2019

The effect of digital game-based learning on student learning: A literature review

Katrina Serrano
University of Northern Iowa

The effect of digital game-based learning on student learning: A literature review

Abstract

Digital game-based learning can be used by educators to support students in developing skills. This review examined the effect of digital game-based learning on student learning at the K-12 level. Sixteen peer-reviewed research studies, two meta-analysis studies, and two literature reviews published between 2011-2019 were selected for analysis. The reviewed research indicated that when digital game-based learning is used that includes key game design elements (collaboration, choice, feedback) as well as instructional design, there typically is a positive impact on student engagement. Research also indicated that digital game-based learning along with collaboration can have a significant effect on student motivation, however, the addition of instructions and feedback were not found to have a significant effect. Individual studies on digital game-based learning showed a significant positive impact on student achievement, while one of two meta-analysis studies found that there was a small effect size for digital game-based learning on student achievement in mathematics. Further studies should be conducted on digital game-based learning at the K-12 level over an extended period of time with the addition of game design elements and instructional design. More studies where empirical/statistical data is collected, and involving content area experts in research was recommended.

The Effect of Digital Game-Based Learning on Student Learning:

A Literature Review

A Graduate Review

Submitted to the

Division of Instructional Technology

Department of Curriculum and Instruction

In Partial Fulfillment

Of the Requirements for the Degree

Master of Arts

UNIVERSITY OF NORTHERN IOWA

by

Katrina Serrano

Date (July, 2019)

DIGITAL GAME-BASED LEARNING

This Review by: Katrina Serrano

Titled: Effect of Digital Game-Based Learning on Student Learning

has been approved as meeting the research requirement for the

Degree of Master of Arts.

_____	Dr. Leigh E. Zeitz_____
Date Approved	Graduate Faculty Reader
_____	Dr. Deborah Tidwell_____
Date Approved	Graduate Faculty Reader
_____	Dr. Robin Dada_____
Date Approved	Head, Department of Curriculum and Instruction

Table of Contents

Abstract

Digital game-based learning can be used by educators to support students in developing skills. This review examined the effect of digital game-based learning on student learning at the K-12 level. Sixteen peer-reviewed research studies, two meta-analysis studies, and two literature reviews published between 2011-2019 were selected for analysis. The reviewed research indicated that when digital game-based learning is used that includes key game design elements (collaboration, choice, feedback) as well as instructional design, there typically is a positive impact on student engagement. Research also indicated that digital game-based learning along with collaboration can have a significant effect on student motivation, however, the addition of instructions and feedback were not found to have a significant effect. Individual studies on digital game-based learning showed a significant positive impact on student achievement, while one of two meta-analysis studies found that there was a small effect size for digital game-based learning on student achievement in mathematics. Further studies should be conducted on digital game-based learning at the K-12 level over an extended period of time with the addition of game design elements and instructional design. More studies where empirical/statistical data is collected, and involving content area experts in research was recommended.

Keywords: digital game-based learning, engagement, motivation, learning/student achievement, K-12

The Effect of Digital Game-Based Learning on Student Learning: A Literature Review

Introduction

"While actively involved in a game, our brains experience the joy of struggling with, and coming to understand, new systems, concepts, and perspectives. The same principles apply to digital games" (Jukes, 2017). Game-based learning is not a new concept in education, however, it has gained more popularity in recent years, particularly in classrooms where educators are looking to create an engaging learning environment. Digital game-based learning has actually been around for over three decades with advances in information technology and the Internet leading to an increase in use and popularity (Brom, Sisler, & Slavik, 2010). Digital game-based learning can take learning to the next level and support educators in creating a 21st century classroom. Digital game-based learning involves using computer and video games as tools to address learning goals. Digital game-based learning can also be defined as an "Instructional method that incorporates educational content or learning principles into computer or video games with the goal of engaging learners" (Coffey, 2017, para. 1). In Prensky's (2001) book, titled *Digital Game-Based Learning,* he wrote a chapter about the "Games Generations" (p. 1) learners. According to Prensky (2001), "Computer and video games provide one of the few structures we currently have that is capable of meeting many of the Games Generation's changing learning needs and requirements" (p. 25).

Games, and in particular video games, have continued to gain popularity and have become among the most popular forms of entertainment in our society (Barab, Gresalfi, & Ingram-Goble, 2010). Some educators might see digital game-based learning as a way to

hook students, especially those who are gamers, and get them interested in learning. However, there needs to be a more well-developed rationale for using digital game-based learning than just interest and entertainment value. While digital game-based learning is known for being fun, the question is whether it does, in fact, have an impact on learners. Is there research available to support the claim that the digital game-based format has a positive effect on student learning? When integrating technology into the classroom, it is important to do so in a purposeful way and to use research-based strategies and tools. Digital game-based learning is appealing to use in the classroom because it changes the learning environment; however, if there is no effect on students and their learning then there is no purpose and valuable learning time is wasted.

The purpose of this literature review is to analyze available literature and research in order to determine the effects of digital game-based learning on student learning in grades K-12. The results of this review can be applied by educators when determining whether to bring digital game-based learning into their classrooms and the impact that its use will have on their students and their learning. Educators will be able to support their decision to use game-based learning with the findings of this literature review. This literature review is organized into three themes that were found through research on the effects of digital game-based learning. The themes are engagement, motivation, and student achievement.

Terms

Digital Game-Based Learning - "Instructional method that incorporates educational content or learning principles into computer or video games with the goal of engaging learners" (Coffey, 2017, para. 1)

DIGITAL GAME-BASED LEARNING

Engagement - "The student sees the activity as personally meaningful and worthy of trying to get it right (Schlechty, 2011 as cited in Johnston, Beaudoin, Jones, & Waggert, 2015, p. 91).

Instructional Framework - Instruction is designed using research strategies and resources that can meet the individual needs of students (Marzano, 2007).

Motivation - A student's desire to begin learning or taking part in a process and that continues overtime (Keene, 2018).

Intrinsic Motivation - "The doing of an activity for its inherent satisfactions rather than for some separable consequence" (Ryan & Deci, 2000, p. 56).

Extrinsic Motivation - "A construct that pertains whenever an activity is done in order to attain some separable outcome" (Ryan & Deci, 2000, p. 60).

Self Determination Theory - "The more self-determined, or internalized, extrinsic motivation is, the better the observed behaviors or outcomes; for instance, deeper learning" (Ünlü & Dettweiler, 2015, p.688).

ARCS Motivation Model - ARCS was originally developed by John Keller in 1979 to provide a more effective way to understand what influences motivation to learn and ways to identify and solve learning motivation problems (Keller, 1987).

Collaborative Digital Game-Based Learning - When students work with partners or in small groups and are provided with the opportunity to communicate with others and work together to achieve a common goal during game play (Chen, Wang, & Lin, 2015).

Student Achievement - Generally refers to a student's performance in academic areas such as reading, language arts, math, science and history as measured by achievement tests" (Cunningham, 2015, p. 1)

Methodology

Sources on digital game-based learning were located and identified by using Google Scholar and the University of Northern Iowa Rod Library One Search. One Search allows multiple databases to be searched at the same time in order to get a larger number of results and a variety of articles from academic journals than searching one database at a time yields. The databases that were used through One Search were Gale Academic One File, Academic Search Elite (EBSCO), ACM Digital Library, Educational Full Text, Science Direct, Springer Link, Wiley Online Library, JSTOR, and ERIC. In both Google Scholar and One Search, the keywords *digital game-based learning* and *game-based learning* were initially used to search for sources. Then in order to narrow the results more after locating some articles, the Boolean operator "And" was used to search for *secondary, middle school, and high school* along with the previous terms in order to locate more specific articles. An example of how the Boolean term "And" was used is *digital game-based learning AND middle school.* Originally the effects of digital game-based learning at the secondary level was the focus of this review, however, it was difficult to locate enough articles on just secondary level use of digital game-based learning, so the decision was made to expand the focus to K-12.

As sources were located articles with a publication date in the past five years were given first priority. Later the focus was expanded to articles written in the 2000s. Making the scope of this review K-12 also helped in the process of locating articles that were varied, but still relevant. The abstract of each article was read and articles that analyzed the effects of digital game-based learning on students were selected for further review. A table was used to keep track of the sources that were read and to record information which would assist in the

process of finding common themes. The table had six columns with the title identifier (author, date of publication, and the title of the article), level of education, type of measure, number of participants (if applicable), type of assignment, and outcome. Finally, when determining the articles that would be used in this literature review, the following criteria were used: relevant to the topic, written/published from 2011-2019, peer-reviewed, K-12 level (however, could be at the university level if the conclusions of the study could be applied at the K-12 level), and could be either a qualitative or quantitative study.

