PREDICTING TEACHER USAGE OF LEARNING GAMES IN CLASSROOMS

by

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The following individuals read and discussed the dissertation submitted by student Joseph M. Waarvik, and they evaluated his presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

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DEDICATION

This dissertation is dedicated to my wife Alice. Thank you for being my biggest supporter and for sacrificing way too much time with your husband while he finished this program. Thank you also to my kids for putting up with Dad working on the computer for many weekdays and weekends.

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ABSTRACT

This study addresses a problem of ambiguity in academic writing regarding whether learning games are underutilized in educational settings, what type of educators use learning games, and what factors are the most important in predicting educator usage. The purpose of the study is to clarify and explain the current state of educator usage of learning games in these areas in order to inform designers of educator professional development. There are two well-known frameworks that can be used to understand learning game integration by educators: the Technology Acceptance Model (TAM) and the Technological Pedagogical Content Knowledge (TPACK) framework. This study uses a modified version of each framework designed specifically for learning games. There are also additional factors that may have a significant impact on the decision to use learning games, including (a) experience with digital games, and (b) external barriers to usage. This research has three goals: (a) investigate learning game usage, (b) evaluate which framework better predicts educator usage of learning games, and (c) examine additional factors outside of these frameworks that may influence integration. Data was gathered from currently-practicing educators using an online survey and the results were analyzed using SPSS and several statistical methods, including multiple linear regression. The results show that the TPACK framework is slightly better than TAM at predicting teacher usage, experience with games is not a statistically significant factor, and perceived barriers are significant, but their effect can be mediated by game pedagogical knowledge.

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LIST OF ABBREVIATIONS

BSU	Boise State University
CK	Content Knowledge
GTBS	Game-based-learning Teaching Belief Scale
GCK	Game Content Knowledge
GK	Game Knowledge
GPCK	Game Pedagogical Content Knowledge
GPK	Game Pedagogical Knowledge
ICT	Information and Communication Technology
IRB	Institutional Review Board
PCK	Pedagogical Content Knowledge
PE	Perceived Ease of Use
PK	Pedagogical Knowledge
PU	Perceived Usefulness
SAMR	Substitution, Augmentation, Modification, and Redefinition
SDT	Self-Determination Theory
TAM	Technology Acceptance Model
TCK	Technological Content Knowledge
TPK	Technological Pedagogical Knowledge
TK	Technological Knowledge
TPACK	Technological Pedagogical Content Knowledge

TPACK-G	Technological Pedagogical Content Knowledge – Games
TRA	Theory of Reasoned Action

CHAPTER ONE: INTRODUCTION

Over the last few decades, the idea of using digital games as a learning technology has become increasingly popular. There are two main reasons why this idea has experienced a growth in popularity. The first is widespread social changes. Digital games have grown in popularity as an entertainment medium, with the rise in popularity and capability of smartphones being a large driving force of this change. The second reason is digital games have many attributes that lend themselves to being useful learning technologies. For example, digital games are interactive systems with a feedback loop between the player and the gaming interface at the core of a digital game (Whitton, 2014). Both interactive learning (Freeman et al., 2014) and consistent feedback (Hattie & Timperly, 2007) are recognized as having major influences on student achievement. Digital games can be simulations, allowing students to experience real-world situations in a risk-free environment (Becker & Parker, 2009). As a final example, digital games can increase motivation in students by adjusting the game difficulty to the student's performance, effectively keeping the learning within the student's Zone of Proximal Development (Wass & Golding, 2014) and increasing the chances of a student experiencing the state of flow, which in turn increases motivation and retention (Nakamura & Csikszentmihalyi, 2002).

Digital games have the potential for being effective learning systems, and both the 2014 and 2015 NMC Horizon reports list games as one of the technologies driving change in K-12 education (Johnson et al., 2014; Johnson et al., 2015). However, in a study done in response to the *2014 Horizon Report,* most teachers chose games as the featured technology least likely to be adopted (Hodges & Prater, 2014). The interviewed teachers cited administrators, school policies, parent beliefs, and teacher beliefs as reasons why learning games were unlikely to be adopted in traditional K-12 classrooms. There appears to be a disconnect between the potential for games to be effective learning systems and actual classroom usage. Research into usage of learning games is less common than research into potential usage or case studies that demonstrate the benefits of using a game in a classroom for the duration of a study. The Horizon report and the educator response raises a question of whether learning games are being used in most classrooms. If they are being used, is it a specific type of educator that is using them, or are learning games more likely to be used to teach specific contents or age groups? If a certain type of teacher, content, or classroom cannot be identified as significantly more likely to be using learning games, how else can the decision to use learning games be understood? This research is intended to improve the understanding of the integration process of learning games in terms of how often it is occurring, what kind of educator is more likely to integrate learning games, and what factors influence educators during the integration decision process.

Research into why educators choose to integrate or not integrate learning games falls under the category of diffusion of innovations. Rogers' (2003) diffusion of innovation theory is the primary theory in this field. Rogers contends that the acceptance or rejection of an innovation has five steps: (a) knowledge of the innovation, (b) persuasion, where individuals are interested in the innovation and seek more information, (c) decision, where the innovation is accepted or rejected, (d) implementation, where the individual, if accepting of the innovation in the previous stage, uses the innovation, and (e) confirmation, which is an ongoing process of evaluation where the individual chooses to continue using the innovation or discontinue use. This theory is very broad in scope, but several frameworks of a more focused scope can be understood within the diffusion of innovations paradigm.

One of these frameworks is Davis' (1989) technology acceptance model (TAM). TAM focuses primarily on the decision stage of the innovation process. It seeks to predict usage of a technology based primarily on two constructs: (a) an individual's perception of the usefulness of an innovation (perceived usefulness) and (b) an individual's perception of how easy it is to use an innovation (perceived ease of use). TAM explains the use or disuse of an innovation as a cost/benefit analysis. This model has been used by other researchers to predict or explain the usage of technologies by educators, including the use of digital games, although it most frequently is used to measure the intention to use a technology as opposed to the actual usage. Researchers who approach technology integration through a TAM lens tend to believe that technology usage can be increased if the usefulness of a technology is increased and if the technology becomes easier to use.

Another framework that can help explain why educators may or may not use an innovation is the Technological Pedagogical Content Knowledge (TPACK) framework. This framework focuses on the interplay between three different knowledges: (a) knowledge of a technology, (b) pedagogical knowledge, or knowledge about teaching, and (c) knowledge about content. The TPACK framework focuses on these individual knowledges and how they interact, with the overlapping of all three knowledges (TPACK) being the ideal. While the TPACK framework is not strictly a diffusion of innovations framework, it is often used to explain the integration of technology by educators. Knowledge of a technology corresponds with the knowledge stage of the diffusions of innovation process, and the TPACK knowledge at the center of the framework corresponds with the implementation phase. Researchers who use this framework to examine technology integration believe that knowledge of how to use a technology must align with a teacher's pedagogical approach within the context of the content being taught. Often, researchers who approach the use of learning games from the TPACK framework argue that educator usage of learning games would increase if (a) educators had more training on how to use games as a learning tool, and (b) educators were more aware of games that aligned with the content they taught.

The TPACK framework and TAM have areas of potential overlap. For instance, the perception of ease of use of a technology may increase as knowledge of a technology increases, or the perception of the usefulness of a technology may increase as the knowledge of how the technology fits with an educator's pedagogical approach increases. Some combination of these frameworks may be a better way of viewing why educators use learning games in their classrooms.

There are other factors beyond these two frameworks that research suggests may affect educator integration of learning games. These include factors specific to the educator, as in demographics and the level of personal experience with digital games. Other factors include external barriers to implementing learning games including a lack of availability, difficulties in using learning games in a timed classroom setting, social pressures against teaching with games, and a lack of fit between available games and the curriculum (Baek, 2008). These barriers may stop educators from using learning games even if they believe learning games are a useful instructional tool and have the knowledge of how to use them. Researchers who focus on barriers argue that removing these barriers would increase the use of learning games.

The research presented in this paper seeks to examine the current state of learning game usage in K-12 classrooms and to evaluate which framework can best predict educator usage of learning games. First, the author will identify if a significant number of educators are choosing to implement learning games in their classrooms on a regular basis. The demographics of educators will be examined to see if factors like age, gender, years of experience, etc., affect the likelihood of an educator using learning games. The research will examine how well TAM and TPACK can predict usage, as well as how these frameworks interact and can be used to improve each other. The effects of additional factors on usage, including personal experience with digital games and barriers to using learning games, will also be examined.

Problem Statement

Researchers of learning games often write from the perspective of wanting to either increase usage of learning games or improve how learning games are being utilized. These researchers often offer suggestions as to how to achieve these improvements. Their recommendations depend upon the framework they use to understand learning game usage, their belief on whether learning games are widely used or underutilized, and their conception of what type of educators use learning games. Because assumptions and approaches in these three areas have a high degree of variability among researchers, the suggestions for improving learning game usage are also varied. Further clarity in these areas will improve the recommendations of researchers and ultimately improve professional development on learning games for educators.

There are conflicting views in the academic literature as to whether learning games are becoming widespread in education or are being underutilized. Two large surveys of educators with sample sizes over 400 have found that over half (55% and 56%, respectively) of K-12 educators are using digital games at least once a week (Fishman et al., 2014; Takeuchi & Vaala, 2014), which seems to suggest that learning games are becoming widespread in classrooms. However, the researchers in both national surveys included ideas for increasing use of learning games in schools, suggesting they, at least, did not feel the level of usage was adequate. In fact, the assumption that learning game usage should be increased is often present in current academic literature. For example, Denham, Maybe, and Boman (2016) approach learning games in education from the viewpoint of how to increase usage. In an even more recent paper, de Freitas (2018) argues that while resistance to learning games from institutions is strong, the benefits of learning games will, at some point in the future, cause learning games to be widely accepted, suggesting they are not currently widely accepted. While a slight majority of educators may in fact be using learning games regularly, many researchers appear to still believe that learning games are being underutilized in education.

Knowing the percentage of regular users of learning games can clarify the current state of diffusion. Rogers' (2003) diffusion of innovations theory categorizes the rate of adoption by the category of adopters. There are five categories of adopters: (a) innovators, who are the risk takers when it comes to using technologies, (b) early adopters, who often have a higher social standing and education than other categories, (c) early majority, who adopt the innovation after early adopters, (d) late majority, who are more skeptical and adopt an innovation after the average member of the target group, and (e) laggards, those most resistant to change. If learning games have diffused to around half of all K-12 educators, that would mean the adoption process of learning games is potentially moving from the early majority adopters to the late majority adopters. If learning games are going to reach a level of usage that many gaming researchers believe is appropriate to the usefulness of the technology, more of the late majority, which is the more skeptical group, will have to begin using learning games. It is also possible that usage is beginning to peak, and the diffusion process will not reach a critical mass of users but will instead begin to slow. Surveys of usage among educators can continue to track the diffusion learning games to give educators a more accurate picture of how often and in what ways learning games are being used in classrooms.

There is further ambiguity as to the type of educators who use learning games. Researchers of learning games often attempt to create profiles of educators who are most likely to use learning games to better understand how learning games are being used and who is using them because understanding these profiles can help inform strategies for increasing usage. These profiles may be created based on what subject or age group educators teach, characteristics of the educators themselves, or how the educators use learning games. The results of Takeuchi and Vaala's (2014) research points to younger teachers and teachers who themselves played digital games being more likely to use learning games. This suggests that learning game usage will increase as the younger generation of educators becomes more prevalent in the teaching profession and strategies designed to convince older educators to use learning games could be the most beneficial.

On the other hand, Fishman et al.'s (2014) research results suggested that elementary teachers were more likely to use learning games than secondary teachers and argued that educator age did not affect which educators utilized learning games, which would make strategies that targeted older educators less practical. The ambiguity over the profile of a typical educator who uses learning games on a regular basis creates ambiguity about the best strategies to improve usage.

Often the biggest factor that influences the suggestions of researchers on improving learning game usage, whether in terms of getting more educators to use learning games or to improve the effectiveness of learning game usage, is the framework they use to understand the integration process. For instance, Sandford, Uliksak, and Facer (2006) conducted a large survey and corresponding case study of educators and students and consistently focused on the generational divide between students and teachers. The findings of the survey suggested that it was technical issues of running games that was the major barrier to usage and their recommendations included educators setting aside extra time to deal with technical issues. However, approaching the issue of usage of learning games from the cost/benefit framework of the TAM model, de Grove, Bourgonjon, and van Looy (2012) found the difficulties in finding learning games that fit specific curriculum to be the primary factor influencing the decision to use learning games. Denham et al. (2016) approached the usage of learning games from the perspective that learning games were being underutilized and very little professional development existed to train educators how to integrate learning games. Their recommendation was for the creation of professional learning groups for ongoing professional development among educators. The differences in these recommendations stems from the framework that each group of researchers chose to view learning game usage.

If researchers of learning games had greater clarity regarding the current rate and type of usage, they may better understand whether to focus on increasing usage or improving the quality of usage. If researchers better understood the type of educator who uses learning games, then it may be clearer why other educators choose not to use learning games. And if researchers knew which factors had the most influence on the integration of learning games, then professional development in the use of learning games could be better designed. Ultimately, research into learning games would benefit greatly from further clarity into all these aspects of the classroom integration process.

Purpose of Study

The purpose of this study is to clarify and explain the current state of educator usage of learning games. The primary method of accomplishing this will be to evaluate two models based upon well-established frameworks, TPACK and TAM, with the purpose of testing the predictive power of each model on actual educator usage of learning games. The individual factors of each model will also be tested to see which elements of the models have the largest impact on the decision of educators to use learning games. Additionally, the overlap and interplay between the models will be evaluated, including combining factors of the models and exploring the correlations between the models. Other factors that occur consistently in current literature on learning games will also be tested, specifically those that fall under the category of barriers to usage and experience with digital games. Further, the rate and purpose of learning game usage will be explored to establish if learning games are underutilized and if the rate of adoption appears to have increased from the approximately 55% weekly rate of two recent surveys (Fishman et al., 2014; Takeuchi & Vaala, 2014). Finally, the question of what type of educator uses learning games will be answered by examining the demographic information of these educators.

Research Questions

To achieve the research objective, the following research questions will be addressed:

1. Has the rate of adoption of learning games increased from previously reported survey results based on the number of educators who use learning games at least once per week?
2. What, if any, are the typical characteristics of an educator who uses learning games at least once per week?
3. Which of the two major frameworks for viewing learning game usage, TAM and TPACK, represents the most accurate viewpoint for researchers?
4. Which factors of the TAM and TPACK frameworks have the greatest impact on the decision of educators to use learning games?
5. What is the interaction and overlap of the TAM and TPACK constructs?
6. Are there other factors outside of the TAM and TPACK frameworks that have a significant influence on educator usage of learning games?

Theoretical Framework

Since the primary focus of this research is the decision of educators to use or not use learning games, this research falls under the category of a diffusions of innovations study. Rogers' (2003) diffusion of innovations theory is the primary theory of this field and is used as an overarching theoretical framework for this study. The two frameworks that are tested in this study, TPACK and TAM, can be understood within the diffusions of innovations theory, at least in how they apply to technology integration.

Two major components of the diffusions of innovations theory that are a focus in this research are the five step stages of an individual's decision to use an innovation and the process of diffusion within a group based on categories of adopters. The five stages of Rogers' (2003) theory are (a) knowledge, (b) persuasion, (c) decision, (d) implementation, and (e) confirmation. Both major frameworks used in this study can be understood in relation to these five stages. For instance, the TPACK framework focuses on knowledge of a technology and on the knowledge of how to implement the technology into an educator's specific classroom. The knowledge of a technology suggested in the TPACK framework corresponds with both the knowledge stage and the persuasion step since the latter step involves gaining a more detailed knowledge of the innovation and how it could be used by an individual. While the TPACK framework does not strictly focus on actual usage of a technology in a behavior sense, the theory does focus on having all the necessary skills and knowledge to make implementation occur. The TPACK knowledge at the center of the framework, where all three knowledges overlap, is meant to be applied to the integration of technologies. The TAM framework focuses heavily on the factors leading up to the decision to use a technology and the actual behavior of using a technology. The knowledge of a technology is assumed and the factors that make up the TAM model fit into the persuasion stage of Rogers' theory.

The additional factors explored in this study also relate to the decision stage of Rogers' (2003) theory. Experience with digital games fits into the knowledge and persuasion stages. Barriers to usage fits into the persuasion, implementation, and confirmation stage, as barriers to usage may cause educators who temporarily implement learning games to become discouraged or disillusioned and discontinue their usage. Whether educators do not use learning games because they have never implemented them or because they decided to discontinue their usage is not a topic addressed in this study.

Rogers' (2003) theory also categorizes adopters based on how soon they decide to implement an innovation. The five categories are (a) innovators, (b) early adopters, (c) early majority, (d) late majority, and (e) laggards. While these specific categories are not used in the survey at the center of this research, there are two important elements of this part of Rogers' theory that are used: (a) the rate of adoption based on percentage of users in a specific community, and (b) the profile of current users of an innovation. One important concept involved in adoption rate is the idea of a critical mass of users being reached at some point between the early and late majority users. After this critical mass is reached, the chances of an innovation diffusing and becoming ubiquitous within a system are very high. Based on two recent studies (Fishman et al., 2014; Takeuchi & Vaala, 2014), weekly usage of learning games by educators is just over 50%, meaning that the diffusion process of learning games has reached the stage where the late majority begin to adopt and may be approaching a critical mass. However, it is also possible that learning game usage will stagnate or lessen and never reach a critical mass. Surveys like the one used in this study that focus on the rate of usage of learning games will help track the progress of diffusion.

The second element from Rogers' (2003) theory used in this research is the idea of profiling the type of users of an innovation. While the first two categories of adopters are more innovative and change-orientated, if the diffusion process has moved into the late majority category then individuals who are currently adopting the innovation will be more mainstream. In other words, if the rate of adoption has surpassed 50% then distinctions between users and non-users may be dissolving as the profile of educators who use learning games begins to resemble the profile of an average educator.

Significance of the Study

This study is significant because it offers insight into how learning game usage in education can be improved by highlighting the frameworks and factors that best explain the integration process. This study is also significant because it measures actual usage of learning games as the dependent variable. Often, studies that use the TAM framework to examine usage of learning games focus on variables other than actual usage, including an intention to use learning games or attitude towards using games. In a 2017 meta-analysis of quantitative learning games research that used the TAM framework, Wang and Goh identified 50 peer-reviewed articles published between 1989 and 2016 that tested digital game usage and the TAM model. Of these 50 articles, only eight used actual usage as a dependent variable. Studies that relate TPACK to predicting actual technology use are even more rare, with most quantitative TPACK studies focusing on measuring or further developing TPACK in educators (Voogt et al., 2012). In a 2013 review of 74 peer-reviewed articles on TPACK research, Chai, Koh and Tsai identified only four quantitative studies that incorporated TPACK and actual usage of technology by educators. The author's own search on the subject found only one additional recent study on TPACK that focused on usage, but the sample used pre-service teachers and the dependent variable was intention to use, not actual usage (Joo, Park, & Lim, 2018).

Definition of Terms

This section seeks to clarify how the author intends certain terms to be used within this document. The terms are defined within the context of this study.

Computer-Based Technologies

Any of a group of technologies, whether physical tools or innovations, that use computing technologies as a primary means of functioning.

Diffusion of Innovations

The acceptance and use, or lack of acceptance and use, of a technology by a social group.

Experience with Games

Unless otherwise noted, in the context of this study experience with games means experience with digital games outside of a classroom setting, usually for purposes of enjoyment.

Feedback

Communication that results from another communication or action and seeks to clarify the value, correctness, result, or consequence of the previous communication or action.

Improving the Usage of Learning Games

This is a broad term that ultimately is defined by the goals of researchers or educators. The author intends the phrase to include the following possibilities: (a) increase the number of educators using learning games, (b) increase the amount of overall usage of learning games, or (c) improve how learning games are being used. The last phrase can refer to using learning games in a way that improves the chances of students learning from them or simply makes learning a concept easier or more enjoyable.

Interactivity

The level of presence of a feedback loop between an individual and an object, including computer-based technologies and learning games.

Learning Games

In the context of this paper, "digital learning games" and "learning games" will refer to digital games used in classroom environments, virtual or traditional, for helping students achieve learning objectives, either directly or indirectly.

Technology

While the term technology can be very broad, because of the purpose of this study the term in this paper refers to computer-based tools and the process of using them.

Zone of Proximal Development

The theoretical range of difficulty that a learner can be reasonably accepted to attempt in order to grow in their understanding of a topic or skill.

Assumptions and Limitations

Assumptions

Because the survey was conducted online, the author is operating under the assumption that the respondents were, in fact, currently practicing K-12 educators. The author attempted to limit the possibilities of those outside of the target population from responding by sending most survey links to educators with current school email addresses. Survey links were also sent out to graduate education programs that would have a sizeable number of current educators enrolled. However, there is ultimately no surety that all respondents were current educators. As with all self-reported survey data, there is an assumption that respondents were truthful and accurate in their answers. Finally, there is the assumption that the survey questions measure the underlying constructs for which they are intended. This assumption is backed as much as possible with academic research and by statistical procedures, as is detailed in the following chapters.

Limitations

The study has several limitations that need to be addressed. The first limitation is the scope of the sample of educators used in the study. Because of professional connections of the author, a sizeable plurality of respondents come from a rural school district in the Southeast United States. The percentage of respondents from this demographic likely is significantly higher than should be represented in a sample of all K-12 educators in the United States. Further, the intention of the study was to be domestic to the United States and the results may not extend internationally.

The second limitation is the online nature of the survey used for data gathering. First, this limited the respondents to educators who are comfortable and willing to take a survey online, which may eliminate educators who are less comfortable using computer technologies. Second, the online and subsequently anonymous nature of the data gathering does create the possibility that respondents did not answer truthfully, may not have fully understood the questions, or may have been selecting responses without taking the time to fully read the questions. All possible methods of identifying suspect responses and of making the survey easy to understand were used to combat these issues.

