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Evaluating the pedagogy of technology integrated teaching and learning: An overview

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Abstract

The advent of COVID-19 has critically changed how we perceived the process of teaching and learning today. To cope with these changes, the classroom of today is without a doubt full of technologies that makes teaching and learning more effective and exciting. Come to think of it, is it exciting? YES! Is it effective? …well, not so sure. To shed light on this, the current presentation shall focus on the understanding how practitioners are able to evaluate technology integrated education. First, a brief summary of the evolution of educational information technologies and its current types and usages shall be provided. Second, an introduction of the ADDIE and the Technological Pedagogical Content Knowledge (TPACK) model and together with its overarching influences shall be explained. Lastly, a discussion on the theoretical background and sample research studies on the various forms (and derivatives) of the Technology Acceptance Model (TAM) shall be given. In essence, no matter how far information technology advances the pedagogical design created by teachers is still more important than the technology itself. It is hoped that the current presentation can provide various exemplars for practitioners to follow and study during this crucial time of teaching and learning within a pandemic.

Keywords: learning with technology; curriculum design; educational resources; information technology; teaching and learning; pedagogy

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1. Introduction

The COVID-19 pandemic has brought forth drastic changes in our daily living (Haleem, Javaid, & Vaishya, 2020). The practice of social distancing and school closure was urgently needed to control the spread of COVID-19 (Viner et al., 2020). However, scholars noted that it is quite important not to suspend students' learning even during a pandemic (Zhang, Wang, Yang, & Wang, 2020). In effect, various technologies have come into use in helping to ease the problems caused by COVID-19 (Javaid, 2020). More important, the start of the global lockdown of educational institutions has also greatly affected how teachers *teach* and consequently how students *learn* (Burgess & Sievertsen, 2020). Hence, *online teaching* and *learning with the aid of technology* have both become the center stage of recent discussions (Bao, 2020).

Teaching with technology is a wide concept encompassing various educational technologies that are often synonymous to instructional innovations with technologies (Hooper & Rieber, 1995). More recently, this concept has evolved into the role technology played in enhancing the *teaching learning experience*, hence, the term technology enhanced learning or **TEL** (Kirkwood & Price, 2014). A parallel concept is *instructional* or *educational technology* (more commonly referred to as **EdTech**), which is the use of digital tools in enhancing teaching and learning (EdTech Commons, 2016). Kurt (2015) listed several key components within educational technology, such as: hardware (computers, projectors, camera, and many others), software (including learning management systems), the internet (World Wide Web), and their combinations as important factors in curriculum design nowadays. Furthermore, the utilization of the internet as a conduit in learning has also popularized the concept of *online learning* (Anderson & Elloumi, 2004; Anderson, 2008). More so, the recent advent of smart phones and tablets have even furthered the concept to include *electronic learning* (e-learning), *mobile learning* (m-learning), and *digital learning* (d-learning) (Basak, Wotto, & Bélanger, 2018). Likewise, the combination of *social media* and education has also opened up opportunities in mixing formal and informal learning (Greenhow & Lewin, 2016). All in all, the omnipresence of technology within these concepts falls under an emerging educational paradigm known as *ubiquitous learning* (Cope & Kalantzis, 2010).

Looking into the evolution of educational technologies, for instance, if you time travel back to the 1930s and 40s, during that time teaching with the aid of either a *slide projector* (or carousel projector) (Wunderlich, 1972) or even an *overhead projector* would seem to be quite highly technological and futuristic (Chance, 1960; Pond, 1963). After several decades, as technology advances, the rise of the internet and Microsoft windows and its applications (Bonk, 2010; Mikre, 2011), more specifically *powerpoint*; which is described as the combination of the compact disc player and slide projector (DenBeste, 2003), is said to be able to promote a more constructivist approach to teaching and learning (Elliott & Gordon, 2006). In effect, powerpoint has slowly evolved into an indispensable tool in today's schools (Hashemi, Azizinezhad, & Farokhi, 2012).

