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PAPER

Expanding the Technology Acceptance Model (TAM) to Consider Teachers Needs and Concerns in the Design of Educational Technology (EdTAM)

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ABSTRACT

While technological innovations are designed with the users in mind, this same design approach—designing technology to enhance the students' learning experience—often falls short of acceptance with teachers and educators. This paper suggests a theoretical model with which EdTech can be designed to enhance the adoption of technology among teachers. At its core, the Educational Technology Acceptance Model (EdTAM) utilizes a double-user scenario, focusing on both the needs and concerns of teachers as well as the needs of students. As a result, a proof of concept in the form of an educational game designed in strict accordance with the EdTAM Model is presented. Thus showing that the theoretical model can be transferred into the design of a real-world product. A further study testing the effect of the model and the produced games acceptance rate with teachers is planned to support the theoretical model with empirical data.

KEYWORDS

game-based learning, technology acceptance model (TAM), concerns of teachers, educational technology, educational games

1 INTRODUCTION

When Marshall McLuhan published his book "Understanding Media: The Extension of Man" in 1964, he suggested that the media, not the content it carries, should be the focus of study. As an example, he pointed to the light bulb, which does not carry any content yet is a medium that has a vast social effect; a light bulb enables people to create spaces during the night that would otherwise be engulfed by darkness.

Similarly, one could argue that Educational Technology has been able to create learning opportunities through the continuity of teaching during the worldwide COVID-19 pandemic that otherwise would have been impossible due to school closures. This resulted in a situation where the teachers were, more or less,

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forced to adopt new technologies in their teaching practice overnight. In a systematic review of 20 empirical studies from peer-reviewed journals, Bui [24] cites several studies that document serious challenges faced by educators across the world in this hasty process of adopting new technologies. And while the sudden need for technology acceptance was not forced upon the teachers by legislators or administration, it was forced upon them by circumstances and was by no means a voluntary decision. Naturally, the long-term effects of these worldwide ad-hoc implementations are unknown at the moment and are most likely going to be a field of interest for scholars over the coming years. But from the literature, we do know that the attempt to integrate educational technology through a forced, or top-down, approach has previously failed to generate a long-term effect on teaching and learning, in part because it ignores the perceptions of the teachers [1]. Supporting this is the work of Albrini [2], who states that the planning of the implementation of technology in education is focusing too much on the technological aspect as well as its effect on student achievement. Thereby leaving out the teachers, which are actually the true change agents of school and the real drivers of any pedagogical innovation in education, as described so thoroughly by Hord et al. in the classical book "Taking Charge of Change" [3] and likewise supported by Schifter in her notable work "Infusing Technology into the Classroom" [4].

1.1 Technology acceptance model

This means that in order for any technological advances in education to reach the students in the classroom, the teachers, in their role as change agents, will have to accept the new technology. And according to Hoareau et al., a robust and widely used theory to achieve this aim is the technology acceptance model (TAM) [25]. This model was developed on the assumption that when a user is presented with a new technology, two main factors, usefulness and ease of use, will shape the user's attitude towards a potential acceptance, which in turn will influence a behavioral change that might, or might not, lead to an actual use of the new technology [6].

However, Hoaerau et al. also point out that there is a need to adapt the TAM model to the particularities of each context. Likewise, Ajibade [7] argues that while the TAM model is appropriate for acceptance by an individual user, its usefulness is limited in an environment that has to adhere to rules and regulations, such as a corporate or institutional implementation. Supporting this view are the findings of Šumak et al. [5], where they found a difference in acceptance when studying educational tools versus more office-oriented tools.

1.2 The change vs. continuity paradox

One explanation for this could be that the educational environment is being shaped by opposing forces. One example of this is the global COVID-19 pandemic, which has acted as a catalyst for the increase and adoption of technology in multiple instances, such as corporate environments as well as everyday life in our societies. This change has affected us as citizens, and it is commonly expected that teachers also adapt to this changed reality in their classrooms. After all "*The client of the school, and thus of the teacher, is the whole of society. The institutional clients of the school include every power base: the family, the business and economic community, the artistic, literary, intellectual, and scientific community, the military, the religious community, and* *government itself*," as so precisely stated by Fuller and Bown in their foundational work on the impacts of becoming a teacher [8].

