are learners obtaining the tool? 2. How are learners using and exploring its functions? 3. How are learners incorporating it into their learning routines? 4. How are learners demonstrating its use to others? 5. Why did some learners discard it? 6. Why did some learners never adopt it? 7. How can the answers to the above questions be used to improve overall adoption?

quantitative validity evidence. Although derived from studies on introducing technologies to the work environment, it has since been applied to a wide range of industries [30, 31] including education [32, 33].

The UTAUT, which has been opined to represent an appropriate balance of sophistication and simplicity for most contexts, involves four constructs: (1) *Performance expectancy* refers to the degree to which users believe a new technology will help their job function, related to two contributing attributes: (a) relative advantage — perception that it will help its user stand out among peers and competitors — and (b) job-fit — perception that its advantage will be immediate or imminent. (2) *Effort expectancy* refers to usability, an important concept in the field of user-centered systems design [34] in which it is oftentimes divided into (a) cognitive aspects — whether the technology is efficacious and easy to learn — and (b) affective aspects — whether it is enjoyable, aesthetically pleasing, or even emotionally fulfilling. (3) *Social influence* refers to the degree to which users perceive others believe they should use the technology, related to the TALC (see next section). (4) *Facilitating conditions* refers to the degree to which users believe they will have ready access to technical support [29]. While other extensions including UTAUT2 have subsequently emerged [32, 33], the field of TAM research has since been criticized for unnecessary complexity leading to limited applicability [35].

Applying Technology Acceptance Models: Essential Elements Checklist

Our literature search found that the majority of applications of TAMs used its constructs to evaluate different components of technology-assisted learning, with examples in medical education that include generic online learning [22] and mobile learning applications [24]. As such, the UTAUT may provide a useful checklist of essential elements *related to learner perceptions* to create or evaluate an e-learning tool in medical education, unrelated to its intrinsic andragogic value. It may be most applicable to the design and evaluation stages of an e-learning tool.

Case Example

An educator seeks to develop an online question bank for residents for self-study. Using the tenets of the four constructs, he advertises to residents that the question bank has content more clinically relevant than that found in commercial question banks (*performance expectancy: relative advantage*), with a complexity level appropriate to apply to routine work on the hospital wards or in the outpatient clinic (*performance expectancy: job-fit*). He works with a computer programmer to ensure that the user interface is both intuitive (*effort expectancy: cognitive*) and stylish

(*effort expectancy: affective*). He plans to recruit specific learners to trial the question bank who would provide strong word-of-mouth promotion to increase its reputation (*social influence; see next section*). He ensures that learners have actual and perceived strong technical support by providing telephone contacts to troubleshoot issues in real-time and budgeting time to update the interface frequently in response to feedback (*facilitating conditions*).

In this case, failure to apply the UTAUT would be to neglect any one of the checklist elements, such as making the user interface seamless (*effort expectancy: cognitive*). Given that learners are quick to forfeit the use of any optional learning tool, the perception that it is technically cumbersome — even if the other elements in the checklist are optimized — may impede adoption.

Technology Adoption Life Cycle

The TALC, also known as the diffusion of innovation theory, characterizes how users react to new technologies on a spectrum of early adopters to late ones [36]. It places potential users into five groups along the spectrum, with varied profiles of risk acceptance, peer influence, and response to marketing techniques [37]. In 1991, an organizational theorist bolstered the model by introducing the concept of a metaphorical “chasm” between two specific groups. He argues that the chasm is responsible for the failure of adoption of many technologies, and is therefore the junction to which developers should devote the most time and resources during the dissemination phase of a new technology [38].

The TALC divides potential users into five groups, as shown in Fig. 2. *Innovators* have high comfort with technology and high risk tolerance. They are interested in technology for its own sake, representing the easiest market. *Early adopters* (sometimes termed “enthusiasts”) are similarly