Analysis and Discussion

Twenty research articles were identified and included in this review. The articles that were reviewed include sixteen peer-reviewed research studies, two meta-analysis studies, and two literature reviews published from 2011-2019. Each study or article was evaluated by focusing on the participants (for research studies) or grade level, experimental design, the method used to measure the effect of digital game-based learning, and the results of the study. The themes of engagement, motivation, and student achievement were found after analyzing research on the effect of digital game-based learning on student learning.

Engagement

Before reviewing the literature on digital game-based learning and the impact on student engagement, it is important to understand what is meant by engagement. Engagement takes place when students are actively involved in their learning. Sometimes educators might think that students are engaged because they are well behaved, however, engagement is much more than if a student is participating (raising their hand and answering questions) and behaving in class (Johnston, Beaudoin, Jones, & Waggett, 2015). Student engagement is also more than a student looking or being busy when completing assignments or activities. True

student engagement is defined as, “The student sees the activity as personally meaningful and worthy of trying to get it right” (Schlechty, 2011 as cited in Johnston et al., 2015, p. 91).

Engagement during digital game-based learning. In two studies, observations and interviews were used to measure student engagement. Khan, Ahmad and Malik (2017) and Hanghoj, Lieberoth, and Misfeldt (2018) found that there was an increase in student engagement when students were involved in digital game-based learning. Ronimus, Kujala, Tolvanen, and Lyytinen (2014), used survey responses from both student participants and parents to measure student engagement and found that initial engagement with the digital game-based learning was high, however, later in the study engagement decreased. Eseryel, Law, Ifenthaler, Ge, and Miller (2014), used an inventory/questionnaire in their experimental study to measure engagement and found that engagement can decrease when there is a lack of an instructional framework and support for students as they participate in digital game-based learning. Byun and Loh (2018), measured engagement using a questionnaire and found that the use of sound in games can have a positive impact on student engagement.

Khan et al. (2017), in their study, worked to identify the impact digital game-based learning has in secondary science classrooms. Participants in the study were 72 (ages 12-15) 8th grade students from a low-cost private school in Pakistan. Participants were randomly assigned to one of four class sections. Two sections were control groups and received conventional science instruction, which involved a teacher-centered teaching approach and rote learning. Two sections were experimental groups that received the same science content as the controls sections in a digital game-based learning instructional environment that was more student-centered and focused on application of skills and concepts. Four engagement factors were analyzed to determine the effect of digital game-based learning on student

engagement. Researchers looked at positive body language, consistent focus, student confidence, and fun and excitement. The researchers found through observations, interviews, and assessments that digital-game based learning can have a positive impact on student engagement. In interviews, students reported that the digital game-based learning experiences kept them behaviorally, as well as emotionally engaged. When the researchers asked students to compare their experiences with digital game-based learning to the previous mode of instruction in their science classes, they described a clear difference in their engagement level. "They were more involved in this learning experience and they had more fun while learning, in contrast to their previous teacher-centered learning approach" (Khan et al., 2017, p. 2790).

Giannakas, Kambourakis, Papasalouros, and Gritzalis (2017), conducted a thirteen-year literature review (2004-2017) on game-based learning and the shift to mobile (digital) game-based learning due to the increase in electronic device usage. They focused on six dimensions as they reviewed literature which included spatio-temporal (time and location), collaboration/social, session (e.g. quick games, mini games, learning in the real world with online support and guidance), personalization, data security and privacy, and pedagogy. One finding from their analysis of literature demonstrated that the ability to personalize the learning environment when engaged in many mobile game-based learning experiences can increase student engagement. "Many students prefer to learn in their own pace, do things without continuous supervision, and act in a way they prefer under specific circumstances" (Giannakas et al., 2017, p. 36). A particular element of personalization that they found to appeal to learners is the ability to take part in collaborative problem solving, which is when

students work with either partners or a team to solve a problem and complete game objectives.

Eseryel et al. (2014), conducted an experimental study at a rural high school in the midwest with ninth grade students (88 students total. 50 females and 38 males.). The participants played a multiplayer online game that involved them taking on a researcher role in a survivor story. They explored an uninhabited and unexplored island on a distant Earth-like planet. The game's objective was to successfully colonize the planet and be the winning team. In order to measure engagement the researchers had participants respond to an inventory, with a subscale for engagement. Eseryel et al. (2014) found that the participants' engagement was negatively related to their interest and competence during the game. They found that participants' engagement was positively related to their change in self-efficacy while playing the game. Additionally the researchers found that social interaction during game play can have a significant effect on student engagement.

Engagement and game design. The game design of digital game-based learning plays an important role in student engagement. In a study conducted by Ronimus et al. (2014), two game features, challenges and rewards, were investigated to determine the effect on first and second grade students' engagement levels during digital game-based learning. The researchers were specifically interested in whether the game features would result in sustained interest overtime, so the study was conducted for 8 weeks. One hundred thirty-eight students played a digital game-based learning game called Graphogame (Lyytinen et al., 2009) a web-based learning game, which involves students in making letter-sound connections. Students played Graphogame at home for eight weeks after previously playing the game at school. Researchers chose to have students play at home to measure the impact

of more time to engage with the game on student engagement. Engagement was measured using an in game survey that was completed by participants at the end of each game session. Researchers specifically focused on enjoyment, playing time, and interest in reading when determining whether students were engaged. Participants initial enjoyment when playing the game was high and then decreased by the end of the study. The total playing time for all participants was 179.60 minutes. When the researchers analyzed the impact that rewards and challenge had on playing time they found that there was no effect on total playing time. Reward games were found to result in an increase in the duration of a game session initially, however, overtime plays sessions became shorter. The findings were that while the children were interested in the game initially, as time progressed their engagement decreased.

As the researchers in the study began to look at the game's elements and for key game design principles that can increase student engagement they found that several were missing, such as, collaboration, choice, and feedback. The lack of these key elements was proposed as a possible reason for the decline in student engagement overtime during the study. This study concluded that student engagement can be impacted significantly by game design. "When developing digital learning games for young children with poor academic skills, it is important that the game fulfills the design principles that support long-term engagement and interest in the subject matter" (Ronimus et al., 2014, p. 245). Feedback is a key element in a game because if students do not receive feedback on their progress it can lead to a decrease or loss of interest.

Giannakas et al. (2017), found that a lack of instructional frameworks for educators to use along with mobile game-based learning, can result in not enough support for learners, particularly those who struggle academically. As a result, when students struggle or face

challenges and there is not an instructional framework in place to support them; engagement can decrease. Including an instructional framework in teaching means instruction is designed using research strategies and resources that can meet the individual needs of students (Marzano, 2007). Using an instruction framework with digital game-based learning also allows for a connection to be made between the game students are playing and academic content.

Khan et al. (2017) found through their study that using the Applied Model, Game-Based Learning Instructional Design (GBL ID), when designing lessons that incorporate the use of digital-game based learning can enhance engagement. The six phases of GBL ID include:

1. Considering the needs and characteristics of learners.
2. Considering the objectives and goals of the lesson or instruction.
3. Considering what will be acceptable evidence of creating instruction to support students in making progress towards meeting learning goals.
4. Designing and conducting and evaluation of the game, selecting games that meet the needs of learners, planning and developing tech support, and introducing the game in the real-life setting where students will be when they play the game.
5. Selecting strategies and resources for students.
6. Planning and developing instruction, learning experiences, and reflection for game sessions. (Khan et al., 2017, p. 2773)

DIGITAL GAME-BASED LEARNING

Including GBL ID when designing lessons that include digital game-based learning is one way that an instructional framework can be used to support students and make a connection to content areas.

Hanghoj et al. (2018) conducted a study to investigate the effect cooperative video games have on engagement and social inclusion with at-risk students. Thirty-two students who had social difficulties were chosen as the participants in the study. Using cooperative games resulted in an increase in social inclusion and participation for at-risk students. The findings were attributed by the researchers to digital game-based learning enabling students to engage with the curriculum and participate socially in a new way, not due to the fun element of gaming in the classroom. De Freitas (2018), in a literature review written to analyze research and determine whether games are effective learning tools, found that the reviewed research studies substantiated the premise that using educational games in addition to quality game design and elements can positively impact student engagement. Collaboration is a game design element that, when used with digital game-based learning, can support the social aspect of learning and allow students to learn along with and from one another. Eseryel et al. (2014), also found in their study that social interactivity during gameplay (collaboration and competition with others) contributes significantly to student engagement.