Beyond presentation software, various technological and pedagogical enhancements can also be seen within the last 10 years. Besides the very common ones, some novel ideas are for instance: the use of multi-media in teaching religion (Jusoh & Jusoff, 2009), animation in teaching human anatomy (Carmichael & Pawlina, 2002; Hoyek, Collet, Di Rienzo, De Almeida, & Guillot, 2014), simulations in teaching chemistry (Moore, Chamberlain, Parson, & Perkins, 2014), learning educational tourism with virtual reality (Zarzuela, Pernaz, Calzón, Ortega, & Rodríguez, 2013), just to name a few. However, contrary to these advances, the *digital divide* that exists previously still persists today (Wei & Hindman, 2011). Many hindrances to technology use are noted, such as: the availability of adequate hardware and software, faculty willingness and attitudes towards technology, funding, technical support and trainings (Rogers, 2000). In sum, even as technology progresses many of these barriers to implementation still exist today (Hannache-Heurteloup & Moustaghfir, 2020).

Besides the previously mentioned barriers, many criticisms are also being noted within technology use in teaching. In Taiwan, a study was conducted on eight teachers with regards to their technology use, results show that teachers are quite concerned with four key elements, namely: *environmental* (computer related/technical issues), *personal* (personality and beliefs), *social* (peers/students/community influence), and *curricular* (instructional concerns) (ChanLin, Hong, Horng, Chang, & Chu, 2006). Quite similar to previous findings, these critical issues are but just the tip of the iceberg. A more call for concern is the notion that technology is already so **overused** and **abused** in teaching (Jones, 2003; Li, 2007). A shift in focus is now centered rather on the effectiveness of teaching and learning with technology (Kirkwood & Price, 2013). In essence, it is not how much information technology is used in the classroom, but the careful pedagogical planning that is needed in order to achieve an effective teaching learning process (Daniela, 2019; Watson, 2001).

2. Instructional design models

2.1 The ADDIE model

When talking about pedagogical planning within technology integrated teaching, two distinct models would come into mind. First, is the **ADDIE** model (Branch, 2009; Dick, Carey, & Carey, 2015; Morrison, Ross, Morrison, & Kalman, 2019) and second, the Technological Pedagogical Content Knowledge (**TPACK**) model (Koehler & Mishra, 2009; Koehler, Mishra, & Cain, 2013). The ADDIE model first came into focus during the 1970s and has been widely accepted and used in both regular and online course design (CETL, 2020). ADDIE is an acronym for the five main processes of instructional design, namely: *Analysis* (all the variables that need to be considered when designing the course), *Design* (identifying the learning objectives for the course and how materials will be created and designed), *Development* (creation of content), *Implement* (actual delivery of the course), and *Evaluate* (feedback and data collection) (Bates, 2019; Branch, 2009; Dick, Carey, & Carey, 2015; Morrison, Ross, Morrison, & Kalman, 2019). Somewhat similar to the *action research* processes, the ADDIE components are mostly accomplished sequentially; however, during actual implementation the steps are very much inter-related and dynamic (for more information, please read *Instructional design: The ADDIE approach* by Branch; see Figure 1 for the ADDIE model).

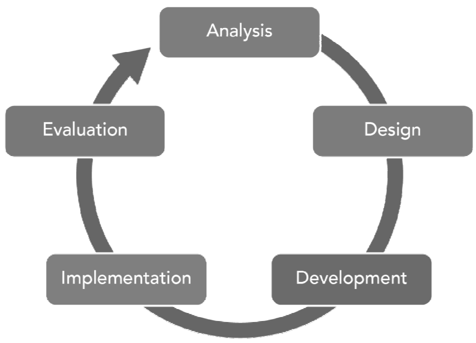

Figure 1. The ADDIE model

Source: Branch (2009), Dick, Carey, and Carey (2015), and Morrison, Ross, Morrison, and Kalman (2019).