Fig. 2 Technology adoption life cycle (Adapted from Moore [38]). This model divides potential users of a new technology on a spectrum of early adopters to late ones. The “chasm” corresponds to the difficulty recruiting the “early majority” to use the technology relative to the ease with which “innovators” and “early adopters” may be recruited

comfortable with technology and have at least moderate to high risk tolerance. They consider technology a way to improve their performance among their peers. They respond readily to influence by innovators, whom they see as leaders that can scrutinize a technological product for them. The *early majority* (sometimes termed “pragmatists”) are risk adverse and suspicious of new technologies. They are immune to influence from innovators and early adopters, whom they view as impractical. Instead, they respond to marketing techniques specific to their needs. They only trust technologies that are complete, helpful but not novel for novelty’s sake, and well-accepted by others in their own group, i.e., other “pragmatists.” The tendency for the early majority to only be influenced by each other as opposed to members of the other groups makes engaging them challenging for developers. As such, “crossing the chasm” corresponds to the transition from recruiting early adopters (relatively easy) to recruiting the early majority (relatively difficult) [38]. Finally, *late adopters* require little directed marketing effort — they will adopt a new technology when it is fully accepted by the first three groups, while *laggards* may either follow suit or never adopt it [36]. Criticisms of the TALC focus on its datedness; it does not take into account the rapid and disruptive pace at which modern technologies spread in today’s highly digitally interconnected world, making traditional models of diffusion less applicable [39].

Applying the Technology Adoption Life Cycle: Targeting Learner Subsets

Our literature search found that the TALC was most frequently used for educational technologies that were considered optional, such that they rely heavily on word-of-mouth. An example is the use of mobile-based resources to learn anatomy [26], which an educator may make available to learners without mandating its use. Medical educators may use the TALC to target learner groups at different times and in distinct ways to maximize overall adoption of an e-learning tool, most relevant during its dissemination phase.

Case Example

In response to concerns that remote lectures are depersonalizing, an educator develops a web-based application that helps learners prepare for scheduled didactics using elements of the flipped classroom model [40, 41]. The application allows learners to complete multiple-choice questions on the didactic topic written by the lecturer as “prework” and to contribute to a “wiki” of notes such as mnemonic devices related to the topic. The educator makes the use of the application optional given residents’ heterogeneous schedules and

competing responsibilities, applying the TALC to maximize engagement.

The educator loosely categorizes residents into the five groups based on their comfort with technology. She first targets one or two innovators — residents who are not only comfortable with technology but also enjoy it for its own sake — and asks them to trial early prototypes and provide detailed feedback on its design. Next, she approaches a few early adopters — residents who are comfortable with technology and may view new learning tools as a means to stand out among their peers, asking them to trial the completed application and provide feedback. Next, the educator “crosses the chasm” by targeting the “early majority” — residents who are moderately comfortable with technology but simultaneously suspicious of new modes of learning, somewhat easily deterred by errors and inefficiencies. She presents the application at a residency meeting, letting residents know that it is in its near-final form, that it is helpful for consolidating knowledge, and that it weaves seamlessly into the current didactics system. She de-emphasizes its novel components, aware that the early majority are more interested in the practical rather than technologically innovative aspects of the tool. She also budgets time to make rapid revisions based on feedback. At this point, the die has been cast whether the application will be successfully adopted by the residency program. If the chasm is crossed, the remainder of residents who have little comfort with technology is likely to later adopt the application as it becomes the new “norm,” while a few may never embrace it.

Failure to apply the TALC in this case corresponds with a break in any part of the chain, in particular the “chasm.” For example, adoption may fail if the educator introduces the application too early to the majority of residents before it can garner a strong reputation among innovators and early adopters, and before early technical issues are addressed.

Domestication Theory

While the TALC focuses on groups of people, the domestication theory focuses on individuals. Originally developed by European researchers, early iterations characterized how individual households adopt new forms of media such as television sets and computers [41, 42]. Since then, it has been used to describe large-scale technological movements, such as how the social networking service Facebook became deeply integrated into the lives of college students in its early years [42] or how smartphone applications have become ubiquitous in Americans’ lives [43]. The theory differs greatly from the quantitatively derived TAM by focusing on the qualitative, social aspects of adoption including how a technology fits into a person’s routines and habits. As such, domestication studies rely heavily on qualitative methods such as interviews and direct observations [44].

The domestication theory classifies technology adoption into stages but emphasizes their non-linear and interconnected relationships [45]. These are *appropriation* — obtaining the technology, *objectification* — using it and exploring its functions, *incorporation* — placing it into daily routines — and *conversion* — displaying its use to others. Related to these stages are two additional concepts of *de-domestication* — the discarding of a technology after it had been embedded into a user's routine — and *non-use* — the rejection of a technology despite acceptance by the vast peer majority [45, 46]. The theory has been criticized for its lack of measurable empirical validation as it was derived primarily via detailed case studies, but this weakness may be germane to the qualitatively derived nature of the model [44].