At the same time, on the level of policymakers and the institutional level, it is expect that teachers work under circumstances which Cuban summarizes as: "*A teacher is required to face twenty to thirty students in a classroom, for a set period of time, maintain order and inspire the class to learn content and skills mandated by the community*" [1, p.81]. So, amidst all the changes that our society is going through, the mandate, the circumstances and conditions, and even the curriculum under which teachers teach, is not being changed. Cuban calls these opposing forces the "*change amidst stability paradox*" [1, p.104]. And in an effort to create a design model for the development of educational technology, that is acceptable for the teachers, or let's call them "the change agents of schools," we should keep this "change vs. continuity" paradox in mind.

The logic being that if we want teachers to increase their use of educational technology in their classroom, we should develop EdTech solutions that cater to both innovation and supporting established educational practices as mandated by policymakers.

1.3 Double-user scenario

This presents us with the next challenge. Because when designing new technology, be it software or other, we have to pay careful attention to the user's needs or questions. Traditionally, this is achieved by describing a basic story of the actions or goal that the user wants to achieve. Translating this into educational technology, the common approach is to pay careful attention to the design of the student's user journey, actions, and goals. While providing the teacher with a detailed report of the learning results.

However, what this paper proposes is that educational technology is a double-user scenario. Students and teachers do not share the same actions or goals and therefore have different needs and requirements for the same educational product.

1.4 Enhancing adoption

Combining all of these facts—that the real change agents of schools are the teachers and that they work in a paradoxical environment that demands simultaneous change and continuity—while educational technology seems to be a double-user scenario that needs to consider both the learning needs of the students as well as the instructional and organizational needs of teachers—presents the challenge that this paper aims to solve.

The reason being that there is a vast richness of models that can help design educational technology that suits and supports the learning needs of students, while there seems to be a lack of models that focus on the needs of teachers as actual change agents.

2 APPROACH

Looking at this task from the perspective of game-based learning, scholars in the field of new media and literacy have linked video games to both dominant learning theories as well as cognitive sciences [9] [10].

And in a notable meta-analysis of 129 papers, Connolly, Boyle, MacArthur, Hainey, and Boyle [11] found evidence for all behavioral and learning outcomes with the use of game-based learning. These outcomes were both knowledge acquisition as well as perceptual and cognitive outcomes. They also included behavioral, affective, motivational, psychological, and social outcomes. Only exception being the so-called soft skills.

While these results were found on the student side, Bourgonjon et al. [12] found several interesting goals or needs on the teacher side, which to some degree contradict parts of the TAM model. Supporting this are the findings of Can and Cagilty [13], who found that some teachers had concerns about classroom management and learning opportunities when using game-based learning. These were factors that cannot be attributed directly to the two parameters of *ease of use* or *perceived usefulness* from the TAM Model.

In line with this, Jong [14] documented 116 teachers' concerns about an educational innovation while studying the implementation of a Virtual Interactive Student-Oriented Learning Environment. His findings showed that the biggest concerns were found in the tasks of implementation as well as issues related to efficiency. Bakar et al. [15] found that teachers were very concerned with selecting the right game for the right classroom and curriculum context, even suggesting that the wrong choice might even be counterproductive.

So, while it is clear that students can benefit from game-based learning, it is also clear that the adoption of this educational technology largely depends on the teacher's acceptance, which is in line with findings in the use of broader integration of ICT in education [2] [16] [17].

2.1 The concerns of the teacher

In order to create a model or framework that is capable of expanding the TAM Model into a design with which educational technology can be designed so that it fits the requirements of both teachers and students, we first have to find out what the main obstacles are that teachers face when using EdTech.

A widely cited model that could give us this insight is the work about teacher concerns and teacher development by Francis Fuller, where she posits that a teacher's development happens in three stages, ranging from the concerns about the self, then the concerns about the tasks, and lastly the concerns about the students and the impact of the teaching [8] [18]. These three concerns are found in two main groups: *early concerns*, which adhere to new teachers starting out in their career as educators, and so-called *late concerns*, which in turn adhere to experienced teachers.