A quick review of recent studies revealed that ADDIE model has been widely adapted in various technology enhanced learning design. ADDIE can be used as a pattern for designing a multi-media rich learning environment on elementary students (Arkün & Akkoyunlu, 2008). Even as a guide in the development of an online collaborative learning project (Nadiyah & Faaizah, 2015), for medical students library instruction course (Reinbold, 2013), for midwife students learning prenatal and maternal care (Hadi, Kuntjoro, Sumarni, Anwar, Widyawati, & Pujiastuti, 2017), for designing a multi-media lower elementary students mathematics learning software (Moradmand, Datta, & Oakley, 2014), and many others. Some studies involving ADDIE can be seen within the domain of language learning (a separate field of study is the *Computer Assisted Language Leaning* or

CALL). Such as for students' listening and reading comprehension (Talal & Mosaab, 2018), for evaluating task based activities in CALL (Khoirul & Rohmy, 2016), as model for CALL software development (Farmer & Gruba, 2006), as a guide in language learning program design for a Massive Open Online Course (MOOC) (Fondo & Konstantinidis, 2018), and even on the development of CALL teachers' professional knowledge (Yeh & Tseng, 2019).

Some more technologically innovative usage of ADDIE is noted in the designing of a game-based multi-media basic programming learning module (Hidayanto, Munir, Rahman, & Kusnendar, 2017), virtual learning within a social collaborative environment (Wang & Hsu, 2008), development of a MOOC for catering course (Ismail, Utami, Ismail, Hamzah, & Harun, 2018), a physics course using augmented reality (Gusmida & Islami, 2017), and many others. Within ADDIE studies, most authors focus their paper discussing how their instructional design is developed and how the use of ADDIE model has benefited the process (as seen from the previously mentioned examples). Although mostly descriptive in framework, many authors provided various insights on how learners' needs are collected and analyzed and how these inputs are further integrated into the overall course design. For instance, qualitative semi-structured interview method was adapted to collect insights from faculty and students with regards to the design of infographics (Ozdamli & Ozdal, 2018). While, some uses thematic content analysis on instructional designers input on the key features of effective courses (Ozdilek & Robeck, 2009). Besides the ADDIE process, it is also important to determine the effectiveness of the instructional design itself; hence, many adapted the pre/post-test experimental control group design to check for performance improvements (Asuncion, 2016; Azimi, Ahmadigol, & Rastegarpour, 2015; Hanafi, Murtadho, Ikhsan, & Diyana, 2020; Thakur, 2014) and overall course satisfaction surveys taken at the end of the semester (Hsu, Lee-Hsieh, Turton, & Cheng, 2014).

In sum, ADDIE can be seen as a very useful framework for designing technology enhanced learning courses. Somewhat similar to the action research process, in order for a course design to become effective, practitioners should first be able to analyze the ***needs*** of the learner (needs analysis) and should also be able to ***evaluate*** the design at the end of the course. More important, appropriate course contents that are combined with technological enhancement and given at a pace the students are able to handle; should be able to assists students with their learning. Ultimately, a successful course design should be accompanied with clear learning objectives, carefully structured contents, faculty controlled student workloads, relevant student activities, and assessments related to the desired learning outcomes (Bates, 2019).

2.2 The TPACK model

When using technology within the classroom, another model that comes into mind is TPACK. Technological Pedagogical Content Knowledge or TPACK is also a highly used framework when it comes to pedagogical planning within technology integrated teaching. Based on Shulman (1986, 1987) concept on how teachers having a set of *content* knowledge (specific knowledge about the subject they are teaching) and a set of *pedagogical* knowledge (specific knowledge on how to teach the subject). TPACK expands on this and adds a third; *technological* knowledge (specific knowledge on what technology to use in teaching) (Koehler & Mishra, 2009; Koehler, Mishra, & Cain, 2013). Considering the three teachers' knowledge as overlapping dimensions, primarily standalone concepts should include: **CK** (content knowledge), **PK** (pedagogical knowledge), and **TK** (technological knowledge), this is then followed with their subsequent interactions such as: **PCK** (pedagogical content knowledge), **TCK** (technological content knowledge), **TPK** (technological pedagogical knowledge), and **TPACK** (technology, pedagogy, and content knowledge) which constitute the combination of the three (Koehler & Mishra, 2008; Mishra & Koehler, 2006; see Figure 2 for the TPACK model).