Finally, like many similar survey-based research projects, the results may have a bias based on who chooses to take the survey. It may be that educators who use learning games were more likely to respond to the survey, inflating the data on how often educators are using learning games. However, a response bias, while it should be acknowledged, is nearly unavoidable in survey-based research.

Conclusion

Research suggests that learning games have the potential to be valuable learning tools for K-12 educators. Socially, digital games have become increasingly ubiquitous, especially with the increased access and use of smart phones. Researchers in the field of learning games generally want to increase the diffusion of learning games and improve their usage in education. However, the literature about learning game usage is ambiguous on several important issues: (a) whether learning games are becoming widespread in education or are underutilized, (b) what type of educator is using learning games on a regular basis, (c) which major theoretical framework is best suited for understanding learning game usage in education, and (d) whether additional factors have a significant effect on an educator's decision to use learning games. This study seeks to clarify the current state of educator usage of learning games by addressing each of these concerns. Results from this study can inform recommendations on how to best improve the usage of learning games in education.

CHAPTER TWO: LITERATURE REVIEW

In this chapter, the author will report on the current literature about the following relevant topics: the potentials benefits of learning games in the classroom, Rogers' theory on the diffusion of innovations, the Technology Acceptance Model (TAM) and its application in the field of learning games, the Technological Pedagogical Content Knowledge (TPACK) framework and its application in the field of learning games, and additional factors that other researchers have suggested may influence the use of learning games. The purpose of this brief literature is twofold: first, the literature review will contextualize the current study and demonstrate how it fits into the current academic discourse on learning games. Second, the literature review will give credibility to the decisions made by the author in the proposed study regarding the frameworks and factors used in the research.

The Potential of Learning Games in Education

The choice of the author to conduct a study of learning games comes from a belief that learning games have the potential to be effective teaching tools. This is not to say that learning games should be used in classrooms or will be more effective than other approaches, simply that there are attributes of learning games that give them the potential to be effective and therefore have enough educational value to justify being researched. The following section will focus on the attributes of digital games that could be leveraged to make learning games effective teaching tools, as well as different pedagogical approaches that can benefit from the use of learning games.

Attributes of Digital Games

Digital games have a unique set of attributes which can be used to help learners achieve objectives in classroom settings. While the individual attributes of digital games are not necessarily unique to games, it is the combination of these attributes that makes digital games an intriguing learning tool that can be used in various situations to increase student engagement and comprehension. While digital games vary by design, in general digital games are interactive, multimedia experiences involving a student, a computer-based technology (i.e., laptop, mobile device), an interface, and the software that contains the game. Through the interface, the player interacts with the game, responding to frequent positive and negative feedback from the game. According to Whitton (2014), games involve some sort of meaningful challenge for the player to overcome. Generally, games are played as a form of entertainment, and because of this typical use, it is reasonable for students to expect there to be some level of entertainment involved in playing a game, even one designed to achieve learning goals. This can increase the motivation of students to use learning games. The next sections will look more closely at the attributes of learning games and how these attributes can influence student learning.

Interactivity

One of the defining attributes of digital games is their interactivity. When students are playing a learning game, they are engaged with the gaming interface through a series of player inputs and feedback from the gaming system. This engagement is a positive attribute of learning games because engaged learners perform better academically than unengaged learners (Lee et al., 2016). A recent meta-analysis suggests that active learning produced better student results on similar assessments and a lower failure rate than passive, or lecture-based, learning (Freeman et al., 2014). However, being engaged with a learning game does not necessarily mean that players will be engaged with the target learning objectives. Students may be engaged with the gaming interface without being engaged in the content area, especially when the learning objectives are peripheral to the core gameplay. Habgood and Ainsworth (2011) conducted a study to see the value of integrating math learning objectives into the core gameplay of a digital game. Their results suggested that not only did the integrated version of the game lead to higher learning gains, but the primary-level students in the study were more motivated to play the content-integrated version of the game. Player engagement is an attribute of digital games; however, good instructional design suggests that this attribute must be leveraged to maximize learning potential.

Feedback

On a very basic level, players act upon a digital game through the physical controls (i.e., keyboard) and through the interface of the computer. Interactivity occurs when the digital game reacts to the actions of the player. When the digital game responds to the player's actions, feedback occurs, and the player responds to this feedback. Whitton describes this process: "At the heart of every computer game is a mechanism for providing feedback to the player; the player takes an action and sees a reaction from the computer within the game; the player then evaluates the consequences of that reaction and makes another action" (Whitton, 2014, p. 148). This constant feedback loop is the essence of the interactivity of digital games and even separates digital games from non-digital games, which require the players themselves to create the feedback, whether through reacting to each other's actions or following the rules of the game. As an example from digital games, a player pushes a button and their avatar slices through blades of glass, revealing a gem with a monetary value. Based on this positive feedback, the player spends a considerable amount of time slicing through blades of grass in hopes of collecting more gems. This type of feedback is essential for the player to learn from the game and adapt her playing style. When learning games are designed with the content integrated into the core mechanics of the game, this feedback can be used to tell the player how well she is learning the content, which is more like the traditional educational definition of feedback. In a review of previous meta-analyses and studies, Hattie and Timperley (2007) describe feedback as one of the five largest influences on student achievement, based on effect size, although the effect size was moderated by the type of feedback. According to Hattie and Timperley, effective feedback answered the questions of where the student is in relation to a goal and to achieving that goal, how they can achieve that goal, and where to go after they achieve that goal. Similarly, the feedback that digital games give players often direct them towards a goal (although the overarching goal may not necessarily be known but revealed along the way), explains the next step towards achieving the goal, lets them know when they have achieved that goal, and lets the player know what to do next. Digital games can also keep track of learners' actions in a way that can inform both the player and a teacher of the student's experience interacting with the game. This can highlight strengths, weaknesses, interests, progress, and other information obtainable from monitoring student/game interactivity (Dexter, 2009). A well-designed learning game will give players quality feedback in a way that will not interrupt the flow of the game and will increase the transfer of knowledge out of the context of the game itself (Dunwell, de Freitas, & Jarvis, 2011). Erhel and Jamet

(2013) detailed an experiment where they framed a learning game as an entertainment game to a group of students during two experiments. In the first experiment, the students did not obtain the learning objectives; however, after adding a correct-response feedback element to the game, the "entertainment" group in the second experiment did experience learning gains. Feedback is an important part of the learning process and is an integral part of the interaction between a digital game interface and a player.

Simulations

Digital games can be considered simulations because they are an interactive multimedia experience, often with the added element of a challenge. The combination of these attributes makes digital games an especially good media for allowing students to conduct risk-free exploratory learning of content areas that would not be reasonably possible outside of a digital simulation (Becker & Parker, 2009). Digital games can simulate other time periods, running a business, flying a plane, brokering peace in the Middle East, or can even represent relatively abstract theories and scientific laws in concrete ways. Anderson and Barnett (2013) describe the use of the digital game *Supercharged!* to teach middle school students electromagnet concepts. The game simulated a spaceship that was maneuvered by manipulating the magnetic charge of the ship as it passed other objects with different positive and negative charges. Data from the study showed that the students who played *Supercharged!* scored higher on a posttest than students taught with a more traditional inquiry-based lesson.

Adaptability of Difficulty

Many digital games, either for entertainment or for learning, are designed to adapt the game difficulty based on the skills of the player, often by creating progressively harder challenges for players to overcome. By adapting the difficulty, well-designed digital games keep the challenge level appropriate to the player's skills. While not an intrinsic characteristic of all digital games, the practice of adaptive difficulty is prevalent enough to be considered an attribute of digital games in the sense that this adaptability is expected by players. A digital game that does not adapt game difficulty to the player will either initially be too difficult, causing frustration on the part of the player, or, if difficulty does not progress with the increasing skills of the player, will eventually become too easy and motivation to play will lessen. Digital games can adapt their difficulty by increasing difficulty at set intervals, by adjusting according to player performance, or by allowing players to adjust the difficulty setting themselves (Sampayo-Vargas, Cope, He, & Byrne, 2013). A notable exception to this rule is games where players compete against each other, although it can be argued that players will often seek out other players of similar skill sets to maintain an appropriate level of challenge for their interest.

The adaptability of difficulty in digital games makes them ideal learning systems because it ties into a learning theory known as scaffolding. Scaffolding is built on Vygotsky's theory of the Zone of Proximal Development (1930), which suggests that children will learn best when they attempt tasks that they can succeed at with some assistance. Scaffolding is a teaching strategy of giving students just enough necessary support to complete a task. As a student's skills increase, the support is withdrawn until a student can accomplish a task independently; at this point, a new task that challenges the student should be introduced so the student is always working within their Zone of Proximal Development (Wass & Golding, 2014). By adapting the difficulty of the gameplay and providing players with the support they need to overcome the next challenge, well-designed digital games align with the teaching practice of scaffolding.

Risk-Free Failure

Digital games have made failure an integral part of their gameplay. This correlates with the concept of interaction and feedback; players learn to play the game by receiving positive and negative feedback from the game. Even if a losing situation is achieved by a player, digital games often employ some method so the player does not lose all of his or her progress, whether through save points, restarting a level, or respawning. Failure has become an attribute of digital games because players do not expect to go through an entire game without encountering some level of failure. The challenge of digital games, and some of the motivation to play digital games, is connected in part to the chance of failure. Digital games train players to fail and repeat a process until they get it right, and in doing so make failure an integral part of the learning process (Baek, 2009). Whitton (2014) argues that this is attitude towards failure is different in formal educational settings, where students view failure as a very negative experience. This is problematic in education because repeating a process until it is correct is important to learning. While digital games have developed in a way that players who interact with the game expect some level of failure and negative feedback, learners in formal learning environments perceive failure and negative feedback as something to avoid. Because of this, learning games have the potential to reshape learner concepts of failure.

Motivation

Digital games are becoming increasingly popular as more and more individuals choose to play them in their free time. It can be reasonably argued based on the proliferation of digital games that there is something intrinsic about digital games that motivates people to play them. According to Lee et al. (2016), motivation and engagement are different constructs that both positively impact student achievement. While the exact causal mechanism of motivation is debated, motivation is the desire or the drive to do something. This can be internally motivated (because someone wants to do something) or externally (i.e., to please parents, stay out of trouble, get good grades, etc.), although some theories of motivation do not distinguish between these two types. Motivated students typically perform better than unmotivated students, partly because students generally show increased persistence in difficult tasks when they are motivated to finish them. Although pinpointing which attributes of digital games motivate students to play them can be difficult, two prominent theories which explain the motivational draw of digital games are flow theory and self-determination theory.

Flow

One possible explanation of the motivational draw of digital games is the psychological concept of flow, which is characterized as a highly-productive absorption into a task. When experiencing flow, which is usually a desirable experience, an individual loses a sense of time (Nakamura & Csikszentmihalyi, 2002). Whitton describes a flow experience as one that "has a challenge that requires skills with an attainable goal and known rules, clear goals, and immediate feedback" (Whitton, 2014, p. 79), all common characteristics of digital games. Research has shown that flow can occur while playing digital games, including digital games for learning. Chen and Sun (2016) examined the state of flow in a music-based game and found roughly half of the players experienced flow during each of the seven levels of the game. They attributed the flow experience partly to the game having clear goals and giving immediate feedback. Takatalo, Häkkinen, Kaistinen, and Nyman (2010) created a model for user experience during gaming based on their study of Finnish players and included flow as one of the primary components in an overall engagement model. The concept of flow is at times indistinguishable from the concept of immersion in a game, a word frequently used to characterize user experiences in digital games (IJsselsteijn et al., 2007). While the exact causal mechanisms may not be known, research into digital games has provided evidence that a state of flow can be a frequent user experience. Further, Engeser and Rheinberg (2008) suggest that experiencing flow can have a predictive and positive influence on performance. If learners experience flow while playing a learning game that focuses on the desired content, overall performance on the learning objectives may be improved.

Self-Determination Theory

Self-determination theory (SDT) offers another explanation for the possible motivational draw of digital games. SDT is a motivational theory that focuses on elements that either increase or decrease motivation (Ryan, Rigby, & Przybylski, 2006). Specifically, SDT argues that a sense of autonomy, competence, and relevance all positively impact motivation. Ryan et al. hypothesized that people are motivated to play digital games in part because it fulfills their need of autonomy, competence, and relevance. Well-designed digital games often offer a sense of competence to players by starting out simple and gradually increasing the difficulty level (Whitton, 2014). While a sense of autonomy can come from deciding to play a digital game, gameplay itself can give players a sense of autonomy by allowing freedom of actions. Large, open-ended games like *World of Warcraft* offer the greatest sense of autonomy, but most digital games give some sense of control to players because the interactivity/feedback loop is guided by the decisions made by the players. Studies done by Ryan et al. support the idea that games which satisfy player emotional needs of autonomy and competence tend to increase the motivation to play them.

Types of Learning Afforded in Digital Games

While the previous section examined attributes of digital learning games that make them potentially good learning systems, this section will examine the different types of learning that digital games support. The level of interactivity that digital games allow affect what kinds of learning can occur in digital games. While players and digital games are constantly interacting, some games allow for different levels of manipulation and control of the environment. Toro-Troconis and Partridge (2010) describe different factors of digital games that affect the experience of players and the kinds of learning the digital game supports. These include the level of learner control, the amount of collaboration emphasized and allowed, and the immersiveness and interactivity of the game. Several different types of learning are discussed below in relation to the level of interactivity that the game allows, as well as how digital games can leverage attributes of digital games to encourage and support different approaches to learning.

Experiential Learning

Because digital games offer a risk-free environment for failure, they are ideal for experiential learning in areas where failure should be avoided. Experiential learning is a learning theory that suggests that all learning is grounded in the experience of the learner; the learner transforms experience into knowledge (Kolb, 1984). By giving learners access to authentic experiences, the theory argues, more authentic learning can occur. Yet while failure can be good for learning, the cost of failure in areas like medicine, war, flying an airplane, and even teaching is often too great to allow learners to fail in authentic environments. Digital games offer opportunities for learners to learn by doing through interacting in environments that are modeled after real, or non-virtual, world situations. This can help increase a transfer of learning and allow learners to apply theoretical understandings to reality-based environments (Baek, 2009). According to Becker and Parker (2009), digital games, and specifically simulations, are the best alternative to learning in the real world because of their interactive and immersive nature coupled with the ability to represent consequences of actions in a risk-free environment. They argue that this is true even while acknowledging that all simulations are representations of beliefs of reality and are ultimately biased. In instances when using a real-life experience as the medium for teaching can be dangerous or impractical, digital games offer a form of experiential learning that allows a level of interactivity between the learner and the object to be learned that would not otherwise exist.

Digital games can also create experiences grounded in both reality and theory that would be impossible to replicate in the real world. For instance, digital games can transport learners to different times in history or can change perspectives of size to allow players to interact with animal and plant cells. By allowing players to assume alternative identities, digital games can allow experiential learning to occur from different perspectives. In summary, digital games are excellent platforms for experiential learning because of their interactivity, immersiveness, and ability to represent authentic experiences that for practical reasons would be too costly, dangerous, irresponsible, or impossible for learners to experience in any other way.

Problem-Based Learning.

Digital games vary in how open-ended they are regarding player choice and options in actions. One subset of games that can be characterized by an open-ended, expansive environment are role-playing games, especially games within the category of massively multiplayer online role-playing games (MMORPGs). Because these digital games allow players to interact with the environment in numerous ways, they can support problem-based learning. According to Dochy, Segers, Van den Bossche, and Gijbels (2003), problem-based learning should be student-centered and self-directed, and the problems encountered in the learning environment should be used to acquire knowledge and skills. The gameplay of digital role-playing games conforms to these characteristics by often allowing players to choose how to solve problems and what problems to solve. Each problem solved, or task completed, usually adds to both a player's skills and knowledge of the environment. MMORPGs tend to encourage players to form small groups to overcome challenges, another defining characteristic of problem-based learning. In their meta-analysis, Dochy et al. (2003) found evidence that problem-based learning had a positive influence on both student knowledge and how to apply that knowledge. Chaka (2010) describes a multiplayer role-playing game called *NUCLEO* that presents the players with various open-ended, complex problems that each group of players must overcome to win. This type of problem solving is only possible in digital games when the players can interact with the environment in numerous and novel ways to overcome the problem.

21st Century Skills and the Common Core

Digital games have several characteristics that make them good candidates for teaching students 21st century skills. The Partnership for 21st Century Skills (2011) published a guide aligning 21st century skills to the Common Core Curriculum, which is followed in 42 states (Common Core State Standards Initiative, 2017). The characteristics of digital games can be used in many of the areas where 21st century skills align with the Common Core. First, both emphasize the use of computer technology and media; simply by being a digital, computer-based technology, digital games align with this criterion. Digital games also promote student growth in critical thinking and communication (Whitton, 2014), self-direction (Lee, 2013), and even global awareness (Pacheco, Motloch, & Vann, 2006). Digital games can promote these skills because of the attributes already mentioned: games are able to immerse students in problem-solving situations, create social and cultural situations, and simulate real-world models.

Current academic literature on learning games supports the idea that learning games have the potential to be influential learning tools. The attributes of digital games align with important characteristics of good learning tools, including feedback and interactivity. Learning games give educators new ways to teach content, including experiential learning and problem-based learning. Current literature suggests that educators have many reasons to use learning games as instructional tools in their classrooms. Yet it appears from how the literature approaches learning game usage that many researchers believe learning games are being underutilized in education. If learning games are to make a meaningful impact on K-12 education, something more must happen other than simply recognizing the potential benefits for using learning games.

Diffusion of Innovations

While understanding the potentials of learning games as instructional tools helps justify the importance of this study, this research is focused on whether educators are using learning games and what factors are affecting the implementation process. In this sense, this research is studying the diffusion of an innovation (learning games) into a social system (K-12 schools). This section of the literature review focuses on the major theory of innovation diffusion, Rogers' (2003) diffusion of innovations. The two major frameworks used in this study, TPACK and TAM, fit into the conceptual paradigm of Rogers' diffusion theory. Organizing the research around the diffusion of innovations theory will provide a strong academic backing and establish a rationale for using the chosen frameworks.

Rogers' (2003) diffusion of innovations theory is focused on the adoption or rejection of an innovation by a social system. Diffusion is the process of communicating an innovation through a social system. Because diffusion deals with innovation, it is communication with the purpose of social change, which brings with it some degree of uncertainty (p. 5-6). Rogers defines an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12). The word innovation is used synonymously with technology, although Rogers defines a technology as "a design for instrumental action that reduces the uncertainty in the cause-effect relationship involved in achieving a desired outcome" (Rogers, 2003, p. 13). Rogers also explains that a technological innovation should benefit the adopters in some way or solve some problem that the adopters face. The previous section of this literature review has established that learning games have the potential to benefit educators. However, it is not enough to simply be beneficial; an innovation is usually meant to replace something else. Innovations that are perceived by adopters to have a relative advantage over what they are meant to replace have a better chance of being adopted. To increase their chances of being adopted, learning games must be perceived by educators to be more advantageous than another learning tool that could be used instead. Innovations must also have some degree of compatibility with the social system in which they are being adopted. The greater the compatibility of an innovation, the better the chances of being adopted. Another factor affecting the likelihood of an innovation being adopted is the potential adopter's perception of the innovation's complexity. The more difficult potential adopters perceive an innovation is to understand or use, the less likely it is to be adopted.

The innovation is not the only element of the diffusion process that matters; innovation diffusion requires a human element. Rogers (2003) defines diffusion as a process of communication between an individual with and an individual without knowledge of an innovation. In the case of learning games, this communication may occur through professional development courses, educational degree programs, from peer to peer in educational systems, or through online forums. This knowledge of an innovation is the first of five stages that Rogers identifies in the decision process that potential adopters go through when deciding whether to adopt an innovation. A diagram of this acceptance process is seen below (Figure 1).

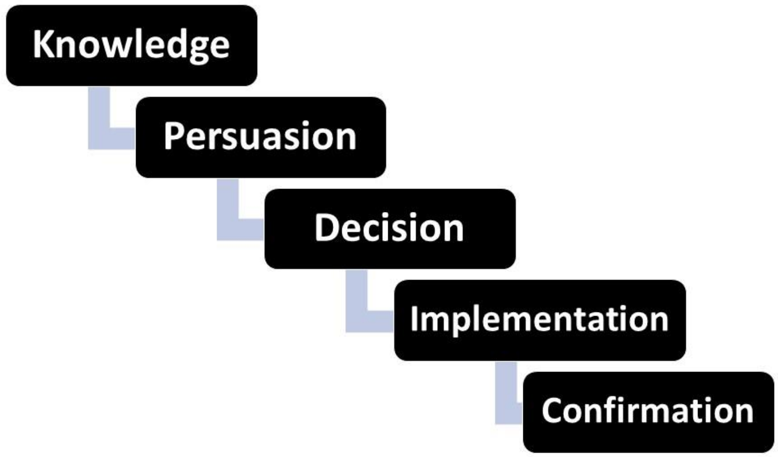

Figure 1. **Rogers' Five Stages of the Innovation Acceptance Process**

The five stages are as follows: (a) knowledge, (b) persuasion, (c) decision, (d) implementation and (e) confirmation. Knowledge does not simply mean being aware of an innovation, but also having some level of understanding of how the innovation works. In the persuasion stage, the adopter looks at how the innovation may or may not be beneficial for their specific situation and begins to perceive the innovation with a positive or negative attitude. The third stage is the decision process, where the potential adopter decides to adopt or reject an innovation. The fourth stage is implementation, which involves the actual use of an innovation. The final stage is confirmation, where an adopter decides to continue or discontinue the use of an innovation. In this research, the focus is on current implementation, or use, of an innovation. If learning games are not being implemented, it is beyond the scope of this research to differentiate whether this is because they were rejected at the decision stage, discontinued during the confirmation stage, or were adopted in the decision stage but not yet implemented.