In a study conducted by Byun and Loh (2015), game sound and the effect on learner engagement during digital game-based learning was examined. The researchers used a randomized control-group posttest-only design, which meant that the control and experimental group were equal or the same when the researchers were assigned participants. 74 students from a Midwestern university participated in the study (52 males and 22

females). The participants were broken up into the voiceover group (experimental) and the non-voiceover group (control). A voiceover is narration used during a game Players hear a voice as they see images on the screen. Engagement was measured using a modified version of the Game Engagement Questionnaire that was originally developed by Brockmeyer et. al (2009). The findings were that game sound (voiceovers) can have a positive impact on student engagement. The researchers recommended a deeper study of sound in digital games and over a longer period of time due to the short amount of gameplay time (less than 15 minutes two times a week) that occurred during the study.

Based on the referenced studies, digital game-based learning can have an effect on students. There is research that shows that digital game-based learning can result in an increase in student engagement due to students collaborating with one another and being involved in social learning. There is also research that has shown that without the addition of instructional frameworks or instructional design (Giannakas et al., 2017; Khan et al., 2017) as well as the presence of critical game design elements (De Freitas, 2018), engagement in a digital game for learning can decrease as time progresses. Several of the researchers pointed out the need for more research over an extended period of time rather than just a few weeks. In the study conducted by Ronimus et al. (2014) they recommended game design elements being added in addition to instructional support for students in future studies to determine whether the increase in engagement that initially occurs when digital game-based learning is used can last over an extended period of time.

Motivation

Motivation differs from engagement. While engagement refers to a student's active involvement during learning, motivation is the student's desire to begin learning or taking

part in a process and that continues overtime (Keene, 2018). “A person who feels no impetus or inspiration to act is thus characterized as unmotivated, whereas someone who is energized or activated toward an end is considered motivated” (Ryan & Deci, 2000, p. 54). There are two motivation types based on the reasons or goals that cause a student to take action. These two different types are intrinsic motivation and extrinsic motivation. “Intrinsic motivation is defined as the doing of an activity for its inherent satisfactions rather than for some separable consequence” (Ryan & Deci, 2000, p. 56). Intrinsic motivation occurs when there is a connection between the individual and the activity. Activities that individuals are motivated to take part in can be referred to as intrinsically motivated activities (Ryan & Deci, 2000).

“Extrinsic motivation is a construct that pertains whenever an activity is done in order to attain some separable outcome” (Ryan & Deci, 2000, p. 60). Extrinsic motivation sometimes occurs through rewards being used, for example, students receiving prizes for completing levels on a game. A concern that is often mentioned in regards to extrinsic motivation is that the effects will not last once rewards are removed. Some proponents for extrinsic motivation point out that extrinsic motivation can become internalized and lead to intrinsic motivation or higher engagement.

According to the self-determination theory of motivation, extrinsic motivation and intrinsic motivation are both key towards influencing and driving behavior through self-determination (Ackerman, 2019). “Self-determination theory maintains that the more self-determined, or internalized, extrinsic motivation is, the better the observed behaviors or outcomes; for instance, deeper learning” (Ünlü & Dettweiler, 2015, p.688). Self-determination is important because it deals with people feeling that they have control over their lives. According to Ünlü and Detweiler (2015), the more extrinsic motivation is

internalized, the more autonomous a person is. Self-determination theory at its core is focused on people feeling they have control over their lives (autonomy) and the impact it has on their motivation to engage in certain behaviors or activities.

Motivation during digital game-based learning. Several studies measured motivation through surveys. Two studies used intrinsic motivation surveys to measure the effect digital game-based learning has on student motivation (Chen & Law, 2016; Liao, Chen, & Shih, 2019). Chen and Law (2016) used a survey to measure whether digital game-based learning, when combined with learning scaffolds (e.g. open ended questions students were required to answer after game play and then they were allowed to go back to the game and and instructional manual developed by two science teachers on force and motion) has an effect on student motivation. They found that collaboration in addition to providing the opportunity to make connections between the game played and content can increase student motivation. Liao et al. (2019) measured motivation through an intrinsic motivation survey adapted from Ryan and Deci (2000), that included fourteen statements to elicit participant responses (e.g. "This activity was fun to do" and "I see the value of the work I learn in the game," p. 47-48) and found that collaboration on its own can have a significant impact on student motivation and that collaboration combined with an instructional video can also result in an increase in student motivation. Chen et al. (2015), used a motivation survey adopted from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & Mckeachie, 1991) to measure the effect of solitary as well as collaborative game-based learning on student motivation. The study found that there was no major difference between the two groups' (solitary and collaborative) motivation levels.

DIGITAL GAME-BASED LEARNING

Two studies used the ARCS Learning Motivation model that was first developed by Keller in 1979 and has been adapted overtime to measure motivation. ARCS has four components which are Attention, Relevance, Confidence, and Satisfaction. ARCS was originally developed to provide a more effective way to understand what influences motivation to learn and ways to identify and solve learning motivation problems (Keller, 1987). The ARCS model can be used to connect learning motivation and the effectiveness of instructional design processes (Woo, 2014). The ARCS Learning Motivation Scale was developed to measure success in the ARCS model. Lee and Hao (2015) used the ARCS Learning Motivation Scale to develop a questionnaire for participants and found that digital game-based learning can result in a higher student motivation level than video teaching.. Woo (2014) used the ARCS scale to develop a questionnaire for participants to respond to after participating in digital game-based learning and found that when digital game-based learning is combined with the ARCS model and cognition, there can be an increase in student motivation.

In the study conducted by Erhel and Jamet (2013) motivation was also measured through a questionnaire. After each session where participants engaged in a digital game-based learning experience, they were asked to complete questionnaires. One questionnaire measured motivation, which included fifteen items developed from and inspired by Elliot and McGregor's (2001) research on learning goals and Shernoff et al.'s (2003) research on intrinsic motivation. Twelve questions assessed the reasons participants engaged in learning and three questions were specifically designed for intrinsic motivation in order to assess the desire participants felt to engage in a task for its own sake.

Lee and Hao (2015) conducted a study that involved integrating the ARCS Motivational Model, humor, and animation into the design of a digital game-based learning experience. The researchers designed what they referred to as the Cat's Cradle Multimedia Learning System that incorporated a fairy tale theme and question-based reviews as well as games after the end of each animation. The content for the digital game-based learning experience was developed using a textbook on natural science and technology published by Nani Book Enterprise CO., Ltd. by a team that included five multimedia designers, one natural science and technology teacher, one computer teacher, and one digital instruction designer.

The main focus in this study was determining the impact the integration of ARCS Motivation Theory/Model had on stimulating motivation. Motivation was measured based upon the ARCS scale with questions to evaluate attraction, relevance, confidence, satisfaction, and an open ended question to evaluate and collect users suggestions and perceptions. The participants were 106 grade six students in Taiwan. This study involved an experimental group and a control group. The experimental group took part in digital game-based learning (fifty-one students) and the control group (fifty-five students) received video teaching. The results showed higher student motivation levels in the experimental group versus the control group. The results also showed that participants felt more actively involved and in control in regards to their learning experience. The researchers concluded that the digital game-based learning experience that was developed in this study can improve student's learning motivation.

Erhel and Jamet (2013) conducted a study to determine the impact instructions and feedback have during digital game-based learning on motivation and learning effectiveness.

Two experiments were conducted in this study. Forty-six participants (twenty-two men and 24 women) took part in this study between the ages of 18-26 years old. Participants were recruited from several universities in Rennes. Participants were broken into two groups, a learning instruction group and an entertainment instruction group. The learning instruction group was asked to learn the game and the entertainment instruction group was asked to play the game. The digital game-based learning experience these participants experienced was a simulation that introduced learners to four aging-associated diseases: Alzheimer's disease, Parkinson's disease, myocardial infarction, and stroke.

During the study an independent variable was used for each group. That independent variable that researchers manipulated was the instructions that each group was given. The learning instruction group received instructions that stressed the simulation's educational dimension by presenting it as a learning module. The entertainment group received instructions that stressed the playful dimension of the simulation by presenting it as a game. The same exact quizzes, sequences, visuals, and oral commentaries were used for both groups. Each session ended with participants completing questionnaires. One questionnaire in particular measured their motivation and asked them to rate their agreement with each item using a seven point Likert scale. Questions measured both motivation towards learning goals as well as intrinsic motivation. The results showed no significant difference between the two groups as far as learning goals and intrinsic motivation. The researchers concluded that the different instructions given to the two groups (whether they considered it a game or a lesson) did not impact motivation in different ways.