CK as previously quoted is the specific knowledge about the subject matter teachers' are teaching. More specifically, this is the content of the subject matter to be taught or learned by the students (Benson & Ward, 2013). Shulman (1986, 1987) noted that this knowledge would include deep understanding of the concepts and theories of the subject matter being taught, and together with the practices and approaches towards developing such knowledge. In practice, an elementary mathematics teacher should at the least either have an education degree from a normal university or education college majoring in elementary mathematics, or a bachelor degree in mathematics plus the required professional education credits. In essence, since knowledge and approaches for each subject matter or field is quite diverse and varied (Koehler & Mishra, 2009), it would only make sense that different subject teachers each have their own set of comprehensive domain specific knowledge.

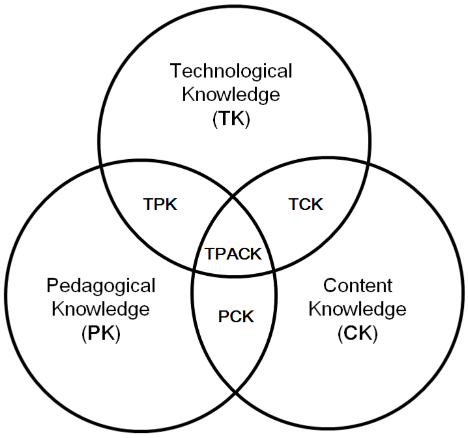

Figure 2. The TPACK model

Source: Koehler and Mishra (2009) and Koehler, Mishra, and Cain (2013).

PK as noted previously is the specific knowledge on how to teach a subject matter. More specifically, these are the various processes or methods on how the subject matters are to be taught or learned by the students (Benson & Ward, 2013). In other words, PK includes the teachers' general understanding of the processes and practices or methods of teaching and learning (Koehler & Mishra, 2009). In practice, PK should include the knowhow on establishing the course/subject learning objectives (aims), together with the related values and/or competencies needed/or focus of the lesson. Furthermore, teachers should also possess the various classroom management strategies, lesson planning, and student assessments/evaluation knowhow (Koehler & Mishra, 2009). For instance, the same elementary mathematics teacher, besides having the content knowledge, should at the least be able to motivate his/her students, create lessons adequate for the target students, and should be able to provide students with the proper assessments in order to determine if students are learning. In essence, as Koehler and Mishra (2009) noted, PK should include the various understanding of the cognitive, social, and developmental theories of learning, and more important, the knowledge on how these theories of learning are applied to students.

TK as previously mentioned is the specific knowledge on what technology to use in teaching. Simply put, this is the technological knowhow of the teachers. As technology is constantly evolving, providing a precise definition is rather quite difficult (Graham, 2011). Graham (2011) further noted that within a larger sense, when discussing about the tools related to the teaching learning process, TK must also include older technologies such as blackboard and chalk, together with the current digital technologies. In practice, TK are the various tasks teachers accomplished using technology. For instance, the elementary mathematics teacher uses powerpoint presentations or even multi-media animations in presenting mathematical concepts, uses Microsoft excel for grade computations, surf the internet for lesson related resources, and replying his/her emails, are all but just day to day ordinary usage of technology. In essence, TK is quite similar to the concept of *computer literacy*, but rather goes beyond to include the understanding of the technology broadly enough to productively apply it in teaching and other education related tasks (Koehler & Mishra, 2009).

Pedagogical content knowledge or **PCK** is actually the pedagogical understanding on how to teach a specific content or subject matter (Shulman, 1986). For the past several decades, PCK has been a highly researched topic in the understanding of the teaching learning processes of students (Abell, 2008). Being accepted as a critical component in successful and effective teaching (Hill, Ball, & Schilling, 2008; Shulman, 1987), in effect, many have tried to assess and measure PCK and its components (Baxter & Lederman, 1999). However, PCK is quite varied and complex as Shulman (1987) noted that PCK constitutes all the *useful forms of representation of teaching ideas, analogies, illustrations, examples, explanations, and demonstrations*; simply put, PCK is the *ways of representing the subject matter that make it comprehensible to others* (p. 9). Hence, PCK should be more effectively measured through observation of instructional events (classroom/teaching observations), teacher interviews, and assessments of content knowledge (learning outcomes evaluations) (Morrison & Luttenegger, 2015). In practice, PCK for the elementary mathematics teacher can be teaching simple additions to Grade 2 students with the use of marbles, demonstrating how addition is done by grouping the marbles, and letting the students count the results. In essence, PCK is a form of teacher understanding that combines content and pedagogy, and more important taking into consideration the learners' characteristics in a unique way that is conducive to learning (Gudmundsdottir & Shulman, 1987).