Rogers (2003) identified the social system as another element in the diffusion of an innovation. He defines a social system as “a set of interrelated units that are engaged in joint problem solving to accomplish a common goal” (Rogers, 2003, p. 23). This research is focused on the social system that is the K-12 educational system in the United States, which are interrelated units that are focused on the general goal of educating children, along with numerous other goals as defined by federal, state, and local requirements and expectations. According to Rogers, the social system can “facilitate or impede the diffusion of innovations” (2003, p. 25). Individual schools vary regarding how much an innovation like learning games are welcomed in a classroom. Schools who make less use of the technology cluster of computer technologies may present more barriers to an educator who is interested in adoption learning games than a school where computer use is much more prevalent in the classroom. Schools may also differ in how much autonomy an educator has in his classroom. Rogers differentiates between three types of innovation decisions based on who has the power to make the decision. The first is the optional innovation-decisions, where the individuals within a system get to make the decisions. While most K-12 teachers are given a curriculum with detailed objectives they must reach, they often have some degree of leeway in how they choose to reach those objectives. The next type of decision making is collective, where members of the system decide together and then all individuals within the system must abide by the decision. An example of this might be a group of educators who teach the same curriculum deciding to choose uniform methods of reaching their objectives so the experience in each classroom is similar for all students. The final type of innovation decision making is authority, where individuals with power in the system make the decisions. For learning games, an example could be a principal deciding that educators should not use learning games in their classrooms. It is the author's own experience that educators fall under the category of optional decision making within the confines of set objectives, but all three types of decision making are likely present in the K-12 system. While the research here is focused on individual responses of educators, examples of educators having to use or refrain from using learning games because of authority-based decisions outside of their control may be made evident through their responses regarding the construct of perceived barriers, which will be addressed towards the end of this chapter.

Re-invention is another concept from Rogers' (2003) diffusion of innovation theory that is relevant to the diffusion of learning games. Re-invention occurs when adopters use an innovation in a way that is useful to the adopter but is not the original purpose of the innovation. The easier it is for an individual to customize an innovation to a specific need, the more likely the innovation is to be adopted. Learning games are very versatile and an imaginative educator can utilize them in a variety of ways. One example is the use of the commercially-popular *Civilization* series, which was intended to be used for entertainment, by social studies teachers to teach students about history, culture, and interactions. Another re-invention is to use learning games not to teach an objective but as a reward to motivate students to finish other assignments. This use of digital games in a classroom stretches the definition of learning games, but that is precisely what re-inventions do. The survey instrument used in this study will focus on the implementation of learning games in any way, and then focus more specifically on how the learning games are used.

According to Rogers (2003), one of the major criticisms of diffusion research is a pro-innovation bias on the part of researchers. It cannot be assumed that learning games should be adopted by educators, regardless of the potential that learning games have as learning systems. While educators may choose not to adopt an innovation because of ignorance or because outside barriers prevent them from doing so, other educators may choose not to adopt learning games because rejection is the most rational and efficient path of action, based on the educator's perception of learning games and their specific situations. This research seeks to know if learning games are being implemented and what elements most affect the choice of implementation without passing judgement on the decisions made by educators.

Rogers' (2003) diffusion of innovation is a useful paradigm to help conceptualize how the different parts of this research fit together. While this overview of Rogers' theory is not intended to be exhaustive, it is intended to illustrate how this research fits into the broader diffusions of innovations research. The author will refer to the diffusion of innovations theory throughout the literature review as necessary to illustrate how the different parts integrate into Rogers' theory.

TPACK

In this section, a knowledge structure framework known as Technological Pedagogical Content Knowledge (TPACK) will be examined. This section of the literature review is relevant because TPACK is one of the two major frameworks at the focus of this study. TPACK is often used to explain the knowledge required by teachers to integrate technology successfully in the classroom. This literature review includes the history of TPACK, research into TPACK and technology integration, and finally research into TPACK and learning game integration.

History of TPACK

The TPACK paradigm can trace its academic roots to at least 1986, when Shulman (1986) argued that teacher pedagogy and teacher content knowledge should not be treated as distinct knowledges, as was the current practice of both educators and policy makers. In fact, according to Shulman, only in the past century had this distinction been made. Shulman proposed a theoretical framework with three knowledges: content knowledge, pedagogical content knowledge (PCK), and curricular knowledge. In 2009, Koehler and Mishra adapted Shulman's theoretical framework and applied it to the field of educational technology. Their framework included three knowledges: knowledge of academic content, knowledge of pedagogy, and knowledge of technology, as well as the interaction between these knowledges. Figure 2 below shows how Koehler and Mishra believe these knowledges interact. Each knowledge has overlaps with other knowledges, with the center of the diagram showing all three knowledges overlapping, a knowledge known as technological pedagogical content knowledge. Teachers who can successfully integrate technology into their classrooms to teach a specific content would exemplify the knowledge structure at the center of this diagram.

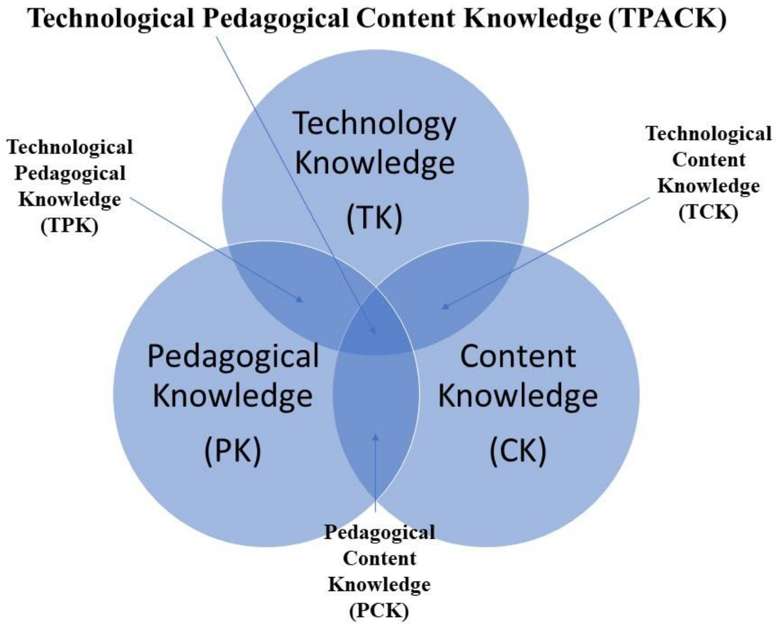

Figure 2. TPACK Framework

Content Knowledge (CK) is a teacher's knowledge of the content they are teaching. Pedagogical Knowledge (PK) is a teacher's general knowledge of how to teach, regardless of the subject being taught. These two knowledges overlap whenever a teacher instructs students in a specific content. This knowledge is an interaction between both a teacher's understanding of content and how to best teach that content. Technological Knowledge (TK) is knowledge of how to use a technology and how it can be applied to an individual's lifestyle and actions. The addition of TK adds several elements to this knowledge base. Technological Content Knowledge (TCK) refers to a teacher's knowledge of how technologies can be applied to a specific discipline. Technological Pedagogical Knowledge (TPK) is the general knowledge of how technologies can be used to benefit teaching and learning. Finally, Technological Pedagogical Content Knowledge (TPACK) is the knowledge of how to successfully use technology to help teach the content and learning objectives of a specific course.

Two broad literature reviews were conducted on the TPACK model in recent years. The first is by Voogt, Fisser, Roblin, Tondeur, and van Braak (2012). The second is by Chai, Koh, and Tsai (2013). A summary of these literature reviews explains how the TPACK framework is currently used and understood in academic literature.

Voogt at el (2012) chose 55 high-quality papers, as judged by the researchers, on TPACK to conduct their literature review. The researchers then sorted papers two separate ways: once by theoretical basis, followed by subcategorization of these, and once by practical basis. The variation in TPACK studies that Voogt et al. (2012) detail in their literature review demonstrates the variety of understandings of and approaches to TPACK. According to Voogt et al. (2012), variations in theoretical approaches to TPACK began almost simultaneously with the popularization of the idea. Some researchers saw TPACK as an integration of technology with pedagogy and content knowledge, while Koehler and Mishra (2005) viewed TPACK as developing out of the three different knowledge bases and all their intersections. However, Voogt et al. argue that studies which have used EFA have failed to show a clear distinction between the many types of knowledges that Koehler and Mishra contend exist. Other researchers viewed the representation of TPACK at the center of the diagram as a knowledge base distinct from the other three components. Further, Voogt et al. pointed out differences in how researchers defined TK, or technology knowledge. Researchers defined the technology aspect of TK as either knowledge of digital technologies, knowledge of emerging technologies, or knowledge of all technologies. The knowledge aspect of TK was interpreted three different ways by researchers: (a) how to functionally use a technology; (b) how to use a technology to teach; or (c) how to use technology to achieve specific professional and personal goals.

In the articles that Voogt et al. (2012) reviewed, a recurring concept was the need to develop the TPACK of educators. This appears to be motivated by an assumption that educators have underdeveloped TPACK, even though the measurement of TPACK is not a straightforward task. Of the articles that Voogt et al. (2012) reviewed that attempted to measure TPACK, only a few provided details as to the instrument used. Eleven of these studies used a self-assessment survey with a Likert-scale, while four measured TPACK by reviewing performance demonstrations. To assist in the development of TPACK, researchers made the following suggestions: (a) educators be involved in developing curriculum that uses technology, (b) educators receive modeling on how to use technology to teach; (c) educators learn the concepts of how technology can be incorporated into a subject matter and how it affects learning. Regarding this last suggestion, very few studies focused on TPACK in specific subject matters. Voogt et al. (2012) highlighted the study of TPACK in specific subject matters as a research need moving forward.

In their literature review of TPACK, Chai, Koh, and Tsai (2013) begin by taking a stance on the concepts and definitions that Voogt et al. (2012) highlighted as having some contention among researchers. In agreement with Koehler and Mishra (2005), Chai et al. view the knowledges of TPACK as distinct, and they view TK as the knowledge of computer technologies, since they believed that including all technologies would make TK less meaningful. 74 papers were chosen by Chai et al. (2013) to be included in their literature review. Of these, nine were theoretical. These theoretical papers did not present criticisms of TPACK but instead supported the framework and suggested that the framework be used in developing educator TPACK. 55 of the papers were data-driven research, with about 60% of these being quantitative. Nine of the papers were case-studies. Findings from the case studies included the importance of understanding how students view technology and how student learning was enhanced when educators used the TPACK framework to integrate technology. However, the research did not support the idea that the use of technology would change pedagogical approaches from teacher-led to student led; educator pedagogical approaches did not tended to change when they integrated computer technologies into their classrooms. Chai et al. wanted to see TPACK expanded to differentiate between the different pedagogical uses of technology, regarding student-led learning as a superior use of computer technologies in schools.

According to Chai et al. (2013), many of the papers included in their review were intervention papers, meaning that the research presented in the paper was intended to improve the TPACK of educators. Most of these interventions included having educators design lessons using a computer technology. A large majority of these papers presented positive outcomes to the interventions. The current research will address this approach to technology integration by examining if a lack of knowledge of integrating learning games has a significant effect on learning game usage. Finally, Chai et al. highlighted the problems in measuring TPACK. Again, relatively few studies attempted to measure TPACK, and all these used self-reported surveys, but many suffered from validation problems. Chai et al. argue for the need to develop valid instruments to measure TPACK and to further develop valid instruments to measure the TPACK of specific subjects, pedagogical approaches, and technologies.

TPACK and Technology Integration

In technology integration research, the TPACK framework is used in at least three ways: (a) to evaluate the technological integration of educators, (b) to improve the technological integration of educators, and (c) to reflect on, or understand, the technological integration of educators. Researchers use the TPACK framework with both pre- and in-service educators and often approach their research with the attitude that technology integration should be increased and improved. Each of these uses of the TPACK framework will be discussed below in more depth.

Evaluating the TPACK of Educators

Researchers who use the TPACK framework to evaluate the technology integration of educators focus either on the knowledge of technology integration itself or on the practical usage of technology in the classroom. When focusing primarily on knowledge separate from usage, self-reported surveys of aptitude or knowledge tests are often used. Researchers who wish to evaluate the TPACK of educators based on usage often observe technology usage and then use evidence from the observation to categorize and quantify the TPACK of the observed educators. Other researchers use some method to score both TPACK separate from usage and technology integration in an educational setting and compare the results of both measurements. The following paragraphs detail studies that seek to measure the TPACK of educators in these ways.

Self-reported TPACK scores are often a quick way to measure the TPACK of educators. Archambault and Crippen (2009) surveyed the self-reported TPACK proficiency of almost 600 online educators in the United States on a scale of one to five. The average score for all items was 3.81, suggesting that online educators have obtained a high level of the TPACK knowledge base. Scherer et al. (2018) sought to measure the TPACK of pre-service educators and compare it to their attitudes towards information and communication technologies (ICT). Their research method involved using an online self-reporting survey of self-efficacy beliefs towards TPACK and ICT. On a scale of zero to four, the pre-service educators rated themselves between 2.5 and 2.7 on all elements of the TPACK domain. The researchers were able to demonstrate a high correlation between attitudes towards ICT and self-efficacy attitudes of TPACK.

Liu, Tsai, and Huang (2015) studied technology integration in a case study of pre-service teachers completing their field practice and their mentors in a public-school setting in Taiwan. Liu et al. approached their research from the standpoint that educator professional development programs do not adequately train teachers how to integrate technology into classrooms. The pre-service teachers and their mentors were encouraged to use technology in their lessons, and this technology integration was subsequently evaluated by Liu et al. through classroom observations. The evaluation tool used was based on the TPACK framework and measured the three overlapping domains of technology content knowledge (TCK), technology pedagogical knowledge (TPK), pedagogical content knowledge (PCK) and ultimately TPACK, the combination of all three knowledge domains. The results of the case study showed that the mentor teachers primarily integrated technology with PowerPoint, and some were influenced by the pre-service teachers to begin incorporating animations into their presentations. The researchers concluded that the influence of the younger pre-service teachers, whom they believed had more experience with technology, improved the TCK of the mentor teachers. The pre-service teachers were able to practice the use of technologies they knew in actual classroom settings and subsequently improved their technology integration from just technology knowledge (TK) to technology content knowledge (TCK) and technology pedagogical knowledge (TPK).

Jen et al. (2016) separated technology integration from TPACK knowledge in a study of in-service and pre-service science educators. The science educators were given a scenario-based questionnaire of their opinion on technology integration in different scenarios. The researchers used these responses to score the educators with a level of TPACK. There were also opportunities in the questionnaire for educators to give examples of how they have implemented technology in their work. These results were used to give the educators a technology integration level. The results of the study showed that most educators were at a level 2 or 3 for TPACK knowledge, but at a level 1 for actual integration of technology, meaning the usage of technology was disproportionally less than the knowledge of how to integrate technology.

Improving the TPACK of Educators

Researchers also use the TPACK framework to evaluate the effectiveness of professional development that focuses on technology integration. This is accomplished by measuring TPACK before and after a professional development and is meant to show that the educators have become better at integrating technologies. Often, the TPACK framework is taught to participants as part of the professional development. Most research of this type shows an improvement in the TPACK knowledge base of participants, although this improvement is not always demonstrated by participants in practical situations.

Harvey and Caro (2016) studied pre-service teachers enrolled in an education class focused on technology integration. They split the teachers into two classes and explicitly taught only one class the TPACK framework. Both groups were given tests to measure their TPACK knowledge before and after their classes. The group that had the TPACK framework explicitly included in their curriculum scored higher than the group that did not, although the improvement in TPACK was not demonstrated when researchers examined lesson plans created by the pre-service teachers for the class. Dalal, Archambault, and Shelton (2017) conducted a mixed-methods study of international students who enrolled in a semester-long professional development course in educational technology. For the quantitative part of the study, the TPACK knowledge base of the students was measured before and after their participation in the course. TPACK scores improved over the course of the semester, suggesting that direct professional development in educational technology will improve the TPACK of educators. However, in the qualitative part of the study, a lesson designed by each student at the end of the class was evaluated for TPACK proficiency. Students showed improvement in the technology knowledge base and technology pedagogy knowledge base but did not make the connection to using technology in a classroom and a specific content knowledge. This suggests that these educators may have a difficult time integrating technologies into their content even with the general understanding of how technologies can be used in instruction.

Morsink et al. (2010/2011) studied in-service elementary school educators who agreed to participate in a seven-month technology integration professional development course. The teachers were first taught the TPACK framework and then paired with a university faculty member to work on a technology-based summer project. When school began that August, the teachers were expected to implement their project in the classroom with their students. The TPACK knowledge base of each teacher was measured three times throughout the course of the study. While very few teachers showed growth on all three subsequent measurements of TPACK, overall there was a statistically significant increase in the teachers' TPACK scores from the start to the finish of the project. Since the purpose of this professional development was to implement a new technology into the teachers' courses, participants also demonstrated a practical application of TPACK. However, no follow-up was done to see if the technology use continued after the case study had ended.

The TPACK framework is also used by researchers to reflect on and evaluate technology integration. Hilton (2015) researched two social studies educators who had completed their first year integrating a set of 30 iPads into an eighth-grade classroom. Hilton asked the two educators reflective questions based on the TPACK framework, as well as reflective questions based on another framework called SAMR. The results showed that responses to reflective questions based on the TPACK framework were focused less on specific activities in the classroom and more on a broad reflection of the overall integration process experienced that year. While the educators acknowledged the need to balance technology, pedagogy, and content, they focused heavily on the technology aspect, specifically on technical issues with integration. Problems highlighted included obtaining email addresses for students, waiting for websites to be unblocked, and the complexity of adding new applications. This reflection was juxtaposed against the SAMR framework responses which tended to focus on specific activities and how the students did with the technology integration. Hilton concluded that the TPACK framework was teacher-orientated and the framework failed to acknowledge the technical issues educators may face trying to integrate new technologies into the complex system of education.

TPACK and Learning Games

Learning games, being a computer-based technology, can also be viewed under the TPACK lens. Researchers have applied the TPACK framework to learning games regarding both how they are designed and how the TPACK framework can guide and explain learning game integration. Hsu and Chai (2012) adapted the TPACK framework specifically to games in education, calling this adapted framework TPACK-G.

TPACK and Game Design

The TPACK framework has been used to understand and influence the design of learning games. Foster and Mishra (2009) argue that learning games are frequently treated by researchers as a "monolithic" (p. 39) entity instead of a category of widely-ranging types of games. Because of this, the differences between genres has been largely ignored by researchers. This is problematic because games come in a wide variety of types and, as Foster and Mishra point out, discussing *Guitar Hero* and *World of Warcraft* as if there were no differences regarding use in an educational setting or expected learning outcomes is shortsighted. Foster and Mishra apply the TPACK framework to thinking about game design, including game genres, and likened the different genres to the interaction between pedagogy and technology. Different gaming genres, they contend, have different ways of teaching the players. The third component to TPACK is content, and Foster and Mishra argue that "the goal of educational game designers is to think how this third circle can be brought into the framework," (pp. 43). TPACK, then, gives researchers a framework to analyze the pedagogical approach of learning games based on genre and how the game does or does not situate itself into the content being taught.

Mukaila and Nleya (2014) put this suggestion to practical use when they used the TPACK framework to guide the design of a mathematical learning game. They situated the game (the technology) within the mathematical context of learning substitution (content) using object-based learning as the pedagogical approach. They studied the results of the game when used by JSS 2 students, which is equivalent to eighth-grade students in the United States. They found that the use of the situated game significantly increased the mathematical performance of the students who used the game when compared to a control group.

Approaching TPACK and game design with a different goal, Sancar Tokmak (2015) applied the TPACK framework to game design with the purpose of increasing the TPACK knowledge base of the educators who designed the games. She measured the TPACK development of pre-service educators who were tasked with designing an instructional game for elementary children. Sancar Tokmak based the growth in TPACK on the personal perceptions of the pre-service educators, direct observations, and the quality of the educator-designed games as decided by the research team. The results showed that the pre-service educators utilized the TPACK framework during their design of the games and showed growth in technology knowledge as they had to learn how to use programs to create their games.

TPACK and Game Integration

While some research focuses on the relationship between TPACK and game design, considerable research involving TPACK and learning games study the integration of games into learning environments. Kennedy-Clark, Galstaun, and Anderson (2011) conducted a study to see if a short workshop on learning games grounded in the TPACK framework could improve the attitude of educators towards learning games. While acknowledging that studying attitude instead of actual usage was a limitation, the intent of Kennedy-Clark et al. was to show that a TPACK-based professional development on learning games could improve the integration of learning games into classrooms. The workshop instructors sought to improve the pedagogical content knowledge of the participants by having them design activities to use a BBC learning game called *Death in Rome* within a science inquiry lesson. Technological content knowledge was to be improved by having participants evaluate online games and virtual environments for usability and effectiveness. Finally, technological pedagogical knowledge was to be improved by having participants evaluate online games to identify what teaching or learning need the games addressed. Results of the study showed a significant improvement in the educators' confidence in using information and communication technologies (ICT) in classrooms using the TPACK framework. Results also showed that the educators/ perceptions of learning games improved, and a greater percentage responded that they intended to use learning games in their classrooms (86.7% on the post-test as opposed to 61.5% on the pre-test). This study suggests that a TPACK-based learning game professional development course could increase the confidence of using ICT and improve the desire of educators to integrate learning games.