The researchers then conducted a second experiment to determine the impact feedback has during digital game-based learning. Forty-four new participants between the

ages of 18-26 from the same universities as experiment one took part in experiment two. The only major change made for experiment two was the addition of feedback. "This new experiment however, was characterized by the addition of feedback for each of the questions in the four disease quizzes. The type of feedback used was KCR feedback and is also called knowledge of correct response. Each time a participant responded correctly, a window opened with the message "Right answer." Each time a participant responded incorrectly, a window opened with the message "wrong answer", plus the correct response" (Erhel & Jamet, 2013, p. 162). The researchers found that the result of using feedback was that the learning instruction group expressed more fear of failure than the entertainment instruction group. There was no significant difference expressed by participants in the different groups in relation to intrinsic motivation.

In a study conducted by Woo (2014), the goals were to determine which design method could be used along with game characteristics that match motivational strategy procedures and whether there is a relationship between motivation, cognition, and performance in digital game-based learning. The game characteristics that match motivational strategy procedures include fantasy, curiosity, control, role-playing, fun, play, rules, goals, interactive, adaptive, win states, conflict/competition/challenge/opposition, problem solving, interaction, multimodal presentation and story, task, and outcomes and feedback. Mayer's multimedia research effects were also used in this study with game characteristics that match ARCS motivation strategy to create a systematic digital game-based learning design method. "Mayer (2001) indicated that in multimedia learning, active processing involves five cognitive procedures: selecting words, selecting images, organizing words, organizing images, and integrating" (Woo, 2014, p. 293).

The participants in this study were second year university students in the Department of Art and Design between the ages of 19-21 (forty-eight females and fifteen males). Participants took part in a lectured course for eight weeks and then engaged in digital game-based learning. The game was called “Operating a Small Factory in Computer-Aided Manufacturing” or OSF-CAM. “OSF-CAM design methods build on the game characteristics and ARCS model (Keller, 1987) to enhance student learning motivation” (Woo, 2014, p. 295). In order to measure motivation, participants were asked questions developed using the ARCS Learning Motivation Scale. The results for this study were that digital game-based learning can stimulate students' learning motivation. It was also concluded through the study that there is a relationship between motivation, cognition, and performance in digital game-based learning. “In summary, this study proposes a systematic DGBL design method that applies game characteristics that match the ARCS motivation strategy and integrates Mayer's multimedia research effects. Based on the research results, when designing DGBL, designers should increase motivation and germane cognitive load to enhance learning effectiveness” (Woo, 2014, p. 303).

Motivation and collaboration. The effect of collaboration during digital game-based learning was examined in a few studies. “Collaborative learning can generally be defined as an instruction method in which students at various performance levels work together in small groups or pairs toward a learning goal” (Chen et al., 2015, p. 238). Digital game-based learning can be used solitarily or collaboratively. Collaborative digital game-based learning takes place when students work with partners or in small groups and provides them with the opportunity to communicate with others and work together to achieve a common goal during game play (Chen et al., 2015). A question that some researchers addressed in their studies

was whether collaboration in addition to other instructional techniques (scaffolds and instructional videos) had an effect on motivation during digital game-based learning.

In a study conducted by Chen and Law (2016) the focus was the relationship between scaffolds, motivation, and learning performance in a digital game-based learning environment. Additionally, the effect that collaborative versus individual digital game-based learning has was examined. This study used a quasi-experimental design for 254 seventh grade students (128 females and 126 males) in Taiwan. There were eight class sections at the middle school where this study took place and each section was randomly assigned to one group with the following conditions: individual-control, individual-scaffold, collaborative-control, and collaborative-scaffold. There were 64 students from class A and B in the individual-control condition and 61 students from class C and D in the individual scaffold condition. The participants taking part in collaborative digital game-based learning were typically assigned to groups with three members during game play, however due to absences and other situations, there was a variance in group size at times with some groups having only two members. There were twenty-two groups with 64 participants in classes G and H assigned to the collaborative-control condition and twenty-two groups with 65 participants in classes E and F assigned to the control-scaffold condition.

All participants engaged in digital game-based learning received an instructional manual on force and motion that was developed by two science teachers. This study include the use of two types of scaffolds which were hard and soft scaffolds. Scaffolds can provide support to students during learning and particularly when they are learning something new. Hard scaffolds are also referred to as fixed scaffold and are static meaning that they do not change or are adapted to meet the needs of students (Chen & Law, 2016). Typically hard

scaffolds are planned in advance of learning based upon what educators perceive will support most students that are experiencing difficulty (Brusch & Saye, 2002). “Soft scaffolds are dynamic, situation-specific aid provided by a teacher or peer to help with the learning process” (Brusch & Saye, 2002, p. 2). Soft scaffolds are provided to respond to the specific learning needs of students and are flexible and adaptable (Chen & Law, 2016) . The hard scaffolds used in this study were open-ended questions that asked students to make explicit connections between the game and science knowledge and were provided after game play to the participants and they were allowed to go back to the game if needed after answering the required questions. “To help students connecting the disconnected pieces, hard scaffolds required students to connect the concept of force to the actions of the rabbits and the characteristics of the carrots in the game” (Chen & Law, 2016, p. 1205). In this study, collaboration was used as a soft scaffold because it allowed students to communicate with one another by providing explanations, receiving explanations, asking questions, and working together to develop ideas and knowledge.

Participants in the individual-control group did not receive any scaffolds and played the game individually. The individual-scaffold group received the hard scaffold (open ended questions) and played the game individually. Participants in this group were required to answer the hard scaffold questions on paper. The collaboration-control group participants played the game with others (soft scaffold) and were able to have discussions during game play. Participants in the collaboration-scaffold group received both the hard and soft scaffolds and were required to play the game with others, were allowed to have discussions during game play, and then answered the open-ended questions on paper.

In order to measure motivation, participants took an intrinsic motivation survey that addressed the three areas of intrinsic motivation (competence, autonomy, and interest). The results of this study were that hard scaffolds when used on their own did not have a significant impact on motivation and students in the individual-scaffold group scored 0.35 to 1.05 points lower than participants that received no scaffolds. The collaboration-control group that only received soft scaffolds (collaboration) did not show a significant impact on motivation. The collaboration-control groups showed a positive impact on interest and competence and in the case of autonomy there was a negative impact. The survey results showed that participants who received both hard and soft scaffolds had positive significant effects in all three intrinsic motivation areas (autonomy, competence, and interest). The researchers concluded from their study that when both hard and soft scaffolds are present they can result in a higher positive impact on student motivation and that collaboration (soft scaffold) in addition to the opportunity for students to make connections between what the game and science content resulted in an increase in student motivation.

Liao et al. (2019) developed and conducted a study that investigated how collaboration and using instructional videos impacted intrinsic motivation as students were learning Newtonian mechanics while engaging in a digital game-based learning environment. The participants in this study were 109 seventh grade students (59 males and 50 females), who were randomly assigned to four experimental groups. There were 25 participants in the video, game, and collaboration condition, 28 participants in the video and game condition, 30 participants in the game and collaboration condition, and 26 participants in the game only condition. The participants' age range was 10-12 years old.

The instructional video used in this study was developed to explain velocity and speed through graphics, animation, sound, and narratives. The videos also served as a scaffold to help participants develop explicit understanding of the relationships between speed, distance, and velocity. An intrinsic motivation survey that included fourteen statements adapted from Ryan and Deci (2000) was administered to participants. One finding this study shows was that collaboration can have a significant effect on motivation. Video and collaboration being combined was also found to have a significant effect on motivation. The instructional video on its own without collaboration did not have a significant effect. The researchers concluded that collaborative learning can increase student motivation during digital game-based learning. Additionally, while there was no effect found for the instructional video when used with digital game-based learning on motivation, there was a significant effect on motivation when collaboration and an instructional video were both used in a digital game-based learning environment.

Chen et al. (2015) conducted a study to compare the solitary and collaborative modes of digital game-based learning on student learning and motivation. Their study's purpose was to examine the effects using different instructional settings (solitary and collaborative digital game-based learning) had on student motivation and learning. There were fifty participants in this study from two seventh grade classes. Participants' average age was 13 years old. This study was designed as a learning activity that connected to instruction they would receive. The participants were randomly assigned to either the individual or collaboration experimental group. There were 25 students in the individual group and 25 in the collaboration group. The collaboration group participants were grouped in 11 partner groups and one 3 person group.