Technological content knowledge or **TCK** according to Mishra and Kohler (2006) is the knowledge teachers need to help identify the best technologies suitable in supporting students in learning the content or subject matter. Kohler and Mishra (2009) further mentioned that it is also important to understand how technology influences the learning content and how they constrain one another. In practice, the elementary mathematics teacher depending on the lesson topic or subject matter to teach, he/she should be able to look for suitable technology to support students' learning. For instance, to use computer animation or simulation in explaining mathematical concept, using powerpoint presentation in presenting lectures, or even to use a computer software or mobile/tablet App for problem solving demonstration.

As for the technological pedagogical knowledge or **TPK,** Mishra and Kohler (2006) identify this as the knowledge teachers need to help determine the best technology to support a particular pedagogical approach. It is also the understanding on how the teaching and learning process can change when a particular technology is applied (Kohler & Mishra, 2009). In practice, let us say the elementary mathematics teacher would want his/her students to form into groups of five students and create a presentation introducing a certain mathematician that will be presented in class after two weeks. The objective of the activity is for the students to be able to work together as a team, search for relevant information, and to be able to summarize, synthesize, and present the ideas in a concise logical way. To achieve these objectives, students would use the internet to search for relevant information, discuss with classmates using either Facebook messenger or Viber App (students can even form a Viber group for discussion, which the teacher can also join and monitor their progress). Lastly, students can create a powerpoint presentation or even a movie to present their report.

Finally, **TPACK** as mentioned before is the combination and interaction of the technology, pedagogy, and content knowledge. Koehler and Mishra (2009) noted that TPACK is actually the basis of effective teaching with technology. In practice, a teacher should know how to present the lesson content using technology effectively. In other words, a teacher should be able to use technology to teach in a constructive and creative way that is conducive to learning. In addition, technology should also be able bridged the gap between easy or difficult to learn concepts (Kohler & Mishra, 2009). Hence, TPACK can be considered as a holistic effort to effectively integrate technology into the teaching learning process.

TPACK is also a highly researched topic besides PCK. Most studies on TPACK are concentrated on the development of the theory itself and on how TPACK can be measured. Studies on TPACK measurement are mostly involved with the examination of the seven factors, wherein teachers (or in some cases practice teachers) are asked regarding their perceived competencies within the following: content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), as well as the combination of the technology, pedagogy, and content knowledge (TPACK) (Castera et al., 2020; Koh, Chai, & Tsai, 2013; Luik, Taimalu, & Suviste, 2018; Lin, Tsai, Chai & Lee, 2013). Some sample items of the seven TPACK factors are as follows: **CK** – *I have sufficient knowledge on the subject matter*; **PK** - *I am able to guide my students to adopt appropriate learning strategies*; **TK** - *I can learn technology easily*; **PCK** - *Without using technology, I can help* *my students to understand the content knowledge of my lessons in various ways*; **TCK** - *I know about the technologies that I have to use for the research on the content of my lessons*; **TPK** - *I am able to facilitate my students to use technology to plan and monitor their own learning*; and **TPACK** - *I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn* (adapted from Lin, Tsai, Chai & Lee, 2013, p. 331).

Since the inception of TPACK, many have expanded the concept to encompass additional constructs (Phillips & Harris, 2018). Yurdakul, Odabasi, Kilicer, Coklar, Birinci, and Kurt (2012) built on the TPACK model to include the *design* (is the creating and developing of curriculum plans), *exertion* (is the implementation of the curriculum design plans), *ethics* (is the practice of the legal and ethical behaviors within the use of technology in education), and *proficiency* (is the improvement of teachers' ability to integrate technology) (p. 973). Benton-Borghi (2015) also expanded on the model to include the *knowledge*, *skills*, and *dispositions* to teach all types of students for an all-inclusive teaching design called universal design for learning (UDL) infused TPACK. Furthermore, Yeh, Hsu, Wu, Hwang and Lin (2014) redefined TPACK to include the *understanding of learners*, *comprehending subject content*, *technology integrated teaching strategies*, *representations of technology integrated curriculum*, *practical instruction*, *application of instructional management*, and the *evaluation of students' progress* (p. 716, 718).