Sancar Tokmak and Ozgelen (2013) studied game integration from a TPACK framework but found that pre-service educators perceived games to be somewhat constricting regarding content and pedagogy. In their study, 26 pre-service educators were tasked with first selecting a learning game to use and then with redesigning a learning game for early childhood education classrooms. Most of the educators in the study selected a learning games that focused on mathematics and most integrated the game with a behaviorist approach. Feedback from the educators showed that some of them felt the available games to be restrictive in what content they could teach and in how they could be used. The learning games these educators selected expected the players to have pre-knowledge of the target content before beginning to play the game, which mostly ruled out their usage with a constructivist approach. It may be that the pre-service educators lacked the complete TPACK knowledge base needed to use learning games in a variety of pedagogical approaches, or there may exist a lack of variety of learning games for young children.

TPACK-G

Hsu and Chai (2012) argue that the TPACK framework can be improved if it was adapted for specific technologies. They adapted the framework for learning games and called the new framework TPACK-G (Technological Pedagogical Content Knowledge - Games). Like the original TPACK framework, TPACK-G consists of several knowledge domains. The knowledge domain GK includes a general knowledge of digital games and the ability to play digital games. GPK is the knowledge of how games can be used with different teaching strategies, like using a puzzle-based game to improve problem-solving skills. GPCK is the application of GPK to a certain content area, as in using a math-based puzzle game to improve a student's ability to solve algebraic equations. Since K-12 educators most often teach specific content, the ideal within this knowledge framework is the overlap of the knowledges, or GPCK.

Hsu, Liang, and Su (2014) continued exploring TPACK-G through a quasi-experimental design study comparing two groups of pre-school educators participating in a game integration course designed around the TPACK-G framework. One group began by learning game pedagogical knowledge (GPK) first, followed by content knowledge (CK) and then game knowledge (GK). The other group began by learning game knowledge first, then content knowledge, and ended with game pedagogical knowledge. The second group, which was taught about games as a technology first, scored higher in the categories of game knowledge and game pedagogical content knowledge (GPCK). Game pedagogical knowledge (GPK) was not statistically different between the two classes. Qualitative analysis of in-depth responses from both groups suggested that the students who were taught game knowledge first had a more in-depth understanding of both teaching strategies employed by learning games and how to integrate learning games into their classrooms. The study suggests that knowledge of games should precede knowledge of how to integrate games into learning. This suggests that teachers who have more personal experiences with games will be better able to integrate them into their classrooms.

Hsu et al. (2017) surveyed the self-reported confidence levels of in-service educators regarding learning games. They measured the TPACK-G of the participants and another construct called the Game-based-learning Teaching Belief Scale (GTBS), which includes the belief, confidence, and motivation of educators regarding learning games. They found that game pedagogical knowledge explained 73% of the variance in an educator's game pedagogical content knowledge (GPCK). Other influential factors included motivation, confidence, and game knowledge, but demographic factors like gender, age, teaching experience, and teaching level were not statistically significant. Taken with the results of the previous study, this suggests that while game knowledge might need to come first, it is the knowledge of how to use learning games with different pedagogical approaches, or at least with the preferred pedagogical approach of the educator, that is the most important influential factor in overall GPCK. Actual usage, however, was not examined in this study.

Hsu and Chai (2012) developed and tested an instrument to measure the extent of GK, GPK, and GPCK in educators. The data from the initial test suggested that teachers scored highest on GK and lowest on GPCK, meaning that teachers had more knowledge of playing digital games than of using digital games to teach specific content areas. Hsu and Chai retained 14 questions from their original survey designed to measure GPCK with reliability coefficients ranging from .90 - .94. The reliability coefficient was further tested by Hsu, Liang, and Su (2015) and again scored in the .90 - .94 range. While Hsu and Chai's study did suggest a positive correlation between GPCK and positive educator attitudes towards learning games, they did not examine a correlation between GPCK and usage of learning games. Hsu et al. (2017) also used the TPACK-G questionnaire in a study of in-service educators and found the internal reliability to be 0.96. In their study, GPCK was the dependent variable, with the other constructs of TPACK-G and additional factors as the independent variables. The current study has adapted the TPACK-G survey created by Hsu and Chai (2012) to measure the TPACK of educators regarding the integration of learning games.

The TPACK framework examines how educators use the overlapping knowledge structures of technology, content, and pedagogy to use technologies to teach students. Research into TPACK and technology integration can focus on evaluating, improving, and reflecting on technology integration. Research into TPACK and learning games is less prevalent and focuses on the design and integration of learning games. The TPACK-G framework adapts the TPACK framework by focusing on the specific usage of games for learning by educators. The TPACK-G framework incorporates the knowledge of using and playing digital games, how digital games can be used with instructional methods, and how digital games can be used with instructional methods to teach specific content areas. The TPACK-G model and the instrumentation developed by Hsu and Chai (2012) are a primary focus of this study.

Technology Acceptance Model

In this section, the theoretical basis and development of the technology acceptance model (TAM) will be reviewed. The TAM model addresses both the level of perceived complexity of a technology as well as the level of perceived usefulness. While the TPACK framework suggests that educators will integrate technologies more when they increase their knowledge of using the technology within their curriculum and desired pedagogical approach, the TAM model suggests that technologies will be integrated if the level of complexity of a technology is outweighed by its perceived usefulness. The focus in this section will be on the concepts behind the TAM model, the robustness of the model in quantitative studies, as well as how the model is frequently adapted by adding additional variables to the core constructs of perceived ease of use and perceived usefulness. The author will use current literature to establish a case for adapting and contextualizing the TAM model for educators and learning games.

Development of TAM

Writing from the field of management information systems, Davis (1989) developed the Technology Acceptance Model (TAM), whose purpose is to depict factors that help explain whether potential users of technology will actually use a technology. He based his work on Fishbein and Ajzen's (1975) Theory of Reasoned Action (TRA). Davis believed that several distinct yet similar models in his field all used variations of the same concepts to explain human action. For instance, proponents of the self-efficacy theory argue that a person's actions are influenced by their belief of how well they can do something and the size of the outcome that action would have. The cost-benefit paradigm argues that behaviors are economic decisions, with individuals using their time and energy in ways that lessen costs and increase benefits. While this paradigm often focuses on objective costs and benefits, Davis believed that perceived costs and benefits are a better indication of behavior. Research into the adoption of innovations often suggests that the more complex a technology is to use, the less likely the technology will be adopted, suggesting validity to the idea of perceived costs. Davis believed that each of these theories and paradigms could be simplified into two constructs. He called these constructs perceived usefulness and perceived ease of use. Davis found similar theories and models supporting his constructs in other fields like marketing and human-computer interactions. Davis tested and refined his TAM model and found it to be a good fit for explaining the usage of technologies. The figure below illustrates the TAM model (Figure 3).

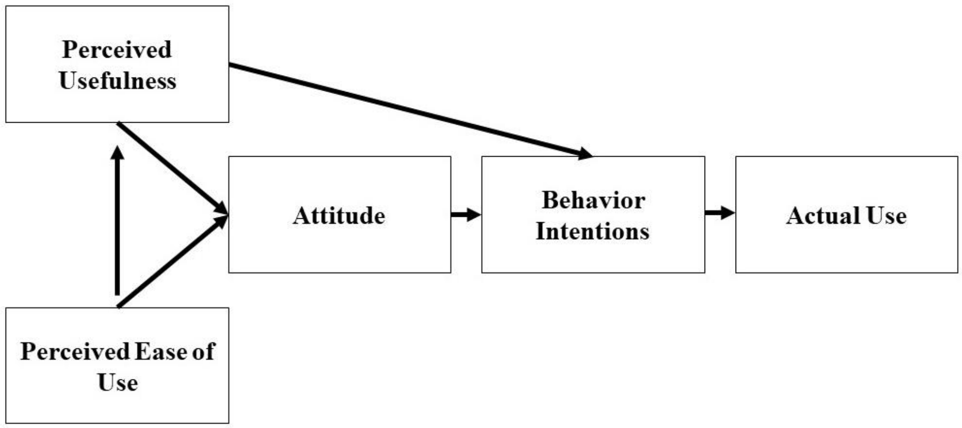

Figure 3. TAM Model

In the model, perceived usefulness (PU) and perceived ease of use (PE) both affect attitudes towards using a model. Perceived ease of use also affects perceived usefulness. Attitude toward usage and perceived usefulness directly affect the intention to use. This step relates to Rogers' adoption or rejection of a technology. Finally, intention to use directly affects actual system use, or the integration of a technology, which is the focus of this research.

Venkatesh and Davis (2000) updated the TAM model, calling the revised model TAM2. The revised model included determinants of social influence, including subjective norms, which influenced both perceived usefulness and intention to use. TAM2 also includes what Venkatesh and Davis term cognitive instrument processes which influence perceived usefulness. Cognitive instrument processes happen when users of technology make assessments as to how well the result of using a technology corresponds with the goals of their current job. Venkatesh and Davis tested their updated model across four longitudinal studies and found that the updated model explained between 34-52% of the variance in usage intentions.

Legris, Ingham, and Collerette (2003) conducted a meta-analysis of current research and found that the TAM and the TAM2 models were robust at explaining about 40% of system use. Legris et al. concluded that the model should be improved so it can explain more than 40% of the variance. After conducting a meta-analysis of 88 studies empirical studies of the TAM model, King and He (2006) reached the following conclusion: the TAM model is a robust model, but moderator variables may help explain the effects of the factors. They identified two moderators: experience of the user and type of user (professional, student, or general). Both Legris et al. and King and He found that perceived usefulness had a much greater impact on usage than perceived ease of use, although perceived ease of use had a statistically significant influence on perceived usefulness.

McFarland and Hamilton (2006) also believed that the TAM model could be improved with additional variables. They argued that computer efficacy, which is based on the concept of self-efficacy, could be added as an intervening variable to improve the TAM model. However, computer efficacy is not generalized but is instead specific to the application, device, or operating system with which the user is interacting. McFarland and Hamilton argue that computer-efficacy is highly contextualized to specific tasks, technologies, and individuals. They found that computer anxiety, prior experience, organizational support, and system quality all affected computer-efficacy and ultimately system usage.

Bourgonjon, Valcke, Soetaert, and Schellens (2010) adapted the TAM model to the context of student preferences towards learning games in the classroom, arguing that positive student acceptance of learning games should not be assumed by researchers or educators. Bourgonjon et al. retained the factors of usefulness and ease of use but made several changes to the model to fit the context for which they intended the model. Since students usually do not have the power to choose to use digital games for learning in the classroom, Bourgonjon et al. (2010) used a preference for learning games as the dependent variable instead of intention to use. The researchers also added three more factors: learning opportunity, experience with video games, and gender. Learning opportunity refers to a student's belief that digital games offer opportunities to learn. Results of their study pointed to all factors being significant, with gender appearing to be a mediating factor that affected experience and ease of use. The model was able to account for 63% of the variance in preference for learning games, which is an improvement from the TAM model.

While Bourgonjon et al.'s (2010) model focuses on student acceptance of learning games, a slight adaptation can contextualize the model to apply to teachers. This would be consistent with the literature, which suggests that the TAM model can be made more robust by adapting it to a specific context. With the focus on educators instead of students, the dependent variable can be changed to actual usage of learning games instead of a preference for digital games. A variation of Bourgonjon et al.'s model will be used in this study.

TAM and Technology Integration in Education

The TAM model has been frequently applied to technology integration in the field of education. While there appear to be more quantitative studies of technology integration in education involving the TAM model than the TPACK framework, many of these studies focus on the student as the end user, not the educator. Most of the studies the author came across were focused on the choices made by university students or other adult learners to use or not use a learning technology. A plurality of studies the author found while reviewing the literature with the keywords of "TAM" and "education" were about the experiences of university students with online classes, although electronic textbooks and the statistical application SPSS also appeared as study topics. Studies that focus on the behavior intentions and actual usage of technologies by adult learners instead of either K-12 students or educators may be less applicable to the current study for the following reasons: (a) most K-12 students do not get to choose how they learn in classrooms, and (b) the motivations of professional educators are often not the same as the motivations of learners. The following paragraphs will briefly summarize the literature on students and the TAM model before moving on to more pertinent, although rarer, literature focused on technology integration by educators.

TAM and Student Usage of Technologies

A significant portion of the more recent research into education using the TAM model focuses on student acceptance of online learning. While the specific results of the studies showed variability, the core constructs of the TAM model, perceived ease of use and perceived usefulness, were always found to be significant factors in either intention to use online learning or the actual usage of online learning. Some of the research found perceived ease of use to have a larger direct effect on usage than perceived usefulness (Sánchez & Hueros, 2010; Sabah, 2016). This suggests that the students in these studies primarily wanted online learning to be simple to use. Other studies showed that perceived usefulness had the largest direct impact on usage or intention to use online learning (Lee, 2010; Liu et al., 2010; Ngai, Poon, & Chan, 2007), suggesting that students may be willing to sacrifice ease of use if they perceive the technology to be beneficial. These conflicting results may be dependent on the sample of students or on the specific technology (i.e., Moodle or WebCT or mobile learning). Many of the researchers added factors that they believed would be important in addition to the core TAM model, including technological support, self-efficacy, and the psychological state of flow, but the consistent findings across all the studies were that the TAM model's two core constructs had significant impacts on student intention to use, or, more rarely in studies, actual use, of online learning technologies.

As an example outside of online learning, Masood and Lodhi (2016) studied three hundred Pakistani university students who used the statistical program SPSS. The dependent variable was their intention to use SPSS in the future. The researchers used the TAM model and added the factors of self-efficacy in SPSS, the perceived learning value that students had for SPSS, social support, and statistical knowledge. Results of the study showed that perceived ease of use and usefulness had positive effects on intentions to use SPSS. The other factors did not have direct effects on intention to use, but social support and learning value positively affected perceived usefulness.

Overall, research into student acceptance of technologies using the TAM model showed that the core constructs of perceived ease of use and perceived usefulness were robust at predicting either actual usage or future intention to use a technology. Whether perceived ease of use or perceived usefulness was more powerful in predicting usage depended on the study. Various researchers also added additional factors that they believed influenced usage of a technology. These factors often ended up indirectly affecting usage through directly affecting either perceived usefulness, perceived ease of use, or both. Results of studies discussed in the following section, which focus on the TAM model being able to predict and explain educator decisions on technology integration, will continue to see the core constructs confirmed as significant factors, although the relative strength of these constructs and the strength of added variables often changes from one study to the next.

TAM and Educator Usage of Technologies

Teo, Su Luan, and Sing (2008) conducted a study of two groups of pre-service educators, one in Singapore and the other in Malaysia, using the TAM model. They included attitudes towards computers as another factor in addition to perceived ease of use and perceived usefulness. Because the educators were pre-service, intention to use was the dependent variable. The results showed that perceived ease of use affected perceived usefulness, both perceived ease of use and perceived usefulness affected attitudes towards computers, and perceived usefulness affected the behavior intention to use computers in classrooms. However, data from only one of the two groups supported the hypothesis that attitudes towards computers affected behavior intention. The attitudes of the Singapore group towards computers did not affect their intention to use the technology, possibly because they felt they would be required to use computers.

Teo (2010) conducted a similar study but added the following additional factors to the core TAM constructs: (a) subjective norms, (b) facilitating conditions, and (c) technological complexity. In this 2010 study, the sample again consisted of pre-service educators and the dependent variable was attitudes towards computer use. Results showed that perceived usefulness had the largest effect on attitudes towards computer usage, perceived ease of use had a small effect on attitudes towards computer usage but a large effect on perceived usefulness, and technological complexity had a small effect on attitudes towards usage. Subjective norms affected perceived usefulness, while facilitating conditions and technological complexity affected perceived ease of use. Sánchez-Prieto, Olmos-Miguelánez, and García-Penalvo (2017) found similar results when researching pre-service educators and the use of a specific classroom technology, mobile learning. The researchers added self-efficacy and mobile anxiety to the core TAM constructs of perceived ease of use and perceived usefulness. Behavior intention to use mobile devices in learning was the dependent variable. Results again showed that perceived usefulness had the largest impact on behavior intention, while perceived ease of use had a marginal effect. Perceived ease of use did have a significant effect on perceived usefulness. The additional factors had direct effects on perceived ease of use, with self-efficacy also having a direct effect on mobile anxiety.

Scherer, Siddiq, and Tondeur (2019) recently conducted a meta-analysis of 114 empirical TAM studies that focused on pre- and in-service educators and technology integration. This meta-analysis covered the years of 1986 through 2017 and encompassed over 34,000 teachers throughout 114 studies. 79 of these studies included Asian teacher samples and only 20 included American samples, which is the focus of the author's research. A focus of Scherer et al.'s research was if the TAM model fit the data of the studies, using the core constructs of perceived ease of use, perceived usefulness, and attitudes towards technology, with the outputs being behavior intention and actual use. The researchers also explored variations in study results regarding correlations between the core constructs of TAM and if other factors affected these variations. These additional factors included teacher experience, type of technology integrated, societal pressures through social norms, computer self-efficacy of educators, and conditions that could represent barriers to using computer technologies. The results of the meta-analysis did show significant variations between studies, suggesting that study type, sample, and technology may affect results. The results also supported a direct effect of perceived usefulness on behavior intention to use technology, as well as a direct effect of attitudes towards technology on usage of technology. Perceived usefulness seemed to have the most significant impact on educator intention to use technology. The researchers concluded that "perceived usefulness, next to the perceived ease of use, significantly predicted behavior intentions via attitudes toward technology…this finding confirms the importance of teachers' perceptions (PEU and PU) and attitudes for user intentions" (Scherer, Siddiq, & Tondeur, 2019, p. 29). However, the meta-analysis did bring to light several limitations to current research into the TAM model and educators. First, very few studies focused on actual usage as opposed to behavior intentions to use. Second, the models of TAM incorporated into the meta-analysis did not include the possibilities of reciprocal relationships between constructs. For instance, Scherer et al. suggest that perceived ease of use and perceived usefulness may be predicted by educator experiences using technology. Ultimately, Scherer at al. argue the TAM model offers an incomplete picture of educators integrating technology into their classrooms. They suggest that incorporating the knowledge base of educators, specifically the TPACK framework, with the TAM model could provide a more complete picture.

TAM and the TPACK Framework

Okumus et al. (2016) conducted a study incorporating both the TAM model and the TPACK framework. They approached the TPACK framework as a lens to analyze the decisions made by educators during technology integration and believed that the TAM model could be understood within the TPACK framework. The two core constructs of TAM, perceived ease of use and perceived usefulness, are dependent on the technology tool chosen and the curricular goal for which the tool is used. Okumus et al. conducted a qualitative study of mathematics educators who taught Algebra or Geometry in secondary classrooms. The technologies integrated by the educators in the case study were two mathematical software tools used by students to create mathematical figures, charts, etc. Because the software allowed students opportunities to manipulate, create, and explore mathematical concepts, the pedagogical approaches for using the software could be different than the approach the secondary educators typically used in their classrooms. The educators in the study were given ongoing professional development that taught both the use of the software programs and how to incorporate the programs into typical classroom tasks. The researchers gathered data in the form of direct observations, interviews, and answers to Likert-scaled and yes/no questions. Findings from the study indicated that educator self-efficacy and perceived ease of use of the software programs did influence intention to use the technology. Self-efficacy and ease of use, however, was not directly connected with the use of the software programs within the curriculum;

educators reported on their confidence in simply using the program, not in integrating it. The researchers also did not observe a direct link between perceived ease of use and perceived usefulness. Regarding usefulness, educators did believe both programs were useful in teaching mathematical concepts to students. However, when it came to the specific use in their classrooms to teach their curriculum, there were more reservations about knowing when to use the software programs and if they fit with the curriculum. There were also differences in how educators perceived the pedagogical fit of the software programs. While some educators saw an opportunity to use the tools to teach math in a new way, combining, according to Okomus et al. (2016), technological content knowledge and technological pedagogical knowledge, others believed that the software programs did not fit in with the way that math should be taught. Alignment with curricular goals ended up having a significant influence on perceived usefulness, which the researchers in turn found to be a significant predictor of actual usage.

Hsu (2016) also conducted a study of educators and technology integration using the TAM model and the TPACK framework. She studied the integration of mobile learning by English as a Foreign Language educators. Hsu used the TPACK framework to understand how educators use technologies to achieve learning goals and used the TAM model to explain the technology adoption process. Hsu hypothesized that the core constructs of the TAM model, perceived ease of use and perceived usefulness, would positively affect attitudes towards use. She further hypothesized that the TPACK knowledge base would positively affect perceived ease of use and perceived usefulness. The results of her study suggested that educator TPACK significantly impacted perceived ease of use and perceived usefulness. Perceived usefulness directly impacted both attitudes towards use and actual usage, but perceived ease of use only indirectly affected usage and did not have a significant impact on attitude toward use. Hsu reasoned that learners are more concerned with the ease of use of technology while educators are more concerned with usefulness, highlighting the differences between using TAM to study student and teacher acceptance of technology.

Joo, Park, & Lim (2018) studied how TPACK, self-efficacy, perceived ease of use and perceived usefulness affected pre-service educator's intention to use technology. The researchers hypothesized that TPACK would positively affect teacher self-efficacy, perceived ease of use, and perceived usefulness, and all these factors would affect intention to use technology. Around 300 Korean pre-service educators were the sample of the study. Data was gathered through a Likert-scaled survey. TPACK had significant direct impacts on teacher self-efficacy, perceived usefulness, and perceived ease of use, but not on intention to use technology. While teacher self-efficacy and perceived ease of use had a significant direct effect on intention to use technology, the size of the effect was considerably smaller than the effect that perceived usefulness had on intention to use. Joo et al. suggested that universities should use TPACK as a framework for training pre-service and in-service educators to improve teacher self-efficacy, ease of use, and perceptions of usefulness towards technology.

Because of the topic of this study, research into the TAM model that incorporates TPACK has been highlighted in the previous few paragraphs. This should not give the impression that most research into educators, technology, and the TAM model use the TPACK framework, just that several researchers have already made a connection between the TPACK framework and the TAM model. Regardless of the use of TPACK as a framework to understanding the technology integration process, many of the TAM studies have come to similar conclusions: (a) the TAM model is relatively robust at predicting usage or intention to use technology, (b) perceived usefulness is often the most important predictor, and (c) the addition of other constructs often strengthens the TAM model, although what those other constructs are is study-specific.