The researchers developed a digital game-based learning environment in order to help students increase their conceptual understanding and motivation in science. Motivation was measured using a survey that was adopted from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991). The survey included six constructs/subscales: intrinsic motivation, extrinsic motivation, task value, control of learning beliefs, self-efficacy of learning, and expectations of success. Participants rated their responses to each item on the survey using a 5-point Likert scale. The researchers found that both individual and collaborative digital game-based learning modes show a beneficial impact on student motivation. The results showed no difference between the individual group and the collaborative groups for all motivation subscales.

Overall, the studies that looked at motivation found that digital game-based learning had an effect on student motivation. There were studies that found digital game-based learning to have a positive or significant impact on student motivation (Lee & Hao, 2015; Woo, 2014). Several of the studies additionally focused on the effect that the use of specific instructional techniques (Instructions, feedback, and scaffolds) had on motivation. Chen and Law (2016) found that both hard and soft scaffolds, when used together, had a significant effect on student motivation. In their study, Erhel and Jamet (2013) found that instructions did not result in a different impact on student motivation for the two groups; one being a learning instruction group and the other an entertainment instruction group that were just asked to play the game. When Erhel and Jamet (2013) conducted a second experiment that added feedback there was also no difference shown between the two groups motivation and additionally the instruction group ended up expressing more fear of failure than the entertainment group.

Collaboration with digital game-based learning was examined in a few studies (Chen et al., 2015; Chen & Law, 2016; Liao et al., 2019). These studies found that collaboration has a positive effect on student motivation. Chen and Law (2016) in their study concluded that collaboration in addition to scaffolds with digital game-based learning can have a significant positive impact on intrinsic motivation. In their study, Liao et al. (2019) found that collaboration on its own during digital game-based learning has a significant impact on student motivation. They also found that while instructional videos on their own did not have a significant effect that when used along with collaboration in a digital game-based learning environment there was an increase in student motivation. Chen et al. (2015) found in their study, however, that there was no difference between solitary and collaborative digital game-based learning modes and the impact on motivation and that both have a significant effect and are beneficial towards student motivation. Overall these studies showed that motivation during game-based learning can be impacted by different instructional strategies and settings.

Student Achievement

Student achievement is typically focused on the level at which students have mastered and acquired skills in content areas. “The most common indicator of achievement generally refers to a student’s performance in academic areas such as reading, language arts, math, science and history as measured by achievement tests” (Cunningham, 2015, p. 1). Schools in the United States are measured by performance and proficiency levels on standardized assessments and strive throughout the school year to identify what will result in an increase in student achievement. When educators are selecting strategies to use in the classroom with students, the main goal is for there to be an impact on student achievement.

DIGITAL GAME-BASED LEARNING

There is a relationship that can be found between motivation, engagement, and student achievement. Engagement is important because it can lead to sustained interaction and continued practice, which can then have an impact on student learning/achievement (Irvin, Dukes, & Meltzer 2007). Liu, Horton, Olmanson, and Toprac (2011) found in a study on learning and motivation that there was a positive relationship between intrinsic motivation and learning scores for students that engaged in digital game-based learning. "Motivating students is important - without it, teachers have no point of entry. But it is engagement that is critical, because the level of engagement, over time is the vehicle through which classroom instruction influences student outcomes" (Irvin et al., 2007, p. 32-33).

Student achievement and digital game-based learning. Three studies measured student achievement by using assessments (Liu et al., 2011; McCarthy, Tiu, & Li, 2018; Ter Vrugte et al., 2015) that were developed to show the level at which students mastered skills related to the content area that was focused on in each study. Liu et al. (2011) measured student achievement by administering a 20-item science knowledge test that was developed by the researchers to test students' knowledge and learning performance after being introduced to science concepts through digital game-based learning and found that there was an increase in students' science knowledge. McCarthy et al. (2018) measured student achievement during their study by having participants complete The Test of Early Mathematics Ability (3rd. ed.; TEMA-3), which was developed by Western Psychological Services (Ginsburg & Baroody, 2003) and tests students' informal and formal mathematics knowledge. They also used The Mathematics Assessment Resources Service or MARS that were first developed by the Bill and Melinda Gates Foundation in 2007, and are performance-based tasks. A Mathematics Vocabulary Assessment was developed by the

researchers in the study and administered as a pre and post assessment as well as a researcher developed mathematics assessment that addressed the mathematics skills the study focused on. They found that there was an increase from pre to post test in students' mathematics understanding and skills. Ter Vrugte et al. (2015) measured student achievement by having students complete an arithmetic tempo test (developed by De Vos, 1992), called the TTR (Tempo Test Rekenen), which assesses student computational fluency in arithmetic computation (addition, subtraction, multiplication, and division). Additionally, a test developed by researchers was used to assess proportional reasoning. The test consisted of 16 questions with 12 questions that presented the same kind proportional problems as the digital game-based learning used in the game and 4 questions that were designed to determine if learning from the game could be transferred to proportional problems that were different from those presented in the game. Researchers found that the students' prior knowledge and ability before the digital game-based learning experience impacted whether competition being added with collaboration increased their motivation.

There were two meta-analysis studies that examined the effect digital game-based learning has on student achievement or learning performance. Byun and Joung (2018) conducted a meta-analysis to examine the effect digital game-based learning has on student achievement in mathematics. They selected research studies to investigate based on the goal of the study, the year of publication, the title of the journal, the academic field of the journal, the expertise of the author(s), the research method, the country of publication, the grade level of participants, and the mathematical content. Byun and Joung (2018) developed their criteria for selecting studies based upon review codes that were used in another meta-analysis study conducted by Dvijak & Tomic (2011). They calculated the effect size for each study that was

selected using a procedure developed by Li and Ma (2010) for a meta-analysis study and found that there was a small effect size for digital game-based learning on student achievement in mathematics. Chen, Tseng, and Hsaio (2018), in their meta-analysis study, examined the effectiveness of digital game-based vocabulary learning. They used Comprehensive Meta-Analysis Version 3 (Borenstein, Hedges, Higgins, & Rothstein, 2014) to analyze data from selected studies. The data provided them with an estimate of the effectiveness of digital game-based learning on vocabulary acquisition and they found that there was an increase in vocabulary acquisition for participants in the study.

Science achievement. In a study by Liu et al. (2011), students engaging in digital game-based learning and the effect on student achievement/learning in science were examined. Two hundred twenty sixth-grade students (119 females and 101 males) from a middle school in a southwestern US city participated in this study. Alien Rescue (Liu et al., 2002) was used with participants for three weeks in their daily 45 minute science class. Alien Rescue is a digital learning environment that includes collaboration and challenge and encourages learning through exploration. Each student had their own computer to use, however, they were able to work in small groups as well. Student achievement/learning performance was measured during the study using a science knowledge test. The test had 20 items which were written to assess students' understanding of concepts that were introduced in Alien Rescue. The test was administered to participants in the study before and after students engaged with Alien Rescue.

The results of the science knowledge test showed a significant increase in scores (correct responses) from pre-test (50.73%) to post-test (81.04%) and there was a small significant difference in scores between males and females (male = 83.53; female = 79.36).

There was also a decrease in unsure responses on the science knowledge test from pre-test (26.15%) to the post-test (8.02%). The findings for this particular study were that there was a significant increase in science knowledge as a result of participants using *Alien Rescue.* The researchers concluded that new media learning environments, such as digital game-based learning, can have a positive impact on student learning as indicated by the increase in scores from pretest to post-test on the science knowledge assessment and the decrease in unsure responses.

Math achievement. Ter Vrugte et al. (2015) studied education mathematics game effectiveness on prevocational students' learning. "Prevocational education is a less advanced level of secondary education in which students are specifically prepared for intermediate vocational education. Students who attend the pre vocational track show wide variety in their cognitive abilities and potential" (Ter Vrugte et al., 2015, p. 43). The researchers in this study focused on mathematics because prevocational students often struggle with math concepts and they wanted to determine if digital game-based learning could impact student learning. They also point out that mathematics is a fundamental skill that affects future school achievement (Ter Vrugte et al., 2015). Participants in this study were 242 students ages 11-15 (118 males and 124 females) from three different prevocational schools. Four conditions were used in this study with the learning objectives and overall game environment being the same for all groups. Conditions were assigned per class with there being a collaboration/competition group, collaboration group, competition group, and control group (no collaboration or competition).