Applying the Domestication Theory: Deep Dive into Learner Habits

Our literature search found that the domestication theory has not been well-utilized in education, although one relevant article did examine young people's domestication of educational technologies and “how individual learning technologies fit into wider socio-technical systems and networks [27].” Based on the origin of the theory, it may be most applicable to e-learning tools designed specifically for home use, such as commercial e-textbooks. While data analytics that monitor usage patterns of such tools may capture helpful information such as log-in frequencies or number of page visits [46], this information is actionable only when complemented by a deep dive into learners' habits, routines, and preferences during the evaluation phase of an e-learning tool.

Case Example

An educator purchases a commercial e-textbook for residents' use for home study. After the first month, she reviews the analytics data to find that less than half of the residents used the virtual textbook consistently. An electronic survey finds reasons for low use that include “not enough time,” “technical difficulties,” and “n/a.” In response, she holds short, informal interviews with resident groups. Her specific questions include how and when the program is installed onto personal laptops or other devices (*appropriation*), how learners are able to explore its functions (*objectification*), when it is used — for example the reading of a specific chapter in preparation for a scheduled didactic or hospital rotation (*incorporation*), and whether its use is influenced by peers or faculty members who recommend particularly useful content (*conversion*). She also targets specific learners to understand why some early users stopped using the tool (*de-domestication*) and why others never use it (*non-use*).

Based on these answers, she learns that residents greatly value reviewing some chapters to prepare for specific rotations and that infrequent users find the application slows at a specific loading point. In response, she creates a list of suggested chapters to review during individual rotations and provides feedback to the company regarding the technical issue.

Failure to apply the domestication theory in this case would be to assume that poor adoption is due to its lack of quality or fit with the curriculum. Poor specificity in survey answers may lead an educator to prematurely abandon an e-learning tool that would have benefited trainees.

Discussion

This scoping review identified key technology adoption theories that may have highest relevance to e-learning in medical education. Although the TAM has been better represented in the literature than the others, their application as used individually or in combination should be selected based on the appropriate contexts as described, for example the domestication theory for tools designed for home use. In addition, there are a few important nuances to their practical implementation. First, maximizing the adoption of an e-learning tool should not take precedence over evaluating its andragogic advantages or fit within a curriculum. Conversely, a frequently used e-learning tool does not guarantee its andragogic value, as learners may engage for the wrong reasons, such as to appease the educator or for entertainment. As such, educators must rigorously evaluate both the intrinsic value of an e-learning tool and its adoptability.

Second, the rigor with which these models are applied to e-learning tools should be proportional to the risk of failure of adoption. For example, tools that are offered by educators for optional use or intended solely for home use may have higher risk and therefore warrant greater attention on their acceptability. Technology adoption theories may also be more important in certain settings, for example in graduate medical education in which a higher proportion of e-learning tools are asynchronous and non-mandatory compared to in undergraduate medical education. Given the effort and expertise required from educators to apply these theories, the incorporation of basic technology adoption theories into faculty development would be an important area of future research.

Third and more broadly, when considering the use of e-learning in medical education, educators should acknowledge both the potential drawbacks of individual tools [2] and the larger-scale unintended consequences of technology-assisted learning, the latter including distraction and dependency [47] and inappropriate incorporation of technologies based solely on their novelty rather than andragogic

advantages, a concept sometimes termed “edutainment [48].”

Our work has several limitations, first that we attempted to capture a bird’s eye view of the narrow field of technology adoption theories as applied to education. Although our literature search generated a sufficient sample to characterize the field, we could have improved sampling accuracy by expanding the search to other databases such as Scopus. Second, we applied the macroscopic principles of technology adoption theories to the microscopic setting of e-learning in medical education, although we argue that the tenets of these theories translate well to our context. Finally, as germane to literature searches with imperfect search terms, we reviewed a subset of articles irrelevant to the topic that inflated the number of articles per theory, which we have addressed above.

Conclusions

E-learning tools have gained an increasingly prominent role in medical education in recent decades, a phenomenon accelerated by the COVID-19 pandemic. To maximize the acceptability of high-quality e-learning tools and afford trainees their intended andragogic benefits, modern medical educators may apply basic technology adoption theories to better engage learners in the digital age. Although this scoping review has incorporated many robust studies examining their use, further exploration of both the applications of individual theories and their combination may yield best-practice recommendations on their application to medical education.

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Availability of Data and Material Data is available upon reasonable request.

Declarations

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