The TAM model is robust at predicting educator intention to use technologies, with perceived usefulness often being the primary factor affecting usage. However, most studies focus on intention to use instead of actual usage, often because the subjects being studied are pre-service educators who have not had the opportunity to integrate learning games in a classroom. While behavior intention to use has been shown to have a significant effect on actual usage, additional factors may prohibit usage even when educators intend to use a technology. In fact, the correlation between intention to use and actual usage may be as low as .5 (Venkatesh & Davis, 2000), which is a significant but not extremely strong correlation. Actual use of a technology may cause educators to re-evaluate the technology in a negative light and discontinue use. Further research into the TAM model and technology integration should focus on actual usage of in-service educators to see if additional factors do not negatively impact usage even when perceived ease of use and perceived usefulness are high for an educator.

TAM and Learning Game Integration in Education

Wang and Goh (2017) conducted a meta-analysis of 50 peer-reviewed articles that detailed empirical studies of digital games which included at least some of the constructs of the TAM model. Wang and Goh separated out games played for pleasure, which they called hedonic, and games played for utilitarian purposes. Studies into games for utilitarian purposes represented only 15 of the 50 studies. Besides the core constructs of perceived usefulness and perceived ease of use, Wang and Goh also measured the effects of attitude, perceived enjoyment, flow, playfulness, and satisfaction on behavior intention to use digital games. Actual usage was the dependent variable in only eight of the 50 studies. Results from studies on hedonic games were different than results from studies on utilitarian games. The effect of perceived enjoyment on intention to use games was higher for hedonic games, and the effect of perceived ease of use and perceived usefulness were higher for utilitarian games. For hedonic games, perceived enjoyment was the most important predictor of intention to use, while for utilitarian games, perceived ease of use was the most important predictor, followed by perceived usefulness. However, even among utilitarian games, the type of respondent affected the results. Wang and Goh separated respondents into categories of student and non-student, with 18 of the studies using student responders, and reported significant variability between the groups. The results of the meta-analysis by Wang and Goh demonstrate that TAM-based studies into games for pleasure have different results than games for utilitarian purposes, and results from these studies will show variability based on the respondent type. This is likely because the goals held by players of digital games change based on purpose, audience, and degree of choice in playing the game. The following paragraphs will focus on games for the utilitarian purpose of learning with the respondents being part of the formal educational setting, either as students or as educators.

Research into adult use of learning games includes both college students and informal learning environments. Shen and Eder (2009) surveyed the behavioral intention of undergraduate business students to continue using the online game Second Life as a learning platform. Much like many TAM-based studies, the researchers added several constructs to the main two constructs of TAM: computer playfulness, computer self-efficacy, and computer anxiety. Results showed that playfulness and self-efficacy affected perceived ease of use, which in turn affected perceived usefulness. Perceived usefulness was the only construct to show a significant effect on the students' intention to continue using Second Life as a learning platform. Similar results regarding perceived usefulness and perceived ease of use were found when studying elderly adults' use of exercise and cognitive games. Perceived usefulness was a significant predictor of intention to use the games, but perceived ease of use did not have a significant effect on either intention to use or on perceived usefulness (Chen et al., 2018).

Adult learners appear to be most influenced by perceived usefulness when approaching digital game usage from a utilitarian purpose. However, younger students in grades K-12 may be influenced in different ways by the constructs of the TAM model because the goals of K-12 students may not be the same as the goals of adult learners. Some researchers into learning game acceptance assume that enjoyment, not usefulness, is a primary goal of K-12 students. While studying performance through learning games of middle school students, Giannakos (2013) changed the core constructs of the TAM model and used the factors of Enjoyment, Happiness, and Intention to Use, stating that "player enjoyment is the most important goal in gaming" (Giannakos, 2013, p. 431). Giannakos incorporated the constructs of perceived ease of use and perceived usefulness into enjoyment and, to an extent, happiness, although how or if these constructs relate was not established in his study. The results showed a significant correlation between player happiness, enjoyment, and intention to use learning games.

Other researchers did not automatically discount perceived usefulness as being an important construct for students of any age. Cheng et al. (2013) studied the use of an environmental learning game by 4th graders, adding attitude toward use as a third construct of their model. Results of their study showed that perceived ease of use had the largest total effect (.66) on intention to use, although this was entirely indirect effects. Perceived usefulness had the second largest total effect (.59), with attitude towards use having the largest direct effect (.50) on intention to use. Results from Cheng et al. suggest that usefulness does matter to students, even younger ones, although ease of use may be more important than usefulness to younger students.

Bourgonjon et al. (2010) also applied the TAM model to student acceptance of learning games, but, acknowledging that K-12 students often do not control whether they get to use learning games or not, adapted the TAM model by using preference for learning games as the dependent variable instead of intention to use. Bourgonjon et al. conducted their study in part to see if an assumption in educational literature that students preferred to use learning games was true. Besides the core constructs of usefulness and ease of use, Bourgonjon et al. added the constructs of learning opportunities, experience with digital games, and the demographic variable of gender. Their study involved 858 secondary students between the ages of 12 and 20. Results showed that all constructs except gender had significant effects on preference for video games. Usefulness had the largest coefficient (.44), followed by ease of use (.21), learning opportunities (.17), and experience (.11). Gender had a strong effect on experience (.5) but did not significantly affect preference for video games. As far as overall preference for learning games, the total average on a 5=five-point Likert scale was 3.1, with a standard deviation of 1.2, suggesting that student preference for video games cannot be taken for granted. The fact that usefulness was a more important factor than ease of use in this study may have to do with the subjects being older than Cheng et al.'s (2013) study or may be a result of the variability in results that is common in TAM model testing. This study does give support to the idea that students are most concerned with a game's usefulness when the intended use is for learning.

As Bourgonjon et al. (2010) suggested, the integration of learning games is not ultimately the decision of the students in most K-12 schools, but instead of the teachers. In fact, a study done by de Grove, Bourgonjon, and van Looy (2012) goes further to suggest that educators are more gatekeepers of technology in the classroom than administrators. These researchers sent out TAM-based surveys to both administrators and secondary teachers in Flanders. The results showed that administrator responses on school-level concerns, including ICT infrastructure, technical support, perceived ease of implementation, perceived usefulness, learning opportunities, and cost, were not significant factors of behavior intention to use technologies by educators. The researchers do suggest that this may be because schools in Flanders tended to have good ICT infrastructure and technical support and these results may not be replicated in other geographical areas. On the teacher level, de Grove et al. measured perceived usefulness (which in this study focused on job performance), learning opportunities, ease of use, experience (which referred to experience using learning games in their classrooms), and curriculum-relatedness. In the results from 517 secondary educators, this model was able to explain 68% of the variance in behavior intention, continuing to show the robustness of TAM models for behavior intention. In this study, it was learning opportunities that had the largest effect on behavior intention to use learning games, followed by usefulness, then experience, and finally curriculum-relatedness. de Grove et al. did acknowledge that the constructs of learning opportunities and usefulness may be interconnected enough to be considered the same construct, although it was their belief that the two constructs were separate. Based on the interplay between constructs, de Grove et al. found that the educators in the study would be likely to use a learning game if it fit their curriculum, regardless if they believed the game offered learning opportunities. In addition, experience actually negatively impacted belief in learning opportunities of games, suggesting that educators with experience implementing learning games had become somewhat disillusioned with their effectiveness. Overall, this study both confirms the TAM model as a useful model for investigating educator acceptance of learning games and gives evidence to suggest that curricular fit, usefulness, and learning opportunities of games are the most important factors to educators when making implementation decisions.

Bourgonjon et al. (2013) adapted their earlier work with students to focus on in-service educator adoption of learning games. While the previous de Grove et al. (2012) study focused on any kind of learning game, Bourgonjon et al.'s study focused on digital games produced for commercial, not educational, purposes that could be adapted into a curriculum. Their study surveyed 505 K-12 educators in the Flanders region. Bourgonjon et al. adapted the TAM model from their student study (Bourgonjon et al., 2010) to fit their specific research focus of educators. They changed the concept of ease of use to complexity, describing this construct as the opposite of ease of use. Complexity specifically focused on the difficulty integrating learning games into a classroom, not the complexity of the learning game itself. Bourgonjon et al. again incorporated learning opportunities as a separate construct from perceived usefulness. Based on a belief that teachers who have more personal experience with video games would be more likely to use them, Bourgonjon et al. included the construct of experience. Personal innovativeness was added because of Rogers' (2003) theory that early adopters of a technology tend to be more innovative. Finally, social influences were added in the form of two constructs, subjective norm and critical mass. Critical mass refers to when enough members of a social system have adopted a technology for widespread integration to be certain to happen. The results of the study showed again that usefulness had the largest direct effect (.64) on behavior intention to use learning games. Surprisingly, neither complexity nor experience had significant influences in the model. Critical mass was the only other construct to directly affect behavior intention (.22), while learning opportunities, subjective norms, and personal innovativeness affected usefulness, although personal innovativeness had a very weak effect. Results suggested that it was usefulness, strongly influenced by learning opportunities, that had the greatest effect on behavior intention to use learning games. Descriptive results showed that usage of learning games was low among educators, although this study specifically focused on commercially-produced games. Based on the results of this study, educators are much more concerned about usefulness and learning opportunities than the complexity of integrating games into their classrooms, and personal experience with games has little impact on use. Bourgonjon et al. (2013) concluded that professional development should focus on convincing educators of the usefulness of learning games first before focusing on issues of complexity of integration. Although these researchers excluded the construct of ease of use, its replacement, complexity, had no significant impact in the model, suggesting that educators are, perhaps, some of the more utilitarian of the utilitarian users of digital games. While hedonic players and students may be more concerned with games being easy to use, educators may be willing to overcome complexity of integration if they view learning games as useful.

Bourgonjon et al.'s (2010) TAM-based model and survey were adapted for use in this research because it closely followed the original TAM model with additional factors that the author believes may be important to educators. Questions meant for students were easily rephrased for educators. Bourgonjon et al.'s (2013) survey of educators was not used because that study made the decision to use complexity as a construct instead of ease of use, one of the two core constructs of TAM. Bourgonjon et al. (2010) provides a detailed explanation of the formation of their survey. Items focused on ease of use and usefulness were adapted from previous TAM research, while items focused on learning opportunities were written based on the learning opportunities of games outlined in Egenfeldt-Nielesen's 2007 book *Beyond Edutainment*. Bourgonjon et al. did have to create new items for experience and preference for video games. After composing the survey, the researchers presented the survey to a panel of four experts and 128 in-service educators, resulting in some items being removed and others being rephrased. All items were based on a five-point Likert scale. After gathering the data from the surveys, psychometric testing was used to validate the instrument. The data was randomly separated into two equal groups. Exploratory factor analysis was conducted on the data from the first group. The five-factor structure explained 74% of the shared variance, and all factor loadings exceeded .40 only in their own constructs. Confirmatory factor analysis was conducted on the data from the second grouping. Several fit indices were calculated, including chi-squared/degrees of freedom, the root mean square error of approximation, the goodness-of-fit index, the adjusted goodness of fit index, and the comparative fit index. All results were satisfactory, and all items had significant loadings on the latent factors. Internal consistency was demonstrated as the Cronbach's alpha coefficients all exceeded the threshold of .70. Based on the compatibility of the survey with the current research and the extensive testing of the survey items by Bourgonjon et al. (2010), the questions from the survey were adapted for use in this study.

Proctor and Marks (2013) also applied the TAM model to technology integration by educators, but their study was unique in several interesting ways: (a) the sample of educators were those who had won a Milken Educator Award during 1996-2009, (b) the study was retroactive and looked at data trends on usage and perception going back to 1996, and (c) the researchers explicitly incorporated Rogers' (2003) diffusion of innovations theory regarding early and late majority adopters. Perhaps unsurprisingly, data trends showed that the educators from 1996-1999 used learning games less than educators after 2000, although it was the 2000-2004 grouping that used learning games the most. Based on usage data broken down by grades, Procter and Marks argued that the K-6 grouping of educators were in the Late Majority stage (60% usage), while secondary educators were still in the Early Majority stage (25% usage). Regarding the core TAM constructs, the results again showed that perceived usefulness was of greater importance than perceived ease of use for educators. Results also showed that both perceived ease of use and perceived usefulness increased over time, suggesting that the overall trend of learning game usage will improve, either because learning games are becoming more useful to educators, easier to use, or simply more accepted in learning environments.

The TAM model has proven to be a robust and useful model for explaining variance in usage and usage intentions of technology. The model can potentially be improved by adding more specific moderating factors. Researchers who use the TAM model to explain technology integration are focused on perceptions of ease of use and usefulness of the technology, but often add additional factors that they feel will enhance the model. Results regarding digital game usage are varied based on the purpose of the digital game (hedonic or utilitarian) and the population surveyed. While student perceptions of learning games varied regarding whether ease of use or usefulness was more important, results from educators consistently show that the usefulness of learning games is the dominant factor in the TAM model, except in cases where researchers separated learning opportunities from usefulness. The role of experience is still ambiguous, compounded by the fact that some researchers refer to experience with integrating learning games and others refer to experience with video games outside of the classroom. Critics of the TAM model being applied to technology integration in education suggest that the TAM model is too simplistic. Results from the TAM model may be improved if a framework like TPACK is added to the model.

Additional Factors

In this section, additional factors that may influence the decision to use learning games will be discussed. The focus will be on educator-perceived barriers to usage, regardless of whether these perceptions are accurate or not, and profiles of educators who use learning games. The focus on barriers corresponds with literature that suggests the decision to implement learning games can be influenced, often negatively, by external factors not included in the TAM or TPACK frameworks. The discussion of profiles of educators who use learning games is based both on how personal experiences with digital games outside of classrooms, as well as how demographics, specifically age, gender, subjects taught, and grade level taught, may affect integration decisions.

Perceived Barriers

In 2002, the British Education and Technology Agency conducted an informal survey about the use of learning games by educators. Part of this survey included questions about obstacles to learning game usage. Kirriemuir and McFarlane (2003) replicated this survey and included educators from other European nations, as well as the United States. A sizeable portion of their sample came from educators who had previously been involved in research projects involving learning games. While these educators often responded to the use of games favorably, they also often did not continue using learning games in their classroom after the research project ended. It is possible that certain obstacles kept them from using the learning games after the research projects ended, even though the educators had a favorable view of learning game usage. Kirriemuir and McFarlane (2003) noticed trends in the responses about obstacles. Identified obstacles often included limited time in the classroom, lack of knowledge of specific learning games that fit the curriculum, lack of supporting materials, licensing issues, lack of lesson planning time, and the cost of learning games. While this survey was informal, the results suggested that obstacles to implementation of learning games was a serious issue.

While research into perceived obstacles continued for the next several years, Baek (2008) wrote that most research into perceived obstacles was too narrow in scope. He conducted a two-part study of educators in Korea with the purpose of identifying the obstacles that educators believed made implementing digital games more difficult. To achieve a true educator-generated list of perceived obstacles, Baek first had a group of 35 educators create lists of obstacles to using digital games in their classrooms. From these lists, 63 perceived barriers were selected based on the criteria that at least three educators had listed the barrier. All 63 items were then used in a Likert-scale survey of 444 educators. The results showed that 41.16% of the variance in the data could be explained by six factors. These factors, or perceived barriers, were as follows: (a) inflexibility of curriculum, (b) negative effects of gaming, (c) students' lack of readiness, (d) lack of supporting materials, (e) fixed class schedules, and (f) limited budgets.

Watson, Yang, and Ruggiero (2013) conducted a similar study to Baek's (2008) with educators in the United States. They were able to divide the teacher-generated responses about barriers into four categories: challenges of implementing learning games effectively, challenges with using technology, lack of time and support within their current educational systems, and challenges obtaining games. Koh, Kin, Wadhwa, and Lim (2012) surveyed educators in Singapore about the use of learning games (including non-digital games like board games) in their classrooms. They found that while 58% of teachers were using games, most were using them infrequently. The barriers educators in the Singapore survey highlighted were lack of time, limited resources, high costs of games, how relevant games were to the curriculum, the perception that parents would think the educators were not teaching, and a lack of support from the school system.

Wastiau, Kearney, and de Berge (2009) surveyed 500 European educators and reported the following three ranked obstacles as the biggest obstacles: (a) cost and licensing; (b) time constraints of school days; and (c) finding suitable games. In a response to an open question in the same survey, educators listed the following five obstacles most frequently: (a) difficulty integrating games into curriculum; (b) lack of access to computers; (c) negative attitudes towards games; (d) lack of time; and (e) lack of information and support. The results of these three research studies align closely with the results of Baek's 2008 study.

In conclusion, educators from various geographical settings have reported similar barriers to implementing digital games into their classrooms. This suggests that educators often face similar barriers to the implementation of learning games including the following: (a) inflexibility of curriculum; (b) difficulty finding suitable games; (c) perception of negative effects of gaming by parents, administrators, or educators; (d) student lack of readiness; (e) lack of supporting materials; (f) fixed class schedules; (g) limited time; and (h) limited budgets and resources. While perceptions of barriers to usage potentially are impacted by knowledge of how to integrate games and perceptions of ease of use, barriers to usage may also act as a block between educators who have intend to use learning games and actual use. This is one of the reasons this study uses data on actual usage as opposed to behavior intention to use learning games.

Profiles of Game-Using Educators

The final additional factors considered in this research focus on the educators themselves. These factors are based on personal experience with digital games, age and gender of the educator, as well as current job category (subject/age taught). The concept of an educator as a gamer will be discussed first, followed by research into profiles of educators who use learning games.

Gamers

The first demographic factor considered is whether experience with digital games may influence decisions to adopt learning games. This factor will be looked at in two ways: (a) the self-identification of an educator as a "gamer," and (b) the personal use of digital games outside of the classroom. The latter has been discussed already in relation to the TAM model as several researchers have incorporated experience as a factor in an adapted TAM, although at times researchers referred to previous experience integrating games into the classroom instead of personal use. As far as the former, self-identification as a gamer is more complicated than simply someone who plays games. Grooten and Kowert (2015) examine the more traditional and restrictive definition of a gamer as a young, white male who is a social outcast, but this definition of a gamer, if it was ever accurate, is a poor representation of the current demographics of digital game players. As Grooten and Kowert report, 59% of Americans play digital games. Grooten and Kowert developed a model of gamer identification that focuses primarily on self-identification, the community of gamers an individual may identify with, and the social influences of the physical world, including existing stereotypes. The author categorizes educators as gamers through self-identification. The next paragraph will explain how this identification can potentially impact the integration of games in the classroom from the perspectives of the theories and models previously discussed.

Rogers (2003) diffusion of innovations theory goes into depth on differences between individuals who tend to adopt innovations earlier and those who do so later. As far as the diffusion of innovations paradigm (Rogers, 2003), being a gamer would increase an adopters' knowledge of digital games, which is the first stage in the innovation-decision making process. Knowledge of digital games does not necessarily include the knowledge of how to use the digital games as learning games. However, individuals tend to expose themselves to ideas that coincide with their interests, a concept Rogers calls selective exposure, meaning that educators who are more interested in digital games may be more likely to expose themselves to learning games. Further, being a gamer also means that an educator has a positive perception of digital games, which is the second stage in the innovation-decision process, although, again, this may not necessarily translate to a positive perception of using learning games in a classroom. Finally, gamers are more familiar with digital games, so their perception of the complexity of learning games may be lower as well, and innovations with lower perceived complexity are adopted more quickly (Rogers, 2003).

Identifying as a gamer may also impact the factors of the TAM model. First, individuals who are more familiar with digital games, even from a player's perspective, may view digital games in the classroom as easier to use because the technology is more familiar. In addition, gamers may have a more positive attitude towards using digital games in the classroom since they are already motivated to use digital games outside of their classrooms. Regarding perceived barriers, identifying as a gamer may not have as much of an impact because the barriers most often identified by educators are external factors. However, it may be that gamers have a higher motivation to use games and therefore overcome or work through the barriers to usage. This may not impact the perceived barriers to usage but could lessen the effect that the barriers have on actual usage.

Educators Who Use Games

Two national surveys of educators in the United States which looked at usage of learning games and demographic information both categorized educators into different researcher-defined profiles based on usage, experience, and other demographic information which the researchers felt were important. The first study was done by Takeuchi and Vaala (2014) and focused only on K-8 educators. The researchers did not feel that age or gender were important variables, but instead focused on the following variables based on results of a cluster analysis: (a) how frequent an educator plays digital games; (b) how frequent an educator uses learning games in their classroom; (c) how comfortable an educator is integrating learning games; (d) number of barriers faced in using games; (e) support from parents, administrators, and other educators; and (f) the amount of professional development on learning games they access. By grouping educators in this way, the researchers ended up with four distinct groups relatively equal in number.

The first group defined by Takeuchi and Vaala (2014) were “the dabblers.” These educators scored moderate to low-moderate in all six of the variables. While these educators did integrate learning games in their classrooms, they did so just several times a month and expressed a level of discomfit in doing so. They were less likely than other groups to use learning games as a primary means of teaching content. The second group was called “the players,” and consisted of educators who were described as avid gamers themselves but integrated learning games the least often out of any of the four profile categories. This category reported high levels of barriers to implementation and a low belief in the ability of learning game usage to positively impact student behavior. The third group was called “the barrier busters” because although they also reported high levels of barriers to usage, they also reported high levels of usage in their classrooms, suggesting that barriers to usage can exist alongside usage of learning games. The final profile category is “the naturals,” who play games often, teach with them often, and do not report a high level of barriers to usage. This group also reported the highest level of community support for their usage. These four profiles demonstrate the complexity of learning game integration. Within educators who play games themselves, some integrate learning games, and some do not. Within educators who perceived a high level of barriers to usage, some still integrate learning games while others do not. This suggests that perhaps these factors may not be as useful as others in predicting actual usage.