Student learning/achievement was measured by having participants compete an arithmetic tempo test (timed test that measures automaticity on basic arithmetic problems) to

assess computational fluency and a test that had 16 constructed response questions to measure proportional reasoning. The researchers examined the scores for the four conditions based upon the effect the conditions showed with students who were considered to be either above average or below average as determined by a pre-test of their knowledge. Below average students' scores showed no significant effect for competition and no significant effect for collaboration. There was a negative significant effect found when competition was added to collaboration. The researchers found that students with below average prior knowledge benefit more when competition is not present in a collaborative environment (Ter Vrugte et al., 2015). Above average students' scores showed that competition alone and collaboration alone did not have a significant or main effect. There was a significant effect shown in the scores for groups that had both collaboration and competition present. For above average students their scores indicated that collaboration is positively impacted by competition being added, so the researchers concluded that their prior knowledge from collaboration benefited more when competition was present (Ter Vrugte et al., 2015). Overall the researchers found that pre vocational students can benefit from a digital game-based learning mathematics environment.

McCarthy et al. (2018) conducted a study that focused on transmedia interventions (digital and non-digital learning resources, activities, and experiences) which included digital learning games and videos effect on students learning in early mathematics. Two separate studies/experiments were conducted by researchers. Study one was a four-week intervention in a preschool classroom. Participants were 68 students ages 3-5 from a preschool serving low income communities in the San Francisco Bay Area. The intervention involved the using 16 digital learning games that featured Curious George from the book series created by

Rey and Rey. and focused on various early mathematics topics and learning goals (e.g. count by ones up to 20, count 1-5 objects, use a graph to compare numbers), hands-on materials that were downloaded from the PBS Curious George website, three Curious George videos, and books. Researchers called the intervention "Curious George Math". Participants in the study rotated through three learning stations for 30 minutes twice a week. Station one involved students playing Curious George digital game-based learning games, station two was a table with Curious George hands-on activities, and station three was a free play area.

Participants' math academic ability was measured using the Test of Early Mathematics Ability (3rd. ed.; TEMA-3) developed by Western Psychological Services (Ginsburg & Baroody, 2003). The items on the test measured the skills that were addressed in the 16 Curious George digital game-based learning games and materials used in the study. Participants took TEMA as a pre and a post test in order to determine the effect the intervention had on their mathematics learning. The results for study one showed a significant increase in participants' mathematics knowledge (pre = 21.04, post = 23.75). There was a significant increase in number comparison (pre = 5.98, post = 7.06) and informal concept skills *(*pre = 0.86, post = 1.12). When researchers analyzed the differences between participants with different mathematics skills levels as was determined based upon the pre-assessment it was found that those with lower pre-assessment scores increased significantly on numbering *(*pre = 6.24, post = 8.20) and those with higher pre-assessment scores increased significantly on number comparison skills *(*pre = 7.65, post = 9.12) and informal concepts (pre = 1.38, post = 1.77).

For study two, the researchers developed an intervention called "Odd Squad Math". It included videos, two educational online games, short video clips, and five hands-on activities

from the Odd Squad public television series resources. Four first grade teachers and their 83 students from around the San Francisco Bay Area participated in the study. Participants were recruited from schools that served low income communities. The intervention focused on Algebraic Thinking and Number and Operations mathematics domains.

Four assessments were used to measure student learning/achievement in math. The Test of Early Mathematics Ability, which is designed to be used for ages 3 - 8, was administered to participants. The researchers selected and adapted items from the test to measure the Number and Operations domain and skip counting, which were focused on during the intervention. The researchers developed a mathematics assessment that was used before and after participating in the intervention. The assessment was a paper-and-pencil test that was administered to students as a whole class or in small groups. The test was designed to address the Number and Operations and Algebraic Thinking domains. The Mathematics Assessment Resource Service (MARS) assessments which are performance based tasks were examined to determine which tasks were related to the Number and Operations and Algebraic Thinking domains. A subset that addressed the domains for the intervention was administered to students before and after the intervention. The final assessment used to measure student achievement was a researcher developed mathematics vocabulary assessments that was administered to participants before and after the intervention. Participants were assessed one-on-on for this test and verbally provided mathematics related word definitions that were addressed during the intervention.

The results for study two showed a significant increase in students' mathematics knowledge in the Algebraic Thinking and Number and Operations domains (pre = 42.80, post = 48.70). Participants showed an increase from pre to post test in skip counting

*(*pre = 10.92; post = 13.61), pattern recognition *(*pre = 9.49; post = 10.12), and simple addition and subtraction *(*pre = 18.72; post = 20.95). The results also showed an increase in participants' fact families knowledge and mathematics vocabulary. "Analysis of the fact families item indicates that more students were able to partially understand the concept of fact families (pre = 22% vs. post = 47%) and fewer students completely failed the item (pre = 66.3% vs. post = 48.2%) at post" (McCarthy et al., 2018, p. 240). The researchers found on the mathematics vocabulary assessment that the students who provided incorrect definitions decreased on the post assessment and the students that provided correct definitions increased. Overall, the researchers concluded that high quality transmedia, which includes digital game-based learning, can support early mathematics learning.

Byun and Joung (2018) in a meta-analysis of digital game-based learning in K-12 mathematics education analyzed 33 research studies after a two-stage screening process. The first stage involved a title and abstract review for 296 articles. Each article was reviewed based upon whether it included qualitative or quantitative empirical data, involved digital games for instructional purposes, was a study about students' mathematics learning, and if participants in the study were students in regular classrooms in grades K-12. The first stage screening led to 39 articles being identified for further analysis. The second stage involved the full-text copy for each article being obtained for a complete evaluation. Six studies were dropped after the second screening due to either no data reported in the study, not K-12 participants, not written in English, or unable to locate or obtain the full-text copy.

Nine codes were used to locate trends in the 33 articles, which included the goal of the study, the year of publication, the title of the journal, the academic field of the journal, the expertise of the author(s), the research method, the country of publication, the grade level

of participants, and the mathematical content. The overall effect size for each study was determined by using the statistical values found in each study and calculated by following the procedure used by Li and Ma (2010) in their meta-analysis study. 17 studies were identified using the procedure as appropriate for calculating the average effect size. Effect size was calculated by taking the mean difference between control groups and experimental groups and dividing it by the pooled standard deviation. Researchers noted that it was difficult to determine whether each effect size calculated carried the same weight. They decided to calculate and use a weighted effect size that took into account the estimated variance in each study. By determining the weight for each study, researchers felt that they were able to find an unbiased weighted average of the effect for each study (Byun & Joung, 2018).

The findings of this meta-analysis study were that the overall weighted effect size that digital game-based learning has on mathematics student achievement was 0.37, which represents a small effect size. Researchers mentioned that while individual studies have found that digital game-based learning can have a positive effect on students' academic achievement in mathematics, that their study's results indicate that there might be other, more efficient, ways for students to learn mathematics than digital game-based learning (Byun & Joung, 2018). The researchers additionally found that there is a need for more studies that gather empirical data to effectively measure the impact digital game-based learning has on student achievement in mathematics. They point out that while they were initially able to find 296 articles, after further examination only 33 contained empirical data.

Vocabulary learning. Chen et al. (2018) conducted a meta-analysis on digital game-based learning and its effect on vocabulary learning. They analyzed ten primary studies published between 2003 - 2014 that all had the same research design (experimental group

and a control group along with a vocabulary test). The Comprehensive Meta-Analysis Version 3 (Borenstein, Hedges, Higgins, & Rothstein, 2014) was used to analyze data from the studies. The researchers analyzed data to "achieve an overall estimate of the effectiveness of DGBL (digital game-based learning) on vocabulary acquisition, and to investigate the way in which moderating variables regulate the effects of DGBL on vocabulary acquisition" (Chen et al., 2018, p. 70). The main result in this meta-analysis was a large overall effect size (d = 1.027) for digital game-based learning on vocabulary acquisition. Researchers also found that game design has a larger effect on learning in studies where the game was an adventure versus a non-adventure (adventure d = 1.867, non-adventure = 0.705). The researchers concluded that digital game-based learning can have a significant effect on vocabulary acquisition and additional game design can impact learning in a significant way when it includes challenge, which is typically present in the design of adventure digital game-based learning.

Most studies found that digital game-based learning can have a positive effect on student achievement/learning. Two studies that used a pre and post assessment to measure student achievement found that students showed an increase in learning due digital game-based learning being used (Liu et al., 2011; McCarthy et al., 2018). Ter Vrugte et al. (2015) in their study on the effect mathematics digital game-based learning had on prevocational students' learning, measured student achievement using two assessments to test computational fluency and proportional reasoning. The researchers focused on the effect that competition and collaboration have in a digital game-based learning environment on student achievement. They found that below average students in the study benefited more when competition was not included with collaboration and that above average students benefited

from competition and collaboration being present. The researchers found that digital game-based can positively impact pre vocational students' learning in mathematics.