Early concerns include *self-concern*, which Fuller describes as:

- a doubt about their own adequacy
- inability to gain control of the class
- the evaluation of themselves by supervisors or pupils

Late concerns include both *task concerns* as well as *impact concerns*. These can be sorted as follows:

- Task concern
    - concern about the pupils understanding and capacities
    - concern about the specific objectives for the pupils
    - assessment of the pupils gain

- Impact concern
  - outcomes of own contribution to pupils' difficulties and gains
  - evaluation of oneself in terms of pupils gain

Several studies have shown that this concern-based approach has previously been used in the integration of educational technology [19] [20] [21]. So, by sorting the findings about teachers' concerns regarding the use of game-based learning from Can and Cagilty, Jong and Bakar et al. into Fuller's 3 stages of concern, it becomes possible to create a concern-based taxonomy. The aim is to gain insight into which concerns might hold teachers back in the adoption of, in this case, game-based learning.

Table 1. Sorting findings from studies into Fuller's 3 stages of concern

Fuller	Findings in Studies About Game-Based Learning
Self-concern	Classroom management, Can and Cagilty [13] Availability of support and resources, Jong [14]
Task concern	Applicability for all grade levels, Can and Cagilty [13] Suitability for all subject matters, Can and Cagilty [13] Can help students fulfill cognitive goals, Can and Cagilty [13] Can help develop psychomotor goals, Can and Cagilty [13] Can help meet affective goals, Can and Cagilty [13]
Impact concern	Learning opportunities, Can and Cagilty [13] Issues related to efficiency, managing, scheduling and time, Jong [14] Worth and feasibility of implementation, Jong [14] Keen to explore new ways of improving effectiveness, Jong [14] Selecting the right game for the right classroom and curriculum context, Bakar et al. [15] Impact on student learning, Jong [14]

In a notable study about teachers' acceptance of game-based-learning, Bourgonjon et al. [12] gathered data from 505 teachers and tried to understand what the underlying factors for their decision-making were. The results of the study were then compared to the TAM Model's two parameters: *ease of use* and *usefulness*.

And in alignment with the TAM Model, *ease of use* showed no statistical significance for the influence of behavioral change on the teachers. Whereas the parameter of *usefulness* showed to be a strong indicator for behavioral change (.68), linked with learning opportunities, which also seemed to have an influence on the perception of usefulness.

So, by comparing the findings of Bourgonjon et al. [12] with the data we found in the studies centered around teachers' concerns when using game-based learning (the findings shown in Table 1), we are able to validate our data (as shown in Table 2).

Table 2. Linking the TAM Model with data sorted in Fuller's 3 stages of concern, using Bourgonjon et al. as validation

TAM Model	Bourgonjon et al. 2013	Sample Data Sorted in Fuller's Stages of Concern
Ease of use	not significant	Self-concern (2 of 13 concerns)
Usefulness	–.68	Task concern (6 of 13 concerns)
		Impact concern (5 of 13 concerns)

Looking at this data, it seems that the parameter *ease of use* corresponds well with the parameter of *self-concern,* meaning that *doubt about one's own adequacy* seems to be less important than the *usefulness* of technological innovation.

This is very much in line with the findings of Pletz, where a majority of the participants in the study were reluctant to implement immersive virtual reality due to concerns about its usefulness, which was named as highly important, in order to use this innovative technology in training scenarios [26].

Also, the findings of Veiga & Andrade [27] support this, as they found the critical factors of a successful acceptance of technology in the classroom were the availability of technology and speed of access, which we can translate to factors that are related to solving the task or task concern. And a second group of factors were the technological applications of the curriculum and the pedagogical approach, which we can translate to factors that have an impact on the learning, or the impact concern.

In terms of designing EdTech solutions that can enhance technology acceptance amongst the change agents, we should consider a design that primarily eliminates both the teacher's *task concern,* meaning concerns about the students' *understanding and capacities*, as well as *specific objectives* and *assessment*, as well as the *impact concern,* which can be defined as concerns about *one's own contribution to the students learning* and *the evaluation of oneself in terms of the students gain*.

3 RESULT

Putting all this together, this paper proposes that the key ingredients of a design that could enhance teachers' acceptance rate of educational technology in the classroom are:

- an educational technology that should support existing practices in the classroom while adding modern innovation to the teaching experience (the *change/continuity paradox*).
- an educational technology should take into account that it has two user scenarios with different needs (the *double user scenario*).
- and educational technology should address the teachers concerns that lie in the domain of *usefulness*, meaning the technology's ability to support the task of teaching (*task concern*) while giving the teacher feedback on the impact their teaching has on the students' learning (*impact concern*).