A second recent national study of educators and learning games was conducted by Fishman et al. (2014). This study focused on K-12 educators in the United States. Much like the Takeuchi and Vaala (2014) study, the researchers separated educators into four categories based on a cluster analysis of variables. The researchers did not find significant differences between gender, age, teaching experience, subject area, or grade taught among the clusters. The first category is the enthusiastic game-using teacher, which represented 18% of those surveyed. These educators used games the most frequently for all purposes identified in the study, including primary and supplementary delivery methods and for formative assessment. This group reported less barriers than other groups and were most likely to believe in the effectiveness of learning games. The second group was the frequent (but not for core content) game-using teacher and represented 17% of the respondents. As the name of the group suggest, this group was a frequent user of learning games for supplemental purposes, but not for using learning games as a primary method of teaching content or as a formal assessment. Their perception of the effectiveness of learning games was only slightly less than the first group. The third group was the frequent, but not so enthusiastic game user and represented 32% of the respondents. This group was more likely to use learning games to teach core content than other groups of teachers but used games much less for assessment and supplemental content. They perceived learning games to be less effective than teachers in the previous two clusters. The final grouping was the not-so-into games teacher, which represented 32% of the respondents. This group used games the least across all reported uses and was three times less likely to be comfortable integrating digital games than teachers in other groups. They were also the group least likely to see learning games as effective for any purpose. These groupings suggest a high degree of correlation between belief in the effectiveness of learning games and usage in the classroom, as well as a potential correlation between perceived barriers and usage.

Conclusion

This literature review began by examining the research behind the possible benefits of using digital games to positively influence the learning experience of students. With the potentials established, the literature review then examined the theories and models focused on the actual integration of digital games in the classroom. An overview of Rogers' (2003) diffusion of innovation served as an overarching paradigm to the adoption process of technologies. Two major approaches to researching learning game integration were examined. The first was the TPACK framework created by Koehler and

Mishra (2009), which focuses on the three knowledge bases used by educators while integrating a technology: (a) technical knowledge; (b) pedagogical knowledge; and (c) content knowledge. An adaptation of the TPACK framework called TPACK-G which focused specifically on learning game integration was created by Hsu and Chai (2012). The TPACK-G model focuses on different knowledge structures educators need to successfully integrate digital games into classrooms. The second major approach to researching learning game integration is the TAM model (Davis, 1989), which explained variance of technology integration based upon two factors: perceived ease of use and perceived benefits. The TAM model has proven a robust model in explaining the variance in usage or intended usage of technologies, although the importance of the core constructs and additional constructs added by researchers varies. Regarding digital games, results of the TAM model are dependent upon usage intention (hedonic versus utilitarian) and sample population. While results from students using learning games showed variability between whether ease of use or usefulness was the most important factor determining attitude towards usage, results from educators converged on usefulness being the primary factor in predicting intended usage.

The literature review also examined additional factors beyond these two major approaches, including barriers to usage and profiles of educators who use learning games. Based on research done by Baek (2008) and others, a list of teacher-generated barriers to the usage of digital games for learning was proposed. Regarding profiles of educators, the literature review explained how self-identification as a gamer may impact these approaches, especially the first two, and looked at how age, gender, and teaching assignment may affect usage. In conclusion, the author has provided a summary of the literature on the potential benefits of digital games in learning environments and on issues affecting the adoption and integration of learning games into educational settings. The next chapter will describe the methodology of the current study, which is meant to build upon the previous research of digital game integration and make a meaningful addition to the understanding of learning game usage.

CHAPTER THREE: METHODOLOGY

The purpose of this study is to compare the influence of two major frameworks on an educator's decision to use learning games in their classroom, as well as how additional factors interact with the frameworks. Interactions between the major frameworks will also be examined to see if the use of both frameworks creates a stronger prediction model than each framework on its own. The two major frameworks are TPACK and TAM, with the additional factors being barriers to usage and educator profiles. Based on the current research, the researcher has chosen two different models to represent these major frameworks. The two models are the TPACK-G model (Hsu & Chai, 2012), which was derived from the original TPACK (Koehler & Mishra, 2009), and an adaptation of Davis' (1989) TAM model based on Bourgonjon et al. (2010)'s work. Data regarding demographics and the constructs that make up each model will be collected from current educators, along with information on how frequently they use learning games in their classroom. In this chapter, the author will detail the research objectives and hypotheses, the research design, and the methodology regarding sampling, instruments, data collection, and the statistical analyses that will be used.

Research Objectives and Hypotheses

The objective of this study is to compare how two major frameworks and their constructs affect teacher usage of learning games and how they interact with each other, as well as how additional factors affect these frameworks. The factors include game knowledge, game content knowledge, game pedagogical content knowledge, perceived usefulness, learning opportunities, perceived barriers to implementing learning games, ease of use, gender, and experience with video games. The following hypotheses are proposed:

H1. Acceptance of learning games (TAM) will have a significant effect on the use of learning games.

H2. Technological Pedagogical Content Knowledge of Games (TPACK-G) will have a significant effect on the use of learning games.

H3. Educator game knowledge, game pedagogical knowledge, game content knowledge, and game pedagogical content knowledge will have significant effect on learning games usage.

H4. Perceived usefulness, learning opportunities, ease of use, preference for video games, and experience with games will have significant effects on learning game usage.

H5. Teacher perception of the inflexibility of curriculum, the negative effects of gaming, the students' lack of readiness, fixed class schedules, and limited infrastructures will have significant effects on learning game usage.

H6. Experience with video games, age, gender, teaching experience, subject taught, and grade level taught will have significant effects on learning game usage.

Descriptions of Models

To test the hypotheses, two models were adapted from current academic literature on why educators use or do not use learning games in the classroom. A survey instrument was adapted to test how well these models predict the usage of learning games by educators. The following sections describe and visually represent each of the two models.

TPACK-G

TPACK-G stands for Technological Pedagogical Content Knowledge-Game (Hsu & Chai, 2012) and is based on the TPACK framework developed by Koehler and Mishra (2009). It has four constructs. The first is Game Knowledge (GK), which measures an educator's ability to learn how to use a digital game. The second is Game Pedagogical Knowledge (GPK), which is a measure of an educator's understanding of how digital games fit into different pedagogical approaches. The third factor is Game Content Knowledge (GCK), which is a measurement of an educator's understanding of how learning games can fit into their content. The final factor is Game Pedagogical Content Knowledge (GPCK), which is a measurement of an educator's confidence in using digital games to enhance student learning in their classroom environments. Figure 4 illustrates the TPACK-G model.

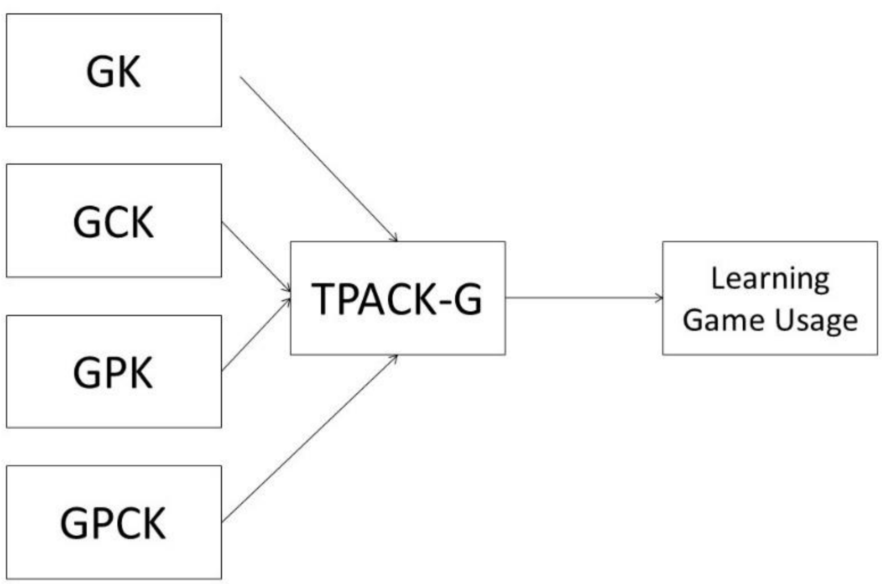

Figure 4. TPACK-G Model

Technology Acceptance Model (Adapted)

Davis (1989) created the Technology Acceptance Model (TAM) to show factors which affect whether end users are likely to use a technology. The TAM model has two core constructs: perceived ease of use and perceived usefulness. Bourgonjon et al. (2010) adapted the TAM model to apply to student acceptance of learning games in classrooms. The factors in the student model include perceived usefulness, learning opportunities, ease of use, preference for video games, and experience with video games. The factors can be adapted to apply to educators instead of students with some rewording. Figure 5 below illustrates the adapted TAM model based on Bourgonjon et al.'s (2010) work.

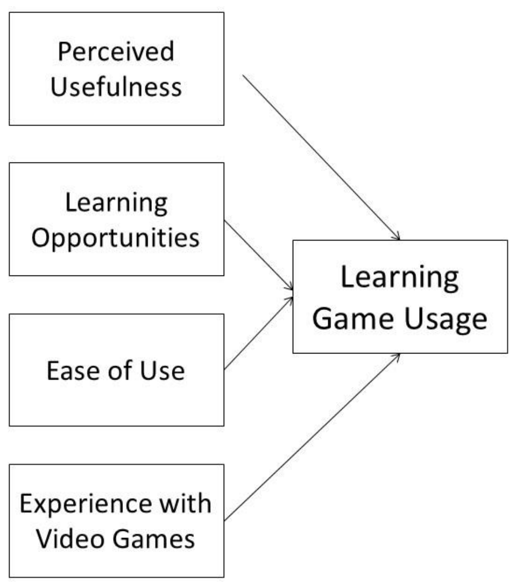

Figure 5. Adapted TAM Model

Additional Factors – Perceived Barriers

There are many potential perceived barriers to integrating learning games mentioned in current literature. Five of these barriers that appear frequently in the literature (Baek, 2008) have been chosen for this study. The first is inflexibility of curriculum. Many educators must follow an established curriculum and even a pacing guide that may not allow for the use of digital games. The second is the negative effects of gaming, which measures an educator's belief that digital games as a medium have a negative effect on students. The third is students' lack of readiness. This measures the perception that educators have that students might approach learning games with an attitude that makes games inefficient learning tools. The fourth is fixed class schedules, or the perception that having a rigid time structure for classes does not allow enough time to implement a digital game. The fifth is limited infrastructure, which measures the perception that the infrastructure educators have access to does not support the usage of learning games.

Additional Factors – Educator Profiles

Other researchers have suggested various factors pertaining to educators themselves that may affect the decision to integrate learning games. The first of these factors is age, with the assumption often being that younger educators are more familiar and comfortable with digital games and therefore more likely to use them. The second factor is gender, with the assumption that males play digital games more often than females and are therefore more willing to integrate learning games. Evidence supporting these first two factors is not strong. A related factor is experience with digital games, which in this study refers to overall experience playing digital games instead of experience integrating learning games. This study will approach outside experience both through self-identification as a gamer and through how much an educator agrees with the statement "I play digital games.". This factor is already incorporated into the TAM model, but the individual construct will also be examined. A fourth factor is subject-taught and is based on an idea that some subjects lend themselves to the use of learning games more than others, possibly because of the availability of learning games for different contents. The final factor is grade level taught, with several studies suggesting that educators of elementary students integrate learning games more often than secondary educators.

Instrumentation

To test the hypotheses, the author conducted a survey-based correlational study with the goal of comparing the effects of each construct on the dependent variable of usage, as well as examining how each construct correlates with the other constructs. More parsimonious models will be examined with the goal of understanding the most important factors affecting usage and how the two major frameworks interact. The research involved the following phases: survey development, pilot testing and pretesting, data collection, data analysis including hypotheses testing through multiple regression and correlations, and data interpretation.

The research conducted in this study was survey-based research. The instrument used was an online survey. It was constructed mostly by adapting and combining questionnaires from previous research into the two models that represent the major frameworks being studied. Additionally, the author created questions about frequency of learning game use. All questions, unless noted otherwise, will be answered on a six-point Likert scale with the following labels: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, and strongly agree. A list of questions is included in Appendix B.

Technology Acceptance Model

Ten survey questions were adapted from the survey created by Bourgonjon et al. (2010), which is based on the Davis' (1989) Technology Acceptance Model (TAM). Bourgonjon et al.'s survey is meant for students, so the questions were adapted to be suitable for educators. The survey was intended to measure five constructs: perceived usefulness (PU), learning opportunities (LO), ease of use (EOU), experience with video games (EWVG), and preference for video games (PFVG). Psychometric results of Bourgonjet et al.'s survey showed that the five factors explained 74% of the shared variance and all factor loadings exceeding .4 only within their own construct. As far as internal reliability, all Cronbach's alpha coefficients exceeded .70.

TPACK-G

Eight questions will measure the TPACK-G construct. Two questions each will measure the factors of game knowledge (GK), game content knowledge (GCK), game pedagogical knowledge (GPK), and game pedagogical content knowledge (GPCK). The questions are modified from Hsu and Chai's (2012) Technological Pedagogical Content Knowledge - Game survey, which measures an educator's TPACK-G. The survey questions can be found in Hsu, Tsai, Chang, and Liang (2017). The original survey had 14 items and the Cronbach's alpha coefficients were between .90 and .94, with an overall reliability coefficient of .95. The relationship between GPCK and actual usage was not tested in Hsu and Chai's study as it will be in this study.

Perceived Barriers

Ten questions were adapted from Baek's (2008) survey of educator-perceived barriers to using digital games. Baek's survey focused on the following six factors: (a) inflexibility of the curriculum, (b) negative effects of gaming, (c) students' lack of readiness, (d) lack of supporting materials, (e) fixed class schedules, and (f) limited budgets. Baek found that these factors accounted for 41.16% of the variance in usage. Each of the items retained had a loading factor greater than 0.30. The survey used in this study measures the following: (a) inflexibility of the curriculum; (b) negative effects of gaming; (c) students' lack of readiness; (d) fixed class schedules; and (e) limited infrastructure.

Frequency of Use

Four questions in the survey were developed by the researcher to measure usage of learning games in the classroom. The purpose of the model is to depict factors that affect teacher usage of digital games in the classroom. However, digital games can be used in different ways: as a primary means of teaching content, as a supplementary means of teaching content, and as a reward. The model will focus on a dichotomous view of usage in the classroom as the dependent variable, meaning either educators do or do not use learning games at least once per week, but subsequent questions will provide data as to how teachers are using learning games. The questions will focus on how often educators use learning games in any capacity, as well as how often they use them as a primary means of teaching content, a supplementary means of teaching content, or as a classroom reward.

Demographics

Optional questions regarding the demographics of respondents were included at the end of the survey. The questions included personal questions about age and gender of the respondents. The final few questions focused on professional experience, including length of teaching experience and subject and grade taught. These represent potential mediating variables and the correlations between them and usage will be examined.

Population and Sample

The data collection focused on current educators in K-12 schools in the United States and was gathered using an online survey. Current educators are the focus population because prospective educators have not had to work under the constraints of the educational system and former educators are not teaching in the current system. A survey was used to gather large-scale data from many different educators. A survey is appropriate because the research focuses on the perceptions of educators, not necessarily on actual circumstances. For instance, an educator may believe that budget constraints prohibit digital gaming when free options are available. The survey was conducted online because it is more convenient, asynchronous, and a wider geographical sampling can be conducted. The survey was distributed during the Spring and Summer of 2018.

Data Collection

The survey instrument was developed initially by the author based on work by Bourgonjon et al. (2010), Baek (2008), and Hsu and Chai (2012) and then vetted and adapted based on the feedback of the defense committee. The online survey tool Survey Monkey was used to send out the survey and collect the data. Approval was sought and granted from Boise State's Institutional Review Board (IRB) before the survey was distributed. The IRB approval can be found in Appendix E. The survey was initially sent out to a small number (approximately 30) of educators as a pilot test. The purpose of the pilot test was to see if the survey functioned as needed on Survey Monkey, to check for potential areas where the survey was difficult to understand or to finish, and to test if the results could be analyzed as intended. After the initial pilot test, no major modifications had to be made. The author sent out surveys to educators whose email addresses could be obtained. This consisted of educators within the author's current and former employments, as well as educators that are a part of the graduate colleges that the author has attended. To obtain responses from current educators in Boise State's Graduate School of Education, a slight modification to the initial IRB application had to be made. The approval for this modification can be found in Appendix F. Data collection continued until the number of respondents exceeded 100, at which point data analysis began.

Data Analysis

The data collected from the survey was downloaded from Survey Monkey in a format for SPSS 25 to utilize. SPSS 25 was used exclusively to analyze the data from the survey. The data was first screened for responses with a significant number of missing answers and for responses that did not originate from the target population of current K-12 educators. For instance, one respondent listed a university-level class as a response for the subject-taught question. Descriptive data was analyzed for demographic information and for data on current usage of learning games. Internal reliability of the models was examined using Cronbach's Alpha. From this point, multiple regression analyses were conducted on the models and individual factors to test the predictive power of the models and their constructs. Assumptions necessary for multiple regression analyses were tested to verify that this procedure was appropriate. The individual and combined factors of each model were tested, along with the complete models and model interactions.

Based on the data, a new model was also formed and tested. The purpose of this was to examine the potential overlap between TPACK-G and TAM and to see if a synthesized model could perform better than each individual model. Exploratory Factor Analysis was done on the factors to see if the number of constructs between the two models could be narrowed. A multiple regression analysis was then done to test the predictive power of the new model with usage as a dependent variable.

Finally, correlations between major constructs and subconstructs were examined using SPSS 25's multiple correlations tool. A two-tailed Pearson's Correlation value was calculated for each construct and learning game usage. This analysis served as another way to examine how well each model explained educator usage of learning games as well to examine the overlapping ideas between each model.

Conclusion

This chapter detailed the steps the author took to prepare and conduct the research, as well as how the data was analyzed. The research described is a survey-based, quantitative study intended to measure the predictive power of two major frameworks and additional factors on actual usage of learning games by currently-practicing K-12 educators. The following chapter examines the results of the data and draws potential explanations and conclusions from the data, which will be examined in greater depth in the final chapter.

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

This chapter contains the results of the data and an explanation of the statistical analyses that were used on the data to help answer the research questions and to test the hypotheses. As this is a quantitative study, the data explained in this chapter will be the used to draw conclusions for the research. The conclusions drawn, including answers to the research questions and the results of the hypotheses testing, will be explained in the final chapter. The results in this chapter will reveal some trends in the data that can help explain what type of educators use learning games and what factors have the greatest effect on learning game usage.

Descriptives

Demographics

100 responses were kept for the survey. Of these, 73 were female, 25 were male, and two declined to answer. Age ranges were as follows: 22 in the "21-29" age, 33 in the "30-39" range, 27 in the "40-49" range, 13 in the "50-59" range and two in the "60+" range. Two declined to give their age. As far as teaching experience, 12 teachers had zero to three years of experience, 27 had four to six years of experience, 18 had seven to nine years, and 42 had 10+ years, with one declining to answer. As far as age level taught, three were kindergarten teachers, 23 were elementary teachers, 34 were middle school teachers, and 35 were high school teachers, with five declining to answer. 20 teachers taught all subjects, 19 taught math, 14 taught language arts, 12 taught science, six taught social studies, three taught foreign languages, two taught physical education, four taught

art, one taught drama, and eight taught CTE, with 11 in the other category or missing data. Tables 1 through 5 detail this information.

Table 1: Description of Sample Population Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	25	25.0	25.3	25.3
	Female	73	73.0	73.7	99.0
	Decline to answer	1	1.0	1.0	100.0
	Total	99	99.0	100.0	
Missing	System	1	1.0		
Total		100	100.0		

Table 2: Description of Sample Population Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	21-29	22	22.0	22.2	22.2
	30-39	33	33.0	33.3	55.6
	40-49	27	27.0	27.3	82.8
	50-59	13	13.0	13.1	96.0
	60+	2	2.0	2.0	98.0
	Decline to answer	2	2.0	2.0	100.0
	Total	99	99.0	100.0	
Missing	System	1	1.0		
Total		100	100.0		

Table 3: Description of Sample Population Teaching Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-3 years	12	12.0	12.1	12.1
	4-6 years	27	27.0	27.3	39.4
	7-9 years	18	18.0	18.2	57.6
	10+ years	42	42.0	42.4	100.0
	Total	99	99.0	100.0	
Missing	System	1	1.0		
Total		100	100.0		

Table 4: Description of Students Taught by Sample Population

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Kindergarten	3	3.0	3.1	3.1
	Elementary	23	23.0	23.5	26.5
	Middle School	34	34.0	34.7	61.2
	High School	35	35.0	35.7	96.9
	Decline to answer	3	3.0	3.1	100.0
	Total	98	98.0	100.0	
Missing	System	2	2.0		
Total		100	100.0		

Table 5: Description of Subjects Taught by Sample Population

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All subjects	20	20.0	22.5	22.5
	Math	19	19.0	21.3	43.8
	Language Arts	14	14.0	15.7	59.6
	Science	12	12.0	13.5	73.0
	Social Studies	6	6.0	6.7	79.8
	Foreign Language	3	3.0	3.4	83.1
	Physical Education	2	2.0	2.2	85.4
	Art	4	4.0	4.5	89.9
	Drama	1	1.0	1.1	91.0
	CTE	8	8.0	9.0	100.0
	Total	89	89.0	100.0	
Missing	System	11	11.0		
Total		100	100.0		

ANOVA tests and t-tests were run to see if there were significant differences between categories regarding usage. The results showed only the category of subjects taught had a significant effect on usage, although this was potentially due to the low number of respondents in some of the other categories. The results of the ANOVA test and descriptives of the mean comparison are presented below in Tables 6 and 7. Table 7 details the frequency of use by educators per subject and shows that educators who teach all subjects are the most frequent users of learning games.