In sum, as technology advances every day, teaching with technology has become a difficult task. The use of the TPACK model signifies that the content, pedagogy, and technology, all played an important role within the teaching learning context, either standalone or in combination with one another. More important, to effectively teach with technology, teachers should continually learn and adapt to newer technologies, hence creating and re-establishing a dynamic balance among all of the TPACK components (Kohler & Mishra, 2009).

3. Technology Acceptance Model (TAM)

Within technology enhanced learning, it is quite important to understand whether the instructional design (incorporating technology into the teaching learning process) is effective or not. Literature suggests that the Technology Acceptance Model or **TAM** as one of the most useful framework for testing the students' acceptance and usage of technology, as shown by several meta-analyses (King & He, 2006; Scherer, Siddiq, & Tondeur, 2019; Sumak, Hericko, & Pusnik, 2011). TAM is developed from the *theory of reasoned action* (TRA) wherein an ***intention*** to engage in a certain behavior is considered to be the best predictor of whether or not a person would actually ***engages*** in that behavior (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975, 2010). Following the TRA framework, Davis (1989) proposed TAM as a method to explain computer usage behavior. TAM is composed of four factors: **PU** (perceived usefulness), which is the degree to which a person believes that using a particular technology would enhance his/her performance; **PEU** (perceived ease of use), which is the degree to which a person believes that using a particular technology would be free from effort; **BIU** (behavioral intention to use), which is the tendencies that leads people to use the technology; and **AU** (actual use), which is the actual usage of technology (Davis, 1989; see Figure 3 for the original TAM). In sum, within technology enhanced learning, TAM is the explanation of how students come to accept and use a certain technology.

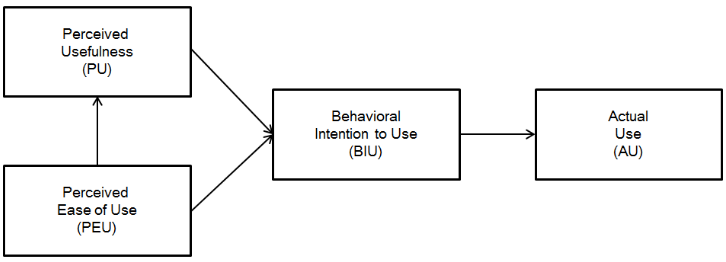

Figure 3. The original TAM

Source: Davis (1989).

The TAM was later improved to encompass the *theory of planned behavior* (TPB), which is to link one's beliefs to behavior (Ajzen, 1991). Figure 4 shows several modification, such as: **Ext** (external variables), these might include gender, age, and other social factors; **ATU** (attitude toward use), which is the general impression of the technology; and **IU** (intention to use), which is similar to BIU (Davis, Bagozzi, & Warshaw, 1989). After a few years, the model was simplified after PU and PEU were found to have a consistent direct influence on BIU, hence, ATU was removed (Venkatesh & Davis, 1996; see Figure 5).

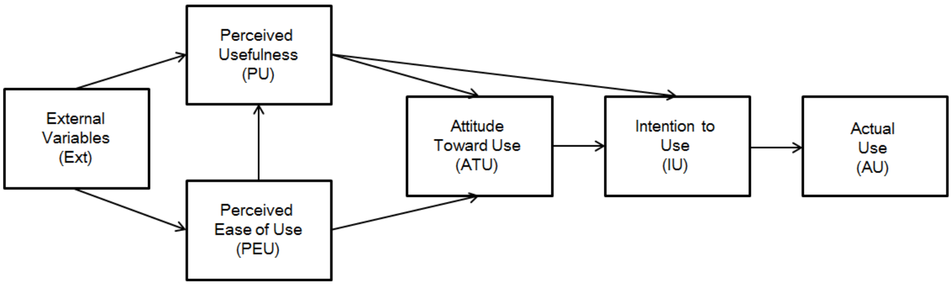

Figure 4. The modified TAM

Source: Davis, Bagozzi, and Warshaw (1989).