With this, we can now form the hypothesis that educational technology can be created to include these parameters in the design by using the design model discussed below.

3.1 The Educational Technology Adoption Model (EdTAM)

1. Break up the change/continuity paradox by designing innovative learning experiences for the students (*supporting change*) whilst giving teachers a direct influence on these experiences (*ensuring continuity*)
2. Designing the students' learning experience which utilize motivational tools such as gamification, exploratory/creative/active learning or similar.
3. Design possibilities for the teacher to configure this experience, in order for it to fit with the actual classroom or student capacities (*task concern*) while offering a way to get into a human exchange with the students about their learning experience (*impact concern*).

Table 3. The EdTAM model

Paradox	Double User Scenario	Usefulness	
Change	Student	Experience: Innovative learning Motivation and fun	EdTech Product
Continuity	Teacher	Influence and configure: Task Concern Impact Concern	

3.2 Creating a prototype

In order to test the hypothesis, a prototype in the form of an educational game was designed while paying strict attention to the parameters of the EdTAM Model (as shown in Table 3). The subject of English as a foreign language was chosen, specifically the process of vocabulary training in primary school. The reason is that vocabulary training traditionally relies on a large amount of repetition, which can become tedious for the students.

Breaking up the paradox. As a first design step, in accordance with the EdTAM Model, it was discussed which features could break up the so-called paradox. The EdTech solution should have both an element of innovation and adhere to existing classroom practice, at the same time.

So by building an educational game that centers on learning a vocabulary, which is mandatory in order to learn a foreign language, we ensure curricular relevance, thereby satisfying the *continuity* side of the *change vs. continuity paradox*. And in order to satisfy the need for change, we present the tedious task of practicing a new vocabulary through repetition as an educational game that makes it fun and rewarding to repeat the vocabulary. Thereby satisfying the *change* side of the *change vs. continuity paradox*.

Considering the double-user scenario. As the second step in the design process, in accordance with the EdTAM Model, it was discussed which features could contribute to an alignment helping the two user groups perceive the game as, on the one hand, innovative and, on the other hand, relevant for the learning objective as defined by policymakers.

So, to make sure the game is both a fun and motivating experience for the user group *student*, a so-called Platform game was chosen due to its successful game mechanics dating back to titles as early as Donkey Kong and Mario Brothers. This gameplay has an inherent "fun factor," which can make repeating the same task fun instead of a chore.

Likewise, to ensure not only curricular relevance with the chosen topic but also a pedagogical impact, we created the learning objectives of the game according to a modern and effective approach to language learning called the lexical approach [22]. This way, we made sure that the needs of the user group *teachers* were met and that the game was not only fun but also contained the latest and most modern approach to teaching a new vocabulary.

Adding usefulness for both user groups. As a third design step, in accordance with the EdTAM Model, it was discussed how it could be ensured that the game also felt useful to both groups of users. After all, students might have fun playing the game, but if they don't experience that it contributes to their learning, why should they play that game instead of a commercial alternative? And likewise, the teachers could ask themselves why they should let their students play the game if it doesn't help their students achieve the goals set by the learning objectives as specified by the curriculum.

So, to add to the user experience of the students, we built-in an AI in the form of Natural Language Processing (NLP), which is used for both text-to-speech, as well as speech-to-Text. This enables the students to not only read the new vocabulary but also hear a proper English pronunciation of it. Likewise, it enables them to train their own pronunciation by repeating the new Vocabulary into a microphone and then getting immediate feedback from the AI. This makes the educational technology not only fun but also gives it a perceived usefulness in the actual goal of the game, which is the learning and expansion of the students vocabulary. The students feel that they are getting better by playing the game.

On the teacher's side, we started by considering the *task's concern.* To mitigate this concern, a dashboard was added that offers teachers control of the game's content by configuring several parameters in the game. These parameters offer control over the type of vocabulary they want their students to train when using the game. They can determine the complexity or level of difficulty of the vocabulary as well as which semantic domain it is part of. This makes it easy for the teacher to create individual games, or game sessions, that connect the game to classroom activities while adapting it to the current level of their students. A second part of the dashboard controls how long a playable session should be, making it possible for the teacher to implement the game at any time and for any length of time.