Table 6: ANOVA Tests Between Subjects Taught

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	48.049	9	5.339	2.794	.007
Within Groups	150.940	79	1.911		
Total	198.989	88			

Table 7: Mean Comparisons Between Subjects Taught

	N	Mean	Std. Deviation	Std. Error
All subjects	20	3.7500	1.29269	.28905
Math	19	2.2632	.99119	.22739
Language Arts	14	2.6429	1.49908	.40065
Science	12	2.5833	1.50504	.43447
Social Studies	6	2.8333	1.32916	.54263
Foreign Language	3	1.6667	.57735	.33333
Physical Education	2	4.0000	.00000	.00000
Art	4	3.0000	2.16025	1.08012
Drama	1	3.0000	.	.
CTE	8	4.3750	1.84681	.65295
Total	89	2.9888	1.50374	.15940

<u>Usage</u>

Out of 100 teachers, 86 teachers use games on average at least once per week, while 14 report no usage of learning games. 32 reported using only once per week, while 11 reported using every day. Of those that used games, 60 reported using games at least once a week for primary instructional purposes, while 82 reported using games at least once a week for supplementary instructional purposes. 64 reported using games at least once a week for purposes of rewards. The following tables show the frequency of usage by type.

Table 8: Dichotomous Usage of Learning Games by Teachers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 - Never Uses Games	14	14.0	14.0	14.0
	1 - Uses Games	86	86.0	86.0	100.0
	Total	100	100.0	100.0	

Table 9: Days per Week Using Learning Games

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 - Never	14	14.0	14.0	14.0
	1	32	32.0	32.0	46.0
	2	24	24.0	24.0	70.0
	3	15	15.0	15.0	85.0
	4	4	4.0	4.0	89.0
	5 - Daily	11	11.0	11.0	100.0
	Total	100	100.0	100.0	

Table 10: Usage of Games as Primary Learning Tool

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	2	2.0	2.2	2.2
	0 - Never	27	27.0	30.3	32.6
	1	35	35.0	39.3	71.9
	2	12	12.0	13.5	85.4
	3	9	9.0	10.1	95.5
	5 - Daily	4	4.0	4.5	100.0
	Total	89	89.0	100.0	
Missing	System	11	11.0		
Total		100	100.0		

Table 11: Usage of Games as Supplementary Learning Tool

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	4	4.0	4.5	4.5
	0 - Never	3	3.0	3.4	7.9
	1	47	47.0	52.8	60.7
	2	16	16.0	18.0	78.7
	3	12	12.0	13.5	92.1
	4	2	2.0	2.2	94.4
	5 - Daily	5	5.0	5.6	100.0
	Total	89	89.0	100.0	
Missing	System	11	11.0		
Total		100	100.0		

Table 12: Usage of Games as Reward

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	3	3.0	3.4	3.4
	0 - Never	22	22.0	24.7	28.1
	1	33	33.0	37.1	65.2
	2	13	13.0	14.6	79.8
	3	7	7.0	7.9	87.6
	4	5	5.0	5.6	93.3
	5 - Daily	6	6.0	6.7	100.0
	Total	89	89.0	100.0	
Missing	System	11	11.0		
Total		100	100.0		

The results of the survey suggest that a large majority of educators (86%) are using games in their classrooms, and 11% are using games in their classrooms daily. 60% of teachers use games as a primary means of teaching at least once per week, while 82% of teachers use games as a supplementary means of teaching at least once per week. Gender, age, teaching experience, and grade taught had no significant effect on usage; however, educators who taught "all subjects" had a significantly higher usage than teachers of language arts, science, and social studies, but not math. Since fixed class schedules significantly correlated with usage, as detailed later in this chapter, it may be that educators who teach all subjects have less rigid class schedules, and these educators also likely teach younger students, two factors that may contribute to higher usage.

Overall, however, it does appear that most educators are using learning games in their classrooms at least once per week to teach content.

Multiple Regression Assumptions

Results of the data were examined for completeness, leaving 80 complete responses. When total scores were calculated for each model, one resulted in an extreme outlier and was removed. The following data analysis focuses on the complete 79 responses without any outliers. The constructs of each model were examined to see if they had a statistically significant effect on total usage, as well as if the data meets several necessary assumptions for multiple regressions. Combined totals were used for each test. For each model, the P-Plot showed a mostly linear pattern, demonstrating normality. No VIF scores were higher than five, suggesting there are no multicollinearity issues with the models. Tables and figures below detail the results of the normality, linearity, and multicollinearity tests. With assumptions met, multiple linear regression was deemed an appropriate method for analyzing the data.

Table 13: TAM Model Collinearity

Model		Collinearity Statistics	
		Tolerance	VIF
1	tam_ewg_total	.697	1.435
	tam_eou_total	.455	2.196
	tam_pfvg_total	.240	4.175
	tam_pu_total	.311	3.216
	tam_lo_total	.503	1.987

a. Dependent Variable: dich_usage

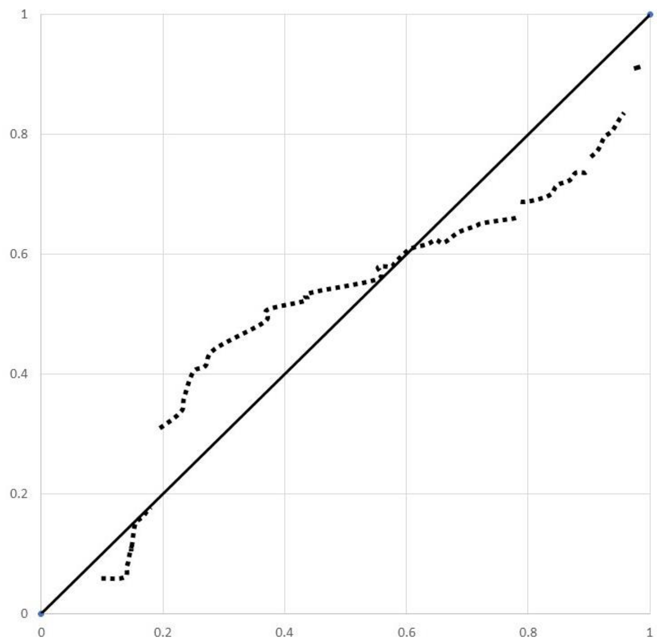

Figure 6. Normal P-Plot of TAM Model

Table 14: TPACK-G Model Collinearity

		Collinearity Statistics	
Model		Tolerance	VIF
1	tpackg_gk_total	.633	1.579
	tpackg_gck_total	.369	2.707
	tpackg_gpk_total	.212	4.722
	tpackg_gpck_total	.250	4.001

a. Dependent Variable: dich_usage

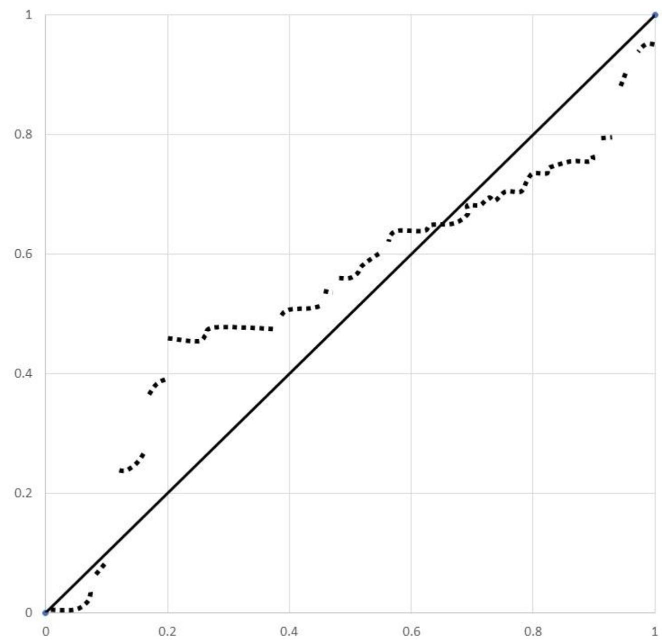

Figure 7. Normal P-Plot of TPACK-G Model

Actual Usage and Intention to Use

While the adjusted R-squared scores discussed in the following sections for the models were relatively low, especially compared to previous results from TAM-based studies, this may be because the study focused on actual usage of learning games while most TAM-based studies focus on the behavior intention to use games. In a report on four longitudinal studies using an extended TAM model, Venkatesh and Davis (2000) found the correlation between intention to use and actual usage behavior to be between the ranges of .44 and .57. While this is certainly a significant correlation of moderate strength, intention to use a technology is not the same thing as actually using a technology. Reporting an intention to use a technology like learning games in the classroom, especially after being part of a study that is focused on the technology being a useful learning tool, is much different than taking the time and risk to implement a new technology on a regular basis.

Even with the lower adjusted R-squared scores of the models, clear trends in the data were seen that help establish the importance of different factors to educators when deciding if they will integrate learning games. Both models showed similar predictive powers, and it was clear that the models could be improved if the frameworks were used to complement each other. Results from the multiple regression analyses will be discussed below and the conclusions will be drawn in the following chapter.

TAM Model

The 10 items of the survey instrument meant to measure the TAM model were tested for internal reliability. The score shows that the model has good internal reliability. Correlation testing was run between the constructs and usage. All constructs except experience with video games were significant at the $p < .01$ level. Preference for video games had the strongest correlation, followed by ease of use and usefulness. Stepwise linear regression was run on the 10 factors. The resulting model was made up of one predictor and had an adjusted R-squared of .250. Each minor construct in the TAM model had two underlying factors. When these scores were combined and averaged, the model was improved slightly. Only "preference for video games" was retained in the stepwise regression. The adjusted R-squared score was .281 and the model was significant at the $p < .01$ level. To see how much each minor construct contributed to the major construct, exploratory factor analysis was run on the five minor constructs. The results showed that all five measured one component and gave factor loading scores for each. These scores were used to calculate a total weighted TAM score. This model had an adjusted R-squared score of .246 and was significant at the $p <.001$ level. Finally, the previous procedure was repeated with only the constructs that were significant, which meant removing the construct of experience with digital games. The new factor loadings are given and the adjusted R-squared value of the TAM model improved to .261 and was significant at the p <.001 level.

Table 15: Reliability Statistics for TAM Model

Cronbach's Alpha	N of Items
.895	10

Table 16: Correlation Between TAM Constructs and Usage

		usage	tam_ewg_total	tam_eou_total	tam_pfvg_total	tam_pu_total	tam_lo_total
usage	Pearson Correlation	1	.257*	.445**	.538**	.415**	.343**
	Sig. (2-tailed)		.022	.000	.000	.000	.002
	N	79	79	79	79	79	79

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 17: TAM Model Uncombined Factors

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.509[a]	.259	.250	.27699

a. Predictors: (Constant), tam_pfvg1

Table 18: TAM Model Constructs

	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.538[a]	.290	.281	.27120

a. Predictors: (Constant), tam_pfvg_total

Table 19: TAM Model EFA

	Component 1
tam_pfvg_total	.917
tam_pu_total	.859
tam_eou_total	.793
tam_lo_total	.781
tam_ewg_total	.649

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table 20: Complete TAM Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.505[a]	.255	.246	.27771

a. Predictors: (Constant), tam_total

Table 21: EFA of TAM Model's Significant Constructs

	Component
	1
tam_pfvg_total	.926
tam_pu_total	.894
tam_eou_total	.791
tam_lo_total	.790

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table 22: Complete TAM Model, Only Significant Constructs

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.520[a]	.271	.261	.27482

a. Predictors: (Constant), tam_total_efa_significant

TPACK-G Model

The questions in the survey meant to measure the TPACK-G model had good internal reliability, with a Cronbach's Alpha score of .928. Correlation testing was run between the constructs and usage. All constructs had a significant moderate correlation with usage except for game knowledge. Game pedagogical knowledge had the highest correlation, followed closely by game pedagogical content knowledge. Stepwise linear regression was run on the eight uncombined factors. The resulting model was made up of one predictor and had an adjusted R-squared of .316. The scores of each construct were combined and stepwise linear regression was run again. The adjusted R-squared was

.298, with game pedagogical knowledge being the only predictor. Exploratory factor analysis was run to get factor loading scores for the complete TPACK-G score. The complete model had an adjusted R-squared of .270 and was significant with p <.001. Exploratory factor analysis was run again only the significant constructs, meaning game knowledge was removed. These loading scores were used to compute a weighted TPACK-G score. This final model had an adjusted R-squared score of .302 which was significant at the p <.001 level.

Table 23: Reliability Statistics for TPACK-G Model

Cronbach's Alpha	N of Items
.928	8

Table 24: Correlation Between TPACK-G Constructs and Usage

		usage	tpackg_gk_total	tpackg_gck_total	tpackg_gpk_total	tpackg_gpck_total
usage	Pearson Correlation	1	.264*	.437**	.554**	.541**
	Sig. (2-tailed)		.019	.000	.000	.000
	N	79	79	79	79	79

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 25: TPACK-G Model Uncombined Variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.570[a]	.324	.316	.26451

a. Predictors: (Constant), tpack_gpk2

Table 26: TPACK-G Model Combined Variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.554[a]	.307	.298	.26793

a. Predictors: (Constant), tpackg_gpk_total

Table 27: TPACK-G Model EFA

	Component 1
tpackg_gpk_total	.922
tpackg_gpck_total	.917
tpackg_gck_total	.872
tpackg_gk_total	.730

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table 28: Total TPACK-G Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.528[a]	.279	.270	.27324

a. Predictors: (Constant), tpackg_total_weighted_average

Table 29: EFA of TPACK-G Model's Significant Constructs

	Component
	1
tpackg_gpk_total	.952
tpackg_gpck_total	.921
tpackg_gck_total	.895

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table 30: Complete TPACK-G Model, Only Significant Constructs

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.558[a]	.311	.302	.26710

a. Predictors: (Constant), tpack_g_total_efa_significant

When comparing the predictive powers of the complete models, the TPACK-G model had a slightly higher predictive rate. Correlations between the combined scores of the models and usage showed similar results. Both TPACK-G and TAM demonstrated a significant moderate correlation with usage, but TPACK-G's score was slightly higher. The correlations also demonstrated that the two frameworks have a significant and strong correlation with each other, suggesting some overlap between the models. This will be discussed in another section in this chapter.

Table 31: Correlations between TPACK-G, TAM, and Usage

		dich_usage	tam_total_weighted_average	tpackg_total_weighted_average
dich_usage	Pearson Correlation	1	.505**	.528**
	Sig. (2-tailed)		.000	.000
	N	79	79	79
tam_total_weighted_average	Pearson Correlation	.505**	1	.753**
	Sig. (2-tailed)	.000		.000
	N	79	79	79

**.Correlation is significant at the 0.01 level (2-tailed).

Additional Factors

Perceived Barriers

Each individual item categorized as a perceived barrier was correlated with usage. Only four of the items were significantly correlated with weak to moderate strengths, two dealing with finding digital games to fit the curriculum, one about controlling student behavior while they are using learning games, and one about having enough time within class periods to integrate learning games. Exploratory factor analysis showed that all four items loaded onto a single construct. These scores were averaged together to create a single construct referred to as perceived barriers. When added to the TPACK-G model of significant constructs, the adjusted R-squared score increased from .302 to .315. When added to the TAM model of significant constructs, the adjusted R-squared score increased from .261 to .309. As a note, unless otherwise specified the TPACK-G models and the TAM models used from now on will consist only of the significant constructs.

Table 32: Perceived Barriers Correlations

		dich_usage	pb_ic1	pb_ic2	pb_ne1	pb_fcs2
dich_usage	Pearson Correlation	1	.404**	.391**	.497**	.330**
	Sig. (2-tailed)		.000	.000	.000	.003
	N	79	79	79	79	79

**. Correlation is significant at the 0.01 level (2-tailed).

Table 33: Perceived Barriers EFA

	Component
	1
pb_ic2	.869
pb_ic1	.856
pb_ne1	.744
pb_fcs2	.564

Extraction Method: Principal

Table 34: TPACK-G + Perceived Barriers

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.577[a]	.333	.315	.26455

a. Predictors: (Constant), perceived_barriers, tpack_g_total_significant

Table 35: TAM + Perceived Barriers

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.572[a]	.327	.309	.26573

a. Predictors: (Constant), tam_total_efa_significant, perceived_barriers

Experience with Games

Regarding educator profiles, most of the variables were tested in the descriptive sections. However, experience with games, which is a subconstruct of the TAM model, has not been distinctly tested. Correlations between the two items making up the construct and usage were tested. The item asking if the educator considered themselves a gamer had an insignificant correlation with usage. The item asking how frequently the educator plays games had a significant weak correlation with usage (.304). The addition of these items did not improve the TPACK-G model (it was already a part of the TAM model).

Table 36: Experience with Games and Usage

		dich_usage	tam_ewg1	tam_ewg2
dich_usage	Pearson Correlation	1	.304**	.157
	Sig. (2-tailed)		.006	.167
	N	79	79	79

**. Correlation is significant at the 0.01 level (2-tailed).

Interaction Between Models and Additional Factors

Results of Models with Added Constructs

Literature into learning game implementation suggests that the TPACK and TAM frameworks may complement each other. To explore this idea, the author took several different approaches to the data. First, each model was complemented with a construct from the other model. When preference for video games was added to the TPACK-G model, the adjusted R-squared score increased from .311 to .338. With the addition of the perceived barriers construct, the score increased further to .344. The TAM model began at .261 and increased to .328 with the addition of game pedagogical knowledge. The addition of perceived barriers further increased the adjusted R-squared to .336.

Table 37: TPACK + Preference for Video Games

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.596[a]	.355	.338	.26023

a. Predictors: (Constant), tam_pfvg_total, tpack_g_total_efa_significant

Table 38: TPACK + Preference for Video Games + Perceived Barriers

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.607[a]	.369	.344	.25907

a. Predictors: (Constant), perceived_barriers, tam_pfvg_total, tpack_g_total_efa_significant

Table 39: TAM + Game Pedagogical Knowledge

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.588[a]	.345	.328	.26206

a. Predictors: (Constant), tpackg_gpk_total, tam_total_efa_significant

Table 40: TAM + Game Pedagogical Knowledge + Perceived Barriers

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.601[a]	.361	.336	.26063

a. Predictors: (Constant), perceived_barriers, tam_total_efa_significant, tpackg_gpk_total

The predictive power of both frameworks combined into one model was tested with and without the addition of perceived barriers. A model with both TPACK-G and TAM resulted in an adjusted R-squared value of .320, which does not represent a significant improvement from the TPACK-G model. With the addition of the perceived barriers construct, the model barely improved to an adjusted R-squared value of .323. The models were more improved when they were complemented with a single construct instead of the entire model. This may be because there is an overlap in the constructs between the models and combining the complete models results in redundant constructs.

Table 41: TAM and TPACK Combined, Full Models

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.581a	.337	.320	.26373

a. Predictors: (Constant), tpack_g_total_efa_significant, tam_total_efa_significant

Table 42: TAM and TPACK Combined, Full Models + Perceived Barriers

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.591[a]	.349	.323	.26306

a. Predictors: (Constant), perceived_barriers, tam_total_efa_significant, tpack_g_total_efa_significant

Overlaps Between Model Constructs

The models show some evidence of overlapping constructs. Exploratory factor analysis was run on all factors from both frameworks. The results showed the items represent three distinct constructs, with only one item not having a significant loading on any of the three constructs. The first construct contains items pertaining to the ability to integrate games, including game pedagogical knowledge, game pedagogical content knowledge, game content knowledge, and perceived ease of use. The second construct contains items pertaining to a desire to use games and a belief that games are useful in classrooms, including perceived usefulness, learning opportunities, and preference for video games. The final construct deals with experience with video games, including game knowledge from the TPACK-G framework and experience with games from the TAM framework.

Table 43: EFA on all TAM and TPACK-G Items

	Component		
	1	2	3
tpack_gpk1	.995		
tpack_gpk2	.887		
tpack_gpck1	.863		
tpack_gck1	.821		
tpack_gck2	.730		
tpack_gpck2	.694		
tam_eou2	.678		
tam_eou1	.670		
tam_pu2		.833	
tam_pu1		.791	
tam_pfvg2		.758	
tam_lo1		.752	
tam_lo2		.724	
tam_ewg2			.844
tpack_gk1			.815
tam_ewg1			.780
tpack_gk2			.689

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Correlations were run with the three constructs and usage. Results showed that the ability to integrate games had the highest correlation with usage, followed by a desire to use games based on a belief in their usefulness. Experience with games was again shown to not be a significant factor. A model with the two significant constructs was run and the adjusted R-squared was .311.

Table 44: Correlations between Overlap Constructs and Usage

		usage	ability_to_ integrate	want_to_ integrate	experience_with _games
usage	Pearson Correlation	1	.550**	.458**	.286*
	Sig. (2-tailed)		.000	.000	.011

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 45: Composite Model Predictive Power

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.573[a]	.329	.311	.26543

a. Predictors: (Constant), want_to_integrate_games, ability_to_integrate_games

The overlap and interaction between constructs were tested one final way. Each of the constructs that make up the two major frameworks and perceived barriers were run through a stepwise multiple regression analysis. Two constructs, one from each framework, were left after the analysis was run. These were game pedagogical knowledge from the TPACK-G framework and preference for video games from the TAM framework. The model consisting of these two constructs had an adjusted R-squared value score of .348 was significant at the p <.001 level. Interestingly, this model has the highest predictive power of all the models tested and is also one of the most parsimonious.