The two meta-analysis studies showed different results in the effect of digital game-based learning on student achievement. Chen et al. (2018) found by analyzing ten studies that digital game-based learning can have a significant effect on student vocabulary acquisition and that game design also can have a significant effect on student learning achievement when an adventure game design that includes challenge is used. Byun & Joung (2018) analyzed 33 studies and specifically examined 17 studies to determine the effect size digital game-based learning has on student achievement in math. They found the overall effect size to be small and concluded that there might be better ways to affect student learning in mathematics than digital game-based learning. The researchers also state that due to limited studies with empirical data more quality studies are needed to effectively determine the overall effect of digital game-based learning on student achievement in mathematics. In this study the researchers also stated that there is a need for studies that look specifically at the strands of mathematics proficiency (conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition). Increased student achievement is one of the main goals of education and it is important to determine the long-term and overall effects digital game-based learning has on student learning/ achievement if it is going to continue to be used with students.

Conclusions and Recommendations

Digital game-based learning is not a new concept in education, however, it has increased in use by educators especially with more school districts moving to 1:1 technology initiatives. Educators are continually looking for ways to use technology in order to support

students in meeting learning goals and digital game-based learning is an option that is often implemented in the classroom. This is especially with the increase in the availability of online sites for digital-game based learning. Educators work daily to meet the needs of students that struggle academically as well as those in need of enrichment. When technology tools, such as digital game-based learning are selected for students to use, it is important for teachers to determine whether students will be highly engaged, motivated to preserve and not give up even in the face of challenges, and if there will be an increase in their learning/ academic achievement as a result.

Conclusions

The purpose of this study was to examine the effect of digital game-based learning on student learning. This study also provides research on strategies that can be used with digital game-based learning and the effects. Additionally this study can provide educators with information to determine whether they should use digital game-based learning in their classrooms and the impact that it can have on student engagement, motivation, and achievement.

Engagement. Based on what was found through research, I believe that digital-game based learning can have a positive effect on student engagement. The studies presented in this literature review have shown that the digital game-based learning typically results in an increase in student engagement. Several studies found that digital game-based learning had a positive impact on student engagement. Khan et al. (2017) gathered quantitative data (pre and post tests) as well as qualitative data (classroom observations and focus group discussions) that showed an increase in student engagement when digital game-based learning was used in science classrooms along with a digital game-based learning model for

instructional design. Gainnakas et al. (2017) after analyzing literature from 2004-2017, determined that mobile game-based learning can result in a positive effect on student engagement.

Studies have found that the presence of or lack of key game design elements and instructional design can have an impact on student engagement. Ronimus et al. (2014) determined that including two game design elements (levels of challenges and rewards) initially had a positive effect on student engagement, however, over time as students continued to play the game student engagement decreased. Additionally, lack of feedback was found to result in a decrease in student engagement. Khan et al. (2017) found that including instructional design geared towards digital game-based learning results in an increase in student engagement. Collaboration and cooperative learning in digital game-based game design, as well as instructional design, were found to be successful in increasing student engagement (De Freitas, 2018; Eseryel et al., 2014; Hanghoj et al., 2018). Byun and Loh (2015) determined through their study that participants who played games with voice overs were more engaged than those who played without voiceovers.

Motivation. Based on the studies that were reviewed, I believe that digital-game based learning can impact student motivation. A majority of the studies examined the impact additional instructional strategies and techniques had on student motivation. Lee and Hao (2015) studied the impact that integrating the ARCS Motivation Model, humor, and animation into digital game-based learning had on motivation. They found that motivation was higher for students who engaged in digital game-based learning. Woo (2014) also used the ARCS Motivation Model to determine if it would impact student motivation in a digital game-based learning environment and found that there was an increase in student motivation.

Woo (2014) also found that there can be a relationship between cognition, motivation, and learning performance during digital game-based learning. Ehrel and Jamet (2013) found that when they compared the two groups, that instructions that stressed either playing a game for learning or entertainment did not have impact student motivation different ways. In their second experiment, they determined that adding feedback did not result in a difference in the two groups' (learning and entertainment) intrinsic motivation. They also found that the addition of feedback resulted in the learning instruction group expressing more fear of failure.

The studies that focused on the effect collaboration has on student motivation found that collaboration can result in an increase or beneficial impact on motivation (Chen, Lang, & Lin, 2015; Chen & Law, 2015; Liao et al., 2019). There were differences found in the studies though in whether collaboration needed to be combined with something else and if other digital game-based learning modes also showed an effect on student motivation. Liao et al. (2019) in their study found that collaboration can have a significant impact on student motivation. They found that instructional videos did not have a positive effect on student motivation, however, when used along with collaboration there was a significant increase in student motivation. Chen and Law (2016) found that while collaboration on its own did not have a significant impact on student motivation, collaboration in addition to providing students the opportunity to make connections between what is learned during digital game-based learning and content can result in an increase in student motivation. Chen et al. (2016) found through their study that both solitary and collaborative digital game-based learning modes are beneficial and can have a positive impact on student motivation.

Student Achievement. Based upon the referenced studies, I believe that digital game-based learning can have an impact on student achievement. The reviewed research indicates that digital game-based learning on its own does not result in a significant increase in student achievement. As was found with engagement and motivation, there are other factors that when used with digital game-based learning can result in a significant effect on student achievement/learning. Three studies focused on the impact digital game-based learning has when used in addition to instructional materials, settings, and techniques on student achievement (Liu et al., 2011; McCarthy et al., 2018; Ter Vrugte et al., 2015). McCarthy et al. (2018) used digital game-based learning along with hands-on materials and videos to create an intervention that resulted in an increase in students' mathematics learning. Ter Vrugte et al. (2015) found in their study that depending upon student's prior knowledge and ability before engaging in digital game-based learning there can be a positive effect when competition and collaboration are added (above average students) or a negative effect (below average students). Liu et al. (2011) in their study examined the impact Alien Rescue, a digital learning environment that combines digital game-based learning with team work/collaboration and challenge. They found that there was a significant increase in student achievement when students took an assessment on their science knowledge after engaging in the digital game-based learning environment.

The two meta-analysis studies showed different results for the impact of digital game-based learning on student achievement. Chen et al. (2018) analyzed the effect digital game-based learning has on student vocabulary acquisition. Digital game-based learning showed a large effect size on vocabulary acquisition. They found in the studies they analyzed that challenge and adventure being added in game design can have a significant effect on

vocabulary acquisition. Byun and Joung (2018) found in their meta-analysis that there was no significant effect size when studies on digital game-based learning and the effect on mathematics student achievement were analyzed. They did say that the results could be due to a low number of quality studies with statistical or empirical data that can be used to effectively measure the effect digital game-based learning has on student achievement in mathematics.

Recommendations

Further research needs to be conducted on digital game-based learning. Giannakas et al. (2017), in the conclusion for their review, mentioned that research on game-based learning is still in the "budding" stage and more will be learned as further research is conducted. A majority of the research on digital game-based learning is occurring in countries other than the United States. While educators can learn from this research, there needs to be more research studies taking place in schools in the United States. Research studies conducted to explore the difference in impact on students at different grade levels, for example, middle school vs. high school or elementary compared to middle school would be beneficial. It could be determined whether different approaches need to be used at different grade levels. Several studies mentioned further studies needed with larger sample sizes so that the results could be applied to a larger population. More studies need to be conducted that take place over a longer period of time to determine if the results change over time and the causes if they do.

There is also a need to conduct studies to provide more evidence on the impact instructional design and game design elements can have on student engagement. Ronimus et al. (2014) proposed in their study that the lack of key game design elements could be the

cause of a decrease in student engagement over time. Future studies could determine whether the addition of additional game design elements as well as instructional design impacts student engagement as a particular digital game-based learning application/game is played over an extended period of time.

Further study into instructional materials and strategies and the impact on student motivation when engaged in digital game-based learning is needed. Liao et al. (2019) recommended in their study that how students are grouped during collaborative digital game-based learning in addition to the impact student's characteristics, such as gender and prior gaming experience have on collaboration and the digital game-based learning effect on student motivation needs to be examined in future studies. As was found with engagement, several studies recommended future studies conducted over a longer period of time than a few weeks to determine the long term effects of digital game-based learning on student motivation and if they last overtime. It is also important that more research is conducted on digital game-based learning at the K-12 level.