Looking at the *impact concern*, the dashboard also offers the possibility for the teacher to add personal and motivational in-game messages, making the teacher an integrated part of the game and thereby adding their *own contributions to the students' difficulties and gains.* And as a last part, the game also contains printable worksheets, which are created according to the chosen settings in the dashboard's difficulty and semantic domain settings. These worksheets support analog classroom activities and connect the game-based learning activity with a human interaction between students and teacher, adding to the teacher's *evaluation of oneself in terms of students gains*.

Table 4 illustrates how the EdTAM model would look like after adding the features of the educational game described above.

Table 4. The educational game for training English vocabulary in primary school modeled after the EdTAM model

Paradox	Double-User Scenario	Usefulness	Product
Change Educational Game	Student Platform Gameplay	Innovative learning AI - Text-to-Speech AI - Speech-to-Text	The EdTech Prototype Platform game
Continuity Learning a vocabulary	Teacher The lexical approach	Task Concern – level of difficulty – semantic domain – game time Impact Concern – in-game messages – printable worksheets	

4 CONCLUSION

While designing, building, and testing the prototype of the educational game to train English vocabulary in primary school (*working title: Bloodey*), the EdTAM Model proved to be a capable framework and guideline to ensure that the needs and concerns of both students and teachers were considered in the design. And while most, if not all, forms of educational technology today try to consider *ease of use*, or what Fuller calls *self-concern*, in one form or another. Tools, such as learning management systems (LMS), also make it possible for teachers to create and configure learning experiences, thereby supporting, at least to some degree, the *task concerns* of teachers.

However, it is this author's opinion that the design of educational technologies can still evolve to consider both the *change* vs. *continuity paradox* as well as the *impact concern*. One way of achieving this could be through a design that uses the EdTAM Model to answer design questions, as suggested in Table 5.

And while this paper is trying to offer this model for developers and software designers with which such a design can be achieved, it should still be seen as a form of introduction or preliminary work into answering the much more interesting question: *is an EdTech product that has been designed strictly after the EdTAM model likely to result in an enhanced adoption rate amongst teachers?*

In order to answer this question, a second study is planned. Using the already developed prototype for English vocabulary training in primary school (*working title: Bloody*), we would like to investigate how useful teachers think the games built-in functions to mitigate *task* and *impact concerns* actually are.

To measure this, we will let the teachers configure and use the game, as well as the worksheets, while wearing an EEG headset. This will give us the possibility to measure the brain waves, or more specifically, the alpha oscillations in the frontal cortex, of the users while they are interacting with the game.

Based on the findings of Moridis et al. [23], a perception of usefulness when interacting with the game will then show up as a frontal asymmetry between the left and right frontal cortex (electrodes AF7 and AF4). Thereby making it possible to get an objective measurement showing whether or not the teachers perceive the tool as useful.

Combining this with an external observation of the game being used in the classroom as well as personal reflection by the teachers, who will be asked to fill out a questionnaire based on the taxonomy of the TAM Model, should give us three separate datasets on the perceived usefulness of the game and the resulting worksheets.

Triangulating these three data sets should then give an interesting insight into whether or not an educational game designed strictly after the EdTAM model is likely to enhance its acceptance rate amongst teachers.

Table 5. Using the EdTAM Model as a design tool to consider both a student and teacher centered design, which includes both innovation as well as established classroom practice

<table>
<tr><th>Paradox</th><th>Double-User Scenario</th><th>Usefulness</th><th>Product</th></tr>
<tr><td>Change

How does the tool support innovation?</td><td>Student

How is the innovation presented to the students?</td><td>Innovative learning

How does this innovation make the students realize they had an increase in learning?</td><td rowspan="2">The EdTech Product</td></tr>
<tr><td>Continuity

How does the tool support existing classroom practice?</td><td>Teacher

How is this practice embedded into, or presented via, the tool?</td><td>Task Concern

How does the tool mitigate teachers concerns about:
– the pupils understanding and capacities
– about the specific objectives
– the pupils assessment of the pupils gains

Impact Concern

How does the tool mitigate teachers concerns about:
– the own contribution to pupils' difficulties
– the evaluation of oneself in terms of pupils gain</td></tr>
</table>

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