Table 46: Stepwise Analysis of Underlying Constructs

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.604[a]	.364	.348	.25823

a. Predictors: (Constant), tpackg_gpk_total, tam_pfvg_total

Strength of Individual Questions

As a final analysis of the data, individual questions were tested for strength of correlation with usage and the amount of variance in usage individual question explained. The following question had the highest correlation with usage (.540) and explained 31.6% of the variance in usage: “I know how to integrate digital games into my teaching.” This question was one of the measures of game pedagogical knowledge. The questions in the following table all had a correlation of over .50 with usage. The text of the questions can be found in Appendix B. All but one of the questions came from the TPACK-G framework.

Table 47: Correlations Between Individual Questions and Usage

	tam_pfvg1	tpack_gpk2	tpack_gpck2	tpack_gpck1
dich_usage	.509**	.570**	.512**	.540**

**. Correlation is significant at the 0.01 level (2-tailed).

Conclusion

This chapter reported the results of a survey on educator usage of learning games. Data was manipulated in several ways to address the research questions and the hypotheses. First, descriptive data on usage trends and demographic variables were compiled and reported. T-tests were run on the data to see which demographic variables, if any, had significant effects on usage. Multiple regression assumptions were tested to see if the data was fit for linear regression. Multiple linear regression was used to test the models. Individual factors, individual constructs, and the total models were tested for their adjusted R-squared score, which is a measure of their predictive power. Correlations between the constructs and usage were determined to see which constructs had a positive correlation with usage. The additional factors of perceived barriers and experience with games were examined. Items about perceived barriers were tested for significant correlations with usage. Four items were found to be significant, and these items could be combined into a single perceived barriers construct. The addition of perceived barriers improved both models, but more significantly improved the TAM model. Experience with games was not very significant on usage. Interactions between models were examined to see if one or both models could be improved by adding constructs from the other framework. Game pedagogical knowledge improved the TAM model, and preference for video games improved the TPACK-G model. Overlaps between the models were also examined and the frameworks were combined into three major constructs. Two of the constructs were significantly correlated with usage, but one construct appearing to measure experience with games was not significant. The two significant constructs explained 31% of the variance in usage. The best model in terms of predictive power consisted of one construct from each major framework: (a) game pedagogical knowledge from TPACK-G and (b) preference for video games from TAM. This model explained 34.8% of the variance in usage.

CHAPTER FIVE: CONCLUSIONS

The final section of this paper will discuss the results of the hypotheses testing. The data will be used to answer the research questions. Finally, the author will end with suggestions for further research based on the data from the surveys and a reflection on how this research could have been improved.

Research Questions Answered

- Has the rate of adoption of learning games increased from previously reported survey results based on the use of learning games at least once per week by educators?

The data from the survey supports the idea that the adoption of learning games has increased. Previous data from Fishman et al. (2014) and Takeuchi and Vaala (2014) reported usage rates around 55%, while survey results from this study report 86% of educators using learning games at least once per week. This substantial increase should be taken with some reservation, however. The question focused on weekly usage, with options including never, once per week, twice per week, etc. However, respondents who use games less than once per week but more than never may have defaulted to responding once per week. 54% of the respondents used learning games twice or more per week, which is very close to the rate of weekly usage reported by the previous two surveys

Data on usage shows that learning games are used in a variety of ways. The most common usage of learning games was supplementary means of teaching content, with 35% of respondents using learning games in this way more than once per week. 31% of respondents used learning games as a reward more than once per week, while 25% of respondents use learning games as a primary means of teaching content more than once per week. Results on usage suggest that a slight majority of educators are using learning games relatively frequently, defined as more than once per week, with usage split relatively evenly between primary means of teaching content, supplementary means of teaching content, and reward, although primary means of teaching content is the lowest usage type.

- What, if any, are the typical characteristics of an educator who uses learning games at least once per week?

There was no evidence that age, teaching experience, or grade level taught influenced the decision of educators to integrate learning games. Gender, which has shown to have a significance in other studies, also did not have a significant influence on learning game integration, although this may have resulted from the low number of male respondents (about 25%). A more evenly-distributed survey may have enough data to show gender differences in usage if they exist.

Educators who identified themselves as teaching “all subjects” were statistically more likely to integrate learning games than other educators. Since previous results have tended to show that elementary educators use learning games more than secondary educators, this may be the result of a combination of factors: (a) educators who teach multiple subjects to students tend to teach younger students, and (b) educators who teach multiple subjects will have more opportunities to integrate learning games into their curriculum than those that teach only one subject.

Somewhat counterintuitively, there is little evidence that educators who play more digital games themselves tend to integrate more learning games into their classroom, and there is no evidence that educators who identify as a gamer tend to integrate more learning games. This may be because only 30% of respondents identified as a gamer, and over half of those only somewhat agreed with the statement “I would describe myself as a gamer,” leaving somewhere less than 15% of respondents agreeing or strongly agreeing with self-identification as a gamer. Another reason may be that educators who play games for hedonic purposes may not relate their experiences with being able to use games for utilitarian purposes in their classrooms. This is supported in the literature by the differences in results when the TAM model is used to explore hedonic or utilitarian uses (Wang & Goh, 2017).

The lack of defining characteristics of educators who use learning games may be because usage rates show that over half of all educators use learning games on a somewhat regular basis. In terms of Rogers’ (2003) diffusion of innovations theory, adoption has moved into the late majority users. Since more educators appear to be using learning game than are not, the defining characteristics that may have existed when usage rates were much lower are now hidden among the general demographics of a typical educator.

- Which of the two major frameworks for viewing learning game usage, TAM and TPACK, represents the most accurate viewpoint for researchers?

The data suggests that both frameworks are nearly equal in their ability to predict usage of learning games. The TPACK-G framework was able to explain 27% of the variance in usage, while the TAM framework explained 24.6% of the variance in usage.

When only constructs that showed a significant correlation with usage were used, which meant dropping game knowledge from TPACK-G and experience with games from TAM, the TAM model increased to 26% and the TPACK-G framework increased to 30.2%. Overall, if one framework had to be chosen over the other, the results from this study provide evidence that the TPACK-G framework is better at predicting educator usage of learning games than the modified TAM framework. This suggests that the best way to increase learning game integration is to provide professional development to teach educators how learning games fit with various pedagogical approaches and contents.

- Which factors of the TAM and TPACK frameworks have the greatest impact on the decision of educators to use or not use learning games?

Within the TPACK-G framework, game pedagogical knowledge was the most important factor in predicting learning game usage. The construct had a significant moderate correlation with usage (.554). The correlation between game pedagogical content knowledge and learning game usage was only slightly lower (.541). Within the TAM framework, a preference for video games was the most important factor, with a correlation of .538. Ease of use (.445) had a stronger correlation than perceived usefulness (.415), which is contrary to most studies involving TAM, educators, and learning games, although the strength in correlation is only slightly greater.

- What is the interaction and overlap of the TAM and TPACK frameworks?

Complementing a framework with a construct from another framework improved each model. This is consistent with literature that suggests the two frameworks together give a more comprehensive picture of the integration process of learning games. When a preference for video games was added to the TPACK-G model, the predictive power increased to 33.8%. When game pedagogical knowledge was added to the TAM model, the predictive power of that model was increased to 32.8%. This suggests that research within the TPACK-G framework could be improved if educator preferences for learning games are also considered. The TAM model could be improved if researchers considered an educator's knowledge of how to teach with learning games.

As far as an overlap between the frameworks, results from exploratory factor analysis suggest that nine constructs of TAM and TPACK could be organized into three major constructs. The first of these consists mostly of TPACK-G constructs, with the deletion of game knowledge and the addition of perceived ease of use. This construct can be labeled "ability to teach with learning games." The second construct is made up of the following factors from the TAM model: (a) perceived usefulness, (b) preference for video games, and (c) learning opportunities. This construct suggests a desire to use learning games based in a belief that they are a useful tool. The third construct contains experience with games and game knowledge. This construct did not have a significant correlation with usage. Ability to use games had a higher correlation with usage (.550) than a desire to use learning games (.458). Results of testing the two new constructs with multiple linear regression show that they can explain 31.1% of the variance in usage. These results provide evidence of several important points: (a) there exists some overlap between the TAM and TPACK-G model, (b) a combination of these two models improves each model, (c) the ability to use learning games is more important to usage than a desire to use learning games, and (d) experience with games outside of educational settings does not significantly affect the decision to integrate learning games.

Overall, the best model in terms of predictive power and parsimoniousness consisted of the TAM construct of preference for video games and the TPACK-G construct of game pedagogical knowledge. This model explained 34.8% of the variance in usage and suggests that educators who want to use learning games and have the knowledge of how games can be used for instructional purposes are the most likely to implement them into the classroom. The data in this study suggests that professional development should be focused on (a) attributes of learning games that make them good learning tools to get educators interesting in using learning games; and (b) how learning games fit into different pedagogical approaches, with the latter focus being the most important. Exposing educators to specific games, focusing on technical knowledge, or explaining how games can be made to fit within curriculums may be less useful than these two approaches.

- Are there other factors outside of the TAM and TPACK frameworks that have a significant influence on educator usage of learning games?

Two additional factors were examined to see if they had a significant influence on learning game usage: (a) educator-perceived barriers to integration, and (b) experience with digital games outside of the classroom. As far as the second factor, little evidence supported experience with games affecting usage. No evidence supported the idea that educator self-identification as a gamer led to more usage of learning games in a classroom. This finding corresponds with results from similar studies and suggests that the hedonic use of video games is different than the utilitarian use of learning games in a classroom. In other words, the motivations and skill sets required to play games for fun is very different than the motivation and skill set required to integrate learning games into a classroom.

Regarding perceived barriers, items pertaining to the inflexibility of curriculums, fixed class schedules, and negative student behavior while playing learning games did have a significant correlation with usage. Exploratory factor analysis supported these items being grouped under a single construct of "perceived barriers." When the perceived barriers construct was added to the TPACK and TAM models, the predictive powers of each improved, especially the TAM model. However, the improvement was not as much as when interactions between TPACK-G and TAM were examined by complementing one framework with a construct from the other framework. The TAM model improved more when game pedagogical knowledge was added to the model as opposed to when the perceived barriers construct was added. This suggests that barriers to usage may be overcome with game pedagogical knowledge. It also suggests that perceived barriers may be declining in importance, perhaps because availability of computers in classrooms and of learning games in general is likely increasing. An increase in the number of educators using learning games, which was suggested from the results of this survey, is also potentially normalizing the use of learning games, further removing barriers that previously existed.

Hypotheses Testing

The following section lists the hypotheses of the study and whether they are confirmed or denied based on the survey data.

- H1. Acceptance of learning games will have a significant effect on the use of learning games.

H1 is supported by the data. The TAM model was found to be significant in predicting educator usage of learning games, explaining 24.6% of the variance in usage (26.1% when experience with video games was removed). The TAM model also had a moderate significant correlation of .505 with usage.

- H2. Technological Pedagogical Content Knowledge of Games (TPACK-G) will have a significant effect on the use of learning games.

H2 is supported by the data. The TPACK-G model was found to be significant in predicting educator usage of learning games, explaining 27.0% of the variance in usage (31.1% when game knowledge was removed). The TPACK-G model also had a moderate significant correlation of .528 with usage.

- H3. Educator game knowledge, game pedagogical knowledge, game content knowledge, and game pedagogical content knowledge will have a significant effect on learning games usage.

H3 is mostly supported by the data. Game knowledge was not significantly correlated with usage at the $p < .01$ level. The remaining constructs had significant moderate correlations with usage. Game pedagogical knowledge had the highest correlation with usage (.554), followed by game pedagogical content knowledge (.541), and game content knowledge (.437).

- H4. Perceived usefulness, learning opportunities, ease of use, preference for video games and experience with games will have significant effects on learning game usage.

H4 is mostly supported by the data. Experience with games was not significantly correlated with usage. The remaining constructs had significant moderate correlations with usage, except learning opportunities which had a significant weak correlation. Preference for video games had the highest correlation (.538), followed by ease of use (.445), perceived usefulness (.415), and learning opportunities (.343).

- H5. Teacher perception of the inflexibility of curriculum, the negative effects of gaming, the students' lack of readiness, fixed class schedules, and limited infrastructures will have significant effects on learning game usage.

H5 is only partially confirmed. Inflexibility of curriculum, fixed class schedules, and negative effects of gaming, specifically student behavior in a classroom while using learning games, were significant. Lack of student readiness and limited infrastructures were not significant factors. Exploratory factor analysis suggested that these factors load onto the same construct, which was named "perceived barriers."

- H6. Experience with digital games, age, gender, experience, subject taught, and grade level taught will have significant effects on learning game usage.

H6 was mostly rejected. Age, gender, grade level, experience with digital games, and teaching experience did not affect usage. Subject taught did have a significant effect on usage, with educators who listed "all subjects" as the best description of what they teach being more likely to integrate learning games into their classrooms.

Suggested Changes to Improve Research

Looking at the survey in retrospect, several changes could be made to improve the survey and therefore the overall research. First, there was a clear focus in the survey on digital games as opposed to non-digital games, both in personal experience and in classroom usage, and this distinction was likely unnecessary. On the experience side, educators who might play non-digital games, including tabletop games like board games or card games, may have answered that they do not play digital games and are not a gamer even if they frequently play non-digital games and consider themselves a (non-digital) gamer. Secondly, some of the questions were too ambiguous and could be improved. For instance, one question about experience with games simply states, “I play digital games” and is answered on a Likert-scale from strongly disagree to strongly agree. This could be replaced by “I play games” and the scale could run from “never” to “occasionally” to “frequently,” etc., or even be more specific as to the number of times a week someone plays games. This data might match up better with the number of times an educator integrates learning games into his or her classroom, digital or non-digital. Changing the survey and the focus of the research to incorporate non-digital games could possibly result in the experience construct becoming statistically significant.

Another possible revision that might change the results of the research is to use non-modified frameworks for TAM and TPACK. Focusing on the core constructs of the TAM model, namely perceived usefulness and perceived ease of use, may change the results since the modified TAM used in this study separated out learning opportunities from perceived usefulness. Using the TPACK framework, which has been more widely tested than the TPACK-G framework, may also generate better results in terms of higher R-squared scores.

Finally, the use of a more randomized method for collecting responses would be more statistically appropriate. If the author was to give the survey again, school districts could be picked first by randomly choosing a state, then randomly choosing a district within the state, and then randomly choosing a school to seek permission from an administrator to distribute the survey. This process could continue until the number of responses exceeded the necessary amount.

Suggestions for Future Research

Given that both the TPACK-G model and the TAM model improved when constructs from one framework were used to complement the other framework, further research into understanding the integration of learning games by educators should look to incorporate both frameworks, especially game pedagogical knowledge and a preference for video games. Factors that affect a preference for games should be further examined. A composite model of the two frameworks was suggested using the constructs of (a) Ability to Use, which is comprised of most of the TPACK-G framework and perceived ease of use; (b) Desire to use, which includes educator preferences and in large part the belief that learning games are useful educational tools; and (c) Experience with Games. Since experience with games outside of classrooms for pleasure does not appear to affect use of learning games in a classroom, this construct could be adapted to focus on educator experience with integrating learning games. In other words, do educators who have had experience using learning games continue to do so? Use of either this new framework or a combination of TPACK and TAM will offer researchers a more complete understanding of the technology integration that educators experience, both with learning games and potentially other innovations and technologies.

Conclusion

Educators are using learning games in their classroom. The profile of an average educator who uses learning games is not necessarily a young male educator who identifies as a gamer but instead is just a typical educator. While barriers to usage may exist, these appear to be less significant than knowing how to integrate learning games and believing that learning games are useful educational tools. If the use of learning games by educators is going to improve, both in terms of amount of usage and the quality of usage, professional development should focus in part on demonstrating the qualities of digital games that make them good learning tools and in part on a pedagogical approach to integration. If educators have the ability to integrate learning games into their teaching, chances are they will make use of learning games as another instructional tool in their repertoire.

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APPENDIX A

Survey Consent

My name is Joseph Waarvik and I am a doctoral candidate at Boise State University. My advising professor at Boise State is Dr. Youngkyun Baek. I am inviting you to participate in this research study.

The title of this study is “Establishing an SEM Model to Depict Relationships Between Factors that Affect Educator Usage of Learning Games.” In current academic literature, there are three different approaches to understanding why educators do or do not use digital learning games in their classroom. This research seeks to model how all three approaches affect adoption of digital learning games and to compare the total effect of each approach. The results of the research will be used to improve current professional development in the area of learning games.

Your participation in this study will involve taking a survey on your interactions with digital learning games. The survey could take 15-20 minutes.

The risks to you as a participant are minimal. These include the chance that your survey answers could be linked back to your email address. To minimize the risk, email and other identifying information will be discarded after the survey results are coded. The survey results will be aggregated, or combined together, and not kept at an individual level.

The results of this study will be published in a dissertation and possibly in scientific research journals or presented at professional conferences. However, your name and identity will not be revealed and your record will remain anonymous.

While there is no direct benefit to individuals who participate in the survey, participation may benefit you indirectly by improving the body of knowledge regarding digital learning games and specifically professional development for teachers in this area.

You can choose not to participate. If you decide not to participate, there will be no penalty to you or loss of any benefits to which you are otherwise entitled. You may withdraw from this study at any point during the survey. Simply close the window before hitting the submit button to withdraw.

If you have questions about this research study, you can call Joseph Waarvik at 907-888-3331 or Professor Youngkyun Baek at 208-426-1023. If you have questions about your rights as a research participant, you can call the Boise State Institutional Review Board at 208-426-5871.

APPENDIX B

Survey Questions Aligned

1. I have read the informed consent above and am a current K12 educator who agrees to participate in this survey.

2. I play video games. (TAM_EWG1)

3. I would describe myself as a gamer. (TAM_EWG2)

4. I find it easy to learn to play digital games. (TPACK_GK1)

5. I have the technical skills to play most digital games effectively. (TPACK_GK2)

6. I am knowledgeable about managing digital games in my classroom. (TAM_EOU1)

7. I understand how to implement digital games in my classroom. (TAM_EOU2)

8. I like to use digital games in my classroom. (TAM_PFVG1)

9. If I could, I would use more digital games in my classroom. (TAM_PFVG2)

10. The use of digital games in the classroom would increase my effectiveness as a teacher. (TAM_PU1)

11. I can identify subject matter content that can be taught with a digital game. (TPACK_GCK1)

12. I can tell whether a digital game includes a targeted subject matter. (TPACK_GCK2)

13. I know about general instructional strategies for using digital games.(TPACK_GPK1)

14. I know how to integrate digital games into my teaching. (TPACK_GPK2)

15. I can create lessons that combine the subject I teach, the methods I use to teach, and digital games. (TPACK_GPCK1)

16. I can select digital games to use in my classroom that enhance what I teach, how I teach, and what students learn. (TPACK_GPCK2)

17. I can find one or more digital games suitable for a given learning objective. (PB_IC1)

18. I can locate a digital game that focuses on learning. (PB_IC2)

19. I could control my students' use of digital games once they are immersed in playing them. (PB_NE1)

20. The use of digital games in the classroom would increase my students' learning. (TAM_PU2)

21. Digital games would offer my students opportunities to think critically. (TAM_LO1)

22. Using digital games in the classroom would motivate my students. (TAM_LO2)

23. Students are skilled enough with digital games to learn from them in a classroom. (PB_LOR1)

24. Too much time would be required for students to learn how to use a digital game in the classroom. (PB_LOR2)

25. The use of digital games in the classroom would contribute to students becoming addicted to gaming. (PB_NE2)

26. The time allotted for the curriculum would allow me to teach using digital games. (PB_FCS1)

27. The amount of time in a given period makes it possible to play digital games during a class. (PB_FCS2)

28. School computing technologies are powerful enough to run digital games. (PB_LI1)

29. School information technology personnel would support the installation and updating of digital games on computers. (PB_LS1)

30. Administration would support my use of digital games for learning. (PB_LS2)

31. I have easy access to computers or other hardware (iPads, etc.) that would allow my students to play digital games during my class. (PB_LI2)

32. On average, how many times a week will your students use digital games in your classroom for any reason (including rewards for finishing work)? (Usage)

32. On average, how many times a week will your students use digital games in your classroom as a primary means of learning content? (Usage)

33. On average, how many times a week will your students use digital games in your classroom as a supplemental means of learning content? (Usage)

34. On average, how many times a week will your students use digital games in your classroom as a reward for finishing work, good behavior, etc.? (Usage)

35. Gender: Male / Female / Decline to answer

36. Age: 21-29 / 30-39 / 40-49 / 50-59 / 60+

37. Teaching experience: 0-3 years / 4-6 years / 7-9 years / 10+ years

38. What grade level best describes the level that you primarily teach? : Kindergarten / Elementary / Middle School / High school

39. What best describes the subject that you primarily teach: all subjects / Math / Language Arts / Science / Social Studies / Foreign Language / Physical Education / Art / Drama / CTE/ AG or Shop / Other

APPENDIX C

Recruitment Email

My name is Joseph Waarvik and I am a doctoral candidate at Boise State University. **I am inviting you to participate in a research study regarding educator use of digital learning games in the classroom.**

Your participation in this study will involve taking a survey on your interactions with digital learning games. **The survey could take 30-45 minutes.**

The survey is anonymous. The combined results of the survey will be published in a dissertation. No individual results will be included; all scores will be combined.

The only requirement for participants is that they are currently practicing educators in K12 education.

I am needing to gather data from at least 150 current educators. You can choose not to participate, but if you are willing to help me reach that goal, please follow the link below to the online survey.

Thank you for your time!

Joe Waarvik

APPENDIX D

Boise State Recruitment Email

Greetings fellow graduate students!

My name is Joseph Waarvik, and I am a doctoral candidate in Boise State's educational technology program. I am inviting currently practicing K12 educators to complete a brief survey on using digital games for learning in the classroom.

The survey has 35 questions and takes about 5 minutes to complete. Participation is voluntary and anonymous. The combined results of the survey will be published in my dissertation.

I really appreciate your help in completing this research. Thank you for your time.

Joseph Waarvik