Student achievement appears to be an area where further studies are needed the most. One reason for this is the importance of student achievement in education. Studies on the relationship between engagement, motivation, and student achievement in digital game-based learning would be beneficial towards determining how to effectively support student learning. "As the growth of technology use and digital resources continues to change how children learn, additional research is warranted around how children are motivated by engaging in well-developed narrative domains, and how this motivation affects learning" (McCarthy et al., 2018, p. 244). Byun and Joung (2018) after finding that the studies they examined for effect size showed a small effect for digital game-based learning on

mathematics achievement recommended that more empirical/statistical studies be conducted in the future. “If more empirical research is conducted, mathematics educators would have better criteria upon which to base their decision to use digital games for their K–12 students” (Byun & Joung, 2018, p. 121). They also recommend that future research studies involve experts in mathematics learning. “Nevertheless, it is clear that if more experts in mathematics learning participated in DGBL research, the quality and applicability of the research would be elevated and more in-depth” (Byun & Juong, 2018, p. 122). Involving experts from the content areas being studied for the effect digital game-based learning has on student achievement needs to occur in future research studies. There is also a need for more studies that address the various content areas. More studies on game based-learning in content areas such as language arts/English, Social Studies, and elective areas (music, art, and word languages) could provide many benefits for education.

Digital game-based learning can be used in multiple content areas (science, social studies, math, art, language arts, world language classes, etc.). By understanding the findings of this literature review educators will be able to use game-based learning in a purposeful way in their classroom. Additionally, they will understand as well as be able to communicate to students, parents, colleagues, and administrators the rationale for using digital game-based learning. Educators need to ensure that when they are choosing to use digital game-based learning in their classrooms that they are looking at whether it will meet the students’ needs and help them to make progress towards achieving learning goals. In the book, *Design for Technology-Enhanced Learning: Integrating Research and Practice,* the author states, “The key point is to draw educators’ attention beyond the superficial aspects of technologies to examine the true underlying features and how they may be used to promote learning”

(Bower, 2017, p. 72). Digital game-based should be used because it can support standards and learning objectives as well as result in an increase in student learning.

References

Ackerman, C. (2019, June 11). *What is the self-determination theory of motivation?* [Incl. Visuals]. Retrieved from https://positivepsychologyprogram.com/self-determination-theory/

Barab, S., Gresalfi, M., & Ingram-Goble, A. (2010). Transformational play: Using games to position person, content, and context. *Educational Researcher, 39*(7), 525-536.

Bower, M. (2017). *Design of technology-enhanced learning: Integrating research and practice*. Bingley, UK: Emerald Publishing.

Brom, C., Šisler, V., & Slavík, R. (2010). Implementing digital game-based learning in schools: Augmented learning environment of 'Europe 2045.' *Multimedia Systems, 16*(1), 23-41.

Brusch, T., & Saye, J. (2002). A summary of research exploring hard and soft scaffolding for teachers and students using a multimedia supported learning environment. *The Journal of Interactive Online Learning, 1*(2), 1-12.

Byun, J., & Joung, E. (2018). Digital game-based learning for K-12 mathematics education: A meta-analysis. *School Science and Mathematics, 118*(3-4), 113-126.

Byun, J., & Loh, C. (2015). Audial engagement: Effects of game sound on learner engagement in digital game-based learning environments. *Computers in Human Behavior*, *46*, 129-138.

Chen, C.-H., & Law, V. (2016). Scaffolding individual and collaborative game-based learning in learning performance and intrinsic motivation. *Computers in Human Behavior, 55*, 1201-1212.

Chen, C.-H., Wang, K.-C., & Lin, Y.-H. (2015). The comparison of solitary and collaborative modes of game-based learning on students' science learning and motivation. *Educational Technology & Society*, *18*(2), 237+. Retrieved from http://link.galegroup.com.proxy.lib.uni.edu/apps/doc/A419268906/AONE?u=uni_rodit&sid=AONE&xid=f7a99083

Chen, M., Tseng, W., & Hsiao, T. (2018). The effectiveness of digital game-based vocabulary learning: A framework-based view of meta-analysis. *British Journal of Educational Technology, 49*(1), 69-77.

Coffey, H. (2017, July). *Digital game-based learning*. Retrieved from http://www.dsu.univr.it/documenti/Avviso/all/all036209.pdf

Cunningham, J. (2015, June). *Student achievement*. Retrieved from http://www.ncsl.org/documents/educ/CharterSchoolStudentAchievement.pdf

Erhel, S., & Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers & Education, 67*, 156-167.

De Freitas, S. (2018). Are games effective learning tools? A review of education games. *Educational Technology and Society, 21*(2), 74-84. Retrieved from https://www.j-ets.net/ETS/journals/21_2/6.pdf.

Eseryel, D., Law, V., Ifenthaler, D., Ge, X., & Miller, R. (2014). An investigation of the interrelationships between motivation, engagement, and complex problem solving in game-based learning. *Educational Technology & Society, 17*(1), 42-53.

Giannakas, F., Kambourakis, G., Papasalouros, A., & Gritzalis, S. (2018). A critical review of 13 years of mobile game-based learning. *Educational Technology Research and Development*, *66*(2), 341-384.

Hanghøj, T., Lieberoth, A., & Misfeldt, M. (2018). Can cooperative video games encourage social and motivational inclusion of at-risk students? *British Journal of Educational Technology, 49*(4), 775-799. doi:10.1111/bjet.12642

Irvin, J., Dukes, M., & Meltzer, J. (2007). *Taking action on adolescent literacy: An implementation guide for school leaders*. Alexandria, Va.: Association for Supervision and Curriculum Development.

Johnston, P., Beaudoin, C., Jones, L., & Waggett, R. (2015). Student engagement or simply participation: How does a beginning teacher know? *Kappa Delta Pi Record*, *51*(2), 90-92.

Jukes. I. (2017). Foreword. In *Game on: Using digital games to transform teaching, learning, and assessment*. Bloomington, IN: Solution Tree Press, xiii-xiv.

Keene, E. O. (2018). *Engaging children: Igniting a drive for deeper learning, K-8*. Portsmouth, NH: Heinemann.

Keller, J. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development, 10*(3), 2-10.

Khan, A., Ahmad, F., & Malik, M. (2017). Use of digital game based learning and gamification in secondary school science: The effect on student engagement, learning and gender difference. *Education and Information Technologies*, *22(*6), 2767-2804.

Lee, L. C., & Hao, K. C. (2015). Designing and evaluating digital game-based learning with the ARCS motivation model, humor, and animation. *International Journal of Technology and Human Interaction*, *11*(2), 80-95. Retrieved from

http://link.galegroup.com.proxy.lib.uni.edu/apps/doc/A416552434/AONE?u=uni_rodit&sid=AONE&xid=7c439de0

Liao, C-W., Chen, C-H., & Shih, S-J. (2019). The interactivity of video and collaboration for learning achievement, intrinsic motivation, cognitive load, and behavior patterns in a digital game-based learning environment. *Computers & Education, 133*, 43-55.

Liu, M., Horton, L., Olmanson, J., & Toprac, P. (2011). A study of learning and motivation in a new media enriched environment for middle school science. *Educational Technology Research and Development, 59*(2), 249-265.

Marzano, R. J. (2007). *Art and science of teaching: A comprehensive framework for effective instruction*. Retrieved from https://ebookcentral-proquest-com.proxy.lib.uni.edu

McCarthy, E., Tiu, M., & Li, L. (2018). Learning math with curious George and the odd squad: Transmedia in the classroom. *Technology, Knowledge and Learning, 23*(2), 223-246.

Prensky, M. (2001). The games generations: How learners have changed. *Digital game based learning* (pp. 1-26). New York, NY: McGraw-Hill. Retrieved from http://www.marcprensky.com/writing/Prensky%20-%20Ch2-Digital%20Game-Based%20Learning.pdf

Ronimus, M., Kujala, J., Tolvanen, A., & Lyytinen, H. (2014). Children's engagement during digital game-based learning of reading: The effects of time, rewards, and challenge. *Computers & Education*, *71*, 237.

Ryan, R., & Deci, E. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54-67.

Ünlü, A., & Dettweiler, U. (2015). Motivation internalization and simplex structure in self-determination theory. *Psychological Reports, 117*(3), 675-691.

Ter Vrugte, J., De Jong, T., Vandercruysse, S., Wouters, P., Van Oostendorp, H., & Elen, J. (2015). How competition and heterogeneous collaboration interact in prevocational game-based mathematics education. *Computers & Education, 89*, 42-52.

Woo, J.-C. (2014). Digital game-based learning supports student motivation, cognitive success, and performance outcomes. *Educational Technology & Society*, *17*(3), 291+. Retrieved from http://link.galegroup.com.proxy.lib.uni.edu/apps/doc/A383852298/AONE?u=uni_rodit&sid=AONE&xid=da835ccf