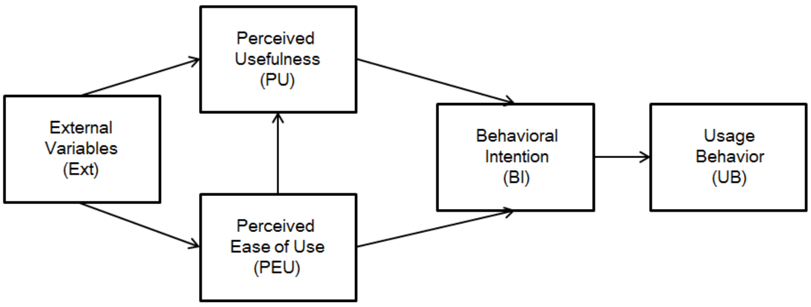

Figure 5. The simplified TAM

Source: Venkatesh and Davis (1996).

Some example of the TAM items include: **PU** – *using the software application will enhance my learning*; **PEU** – *my interaction with computers is clear and understandable*; **IU** – *I plan to use the computer often*; and **AU** – *actual frequency of computer usage* (adapted from Ching, Lin, Wang, and Tchong, 2014, p. 382; Davis, 1989, p. 340; Teo, 2009, p. 311). Further down the road, TAM was later modified to become **TAM2** (Venkatesh & Davis, 2000) and **TAM3** (Venkatesh & Bala, 2008). In TAM2, antecedents for PU were added, such as: *job relevance* (as the perspective on the extent to which the target technology is compatible for the job), *output quality* (as the perception of the technology's ability to perform specific tasks), *voluntariness* (as the extent to which potential adopters perceive the adoption decision to be non-mandatory), and many others, while *subjective norms* (as the perception that other individuals who are important to the user considers that he/she is able to perform a behavior) and previous *experiences* both influences PU and IU (Venkatesh & Davis, 2000). Furthermore, TAM3 incorporates an even more complex framework to include *individual differences* (of the user), *characteristics* (of the technology), *social influence* (of the user), and *facilitating conditions* (of the task) as determinants of PU and PEU (Venkatesh & Bala, 2008).

In the midst of TAM2 and TAM3, Venkatesh, Morris, Davis, and Davis (2003) revised the old models and proposed the unified theory of acceptance and use of technology (**UTAUT**). UTAUT identifies four key factors, such as: *performance expectancy* (of the user), *effort expectancy* (of the user), *social influence* (of the user), and *facilitating conditions* (of the task), and together with four user moderators, such as: *age*, *gender*, *experience*, and *voluntariness*, that are related to predicting the BIU and AU (Venkatesh, Morris, Davis, & Davis, 2003;

Venkatesh, Thong, & Xu, 2016). In sum, TAM is an evolving framework with various extensions and their applications are quite varied and multi-disciplinary (Momani & Jamous, 2017). Many practitioners incorporate TAM to test for the relationships between the various factors that influence the teaching learning process. In practice, TAM is able to help teachers better understand how students' perceived education related technology.

4. Conclusion

The current paper summarizes the various tools that teachers are able to use in designing their lessons in times of pandemic. The ADDIE can be seen as a very useful framework to follow when designing technology enhanced learning courses. Very similar to the action research process, needs analysis is crucial to evaluate the needs of the learner, while later evaluation of the course is also helpful in providing future inputs for later redesigning of the lesson. While TPACK is also important in checking how the teachers' technology, pedagogy, and content knowledge (and their interactions) is able to become effective in the teaching learning process. Lastly, TAM and its modifications are able to help explain the various factors surrounding computer usage behavior of students. In sum, instructional design of technology enhanced learning course is not an easy task. Careful designing of what type of technology is effective in a certain kind of lesson within a certain kind of teaching method is also a tedious undertaking. It is hoped that with these tools, designing effective lessons would be more scientific.

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