USING DIGITAL GAMES IN THE SCIENCE CLASSROOM

by

Tamara L. Anderson

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Education in Educational Technology

Boise State University

May 2021

BOISE STATE UNIVERSITY GRADUATE COLLEGE

DEFENSE COMMITTEE AND FINAL READING APPROVALS

of the dissertation submitted by

Tamara L. Anderson

Dissertation Title: Using Digital Games in the Science Classroom

Date of Final Oral Examination: 17 March 2021

The following individuals read and discussed the dissertation submitted by student Tamara L. Anderson, and they evaluated the student's presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

Youngkyun Baek, Ph.D.	Chair, Supervisory Committee
Yu-hui Ching, Ph.D.	Member, Supervisory Committee
Dazhi Yang, Ph.D.	Member, Supervisory Committee

The final reading approval of the dissertation was granted by Youngkyun Baek, Ph.D., Chair of the Supervisory Committee. The dissertation was approved by the Graduate College.

ACKNOWLEDGMENTS

I would like to thank my husband for supporting me through the process of obtaining my doctoral degree. He has helped make this journey possible. Next, I would like to thank all of my classmates. In every class that I took at Boise State University, they helped me think through my ideas by challenging me to expand my knowledge. The relationships that I built over the course of four years will never be forgotten and it was awesome to have their support as I worked through this process. Lastly, I would like to thank all of my professors at Boise State University. The patience and professionalism that they showed helped me create the best possible product no matter what I was working on at the time.

ABSTRACT

High school science classes can be difficult for students to be successful in because of the content-specific vocabulary and the expectation of prior knowledge in the subject area that teachers have of their students. The use of digital games in the classroom can provide teachers with the tools to help students scaffold their learning and better grasp the vocabulary necessary to be successful in science class. The purpose of this mixed methods study was to focus teachers' and students' perceptions of digital games in the high school science classroom on vocabulary development, scaffolding learning by activating prior knowledge, and self-efficacy. Findings suggest that teachers and students believed that using digital games positively impacted the development of vocabulary knowledge and helped scaffolding learning. Some students found that their levels of self-efficacy were positively impacted by using digital games in their science classes. Teachers can use these findings to make informed decisions about how to integrate digital games into their science curriculum.

Key Terms: digital games, vocabulary knowledge, self-efficacy, scaffolding learning

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I: INTRODUCTION

In an ideal situation, students entering a high school science class should have the necessary background knowledge to help them successfully understand the content being presented, conduct comprehensive experiments, and participate in the discussions that will occur throughout the course. During the course of the school year, the teacher would be able to build upon the prior knowledge of the students, use content-specific vocabulary, and expand upon their understanding of the science concepts. Through this learning process, students would gain new knowledge that they would need to continue to be successful in all of their high school science courses.

In reality, though, students come from a variety of backgrounds and not all of the students have had the opportunity to develop the necessary prior knowledge and content-specific vocabulary to help them be successful in the science classes available at the high school level. Science is a difficult course for students if they do not have the essential prior knowledge and content vocabulary from their previous courses to build upon in the current class. Additionally, students tend to focus on learning just what they need to know right now for upcoming quizzes or tests and then do not worry about how it connects to the bigger picture. The short-term goal of being successful for one event makes it difficult for students to make connections to what they are learning in class to their everyday life.

Background of the Study

With the increased demand for technology in the classroom, teachers need to contemplate the benefits that can be achieved through the use of the available technology resources for classroom instruction (Dellos, 2015) and how digital games can be used as complementary educational material that is attractive to our current generation of students. When teachers use digital games in the classroom, they provide students with the opportunity to share learning experiences with peers and rehearse using skills that they can use in class as well as outside of the classroom (de Freitas, 2006). Digital games support skills that can be transferred to any content area and can be used to develop problem-solving skills. Teachers who use digital games in the classroom believe that games can promote deeper learning and can effectively support learning in their content area (Stieler-Hunt & Jones, 2015; Liu et al., 2014). The use of technology in the classroom creates an active learning environment that allows students to develop their understanding of the facts, experiences, and practices taught as part of the science curriculum (Oblinger, 2004). Providing students with the opportunity to expand their learning with digital games gives students ownership of their learning (Annetta et al., 2014).

Additionally, digital educational games are well suited to the *Next Generation Science Standards* (NGSS) because they allow students to learn science “by doing and help them develop transferable knowledge and skills” (An, Haynes, D’Alba, & Chumney, 2016, p. 416), and helps students see science being used in a realistic method. Through the process of playing the game, students are learning “by trial and error: hypotheses are tested, and users learn from the results”, (Oblinger, 2004, p. 8) which are essential pieces of the scientific process. Hickey et al. (2009) found when teachers used digital games to demonstrate science content their students showed greater gains in understanding scientific concepts and in achievement compared to students who were not exposed to the use of digital games. Science teachers need to understand how using digital games can be more than just a supplement to the curriculum and that it can engage and motivate students to achieve a greater understanding of science.

Extensive research has been done on the use of digital games in the classroom and the impact digital games can have on student self-efficacy. The effects of activating prior knowledge as an instructional strategy and the necessity of developing content-based vocabulary knowledge are also well known in education. The intersection of digital games, self-efficacy, activating prior knowledge, and vocabulary development in science classrooms is not as well documented in research journals.

Purpose of the Study

The purpose of this mixed-methods study was to focus on the impact digital games that use student response systems such as Kahoot! and Quizlet has in the high school science classroom on teachers' and students' perceptions of vocabulary development, scaffolding learning by activating prior knowledge, and students' self-efficacy. An explanatory sequential mixed methods model was used in this research. It involved collecting quantitative data first then explaining the quantitative data results with in-depth qualitative data. In the first phase of the study, quantitative data were collected using a Likert scale survey about the impact of digital games on vocabulary development in science classes and if digital games scaffold learning by activating prior knowledge in science class was collected from high school science teachers. Additional

Likert scale survey data was collected from students of the participating teachers' classes who responded to the teacher survey about the impact of digital games on student's self-efficacy in the science classroom. The second, qualitative phase was conducted as a follow-up to the quantitative results. The qualitative data was collected through teacher interviews and student data will be collected using open-ended questions using online questionnaires. This provided an in-depth, multifaceted analysis of the research questions.

The goal of this study was to answer the following research questions:

1. How do students and teachers perceive the use of digital games on their vocabulary development in high school science classes
2. How do students and teachers perceive the use of digital games to scaffold learning by activating prior knowledge in high school science classes?
3. What is the impact of digital games on a student's self-efficacy in the science classroom?

Significance of the Study

Although there has been significant research into the use of digital games in educational settings there has not been considerable research on how digital games can be used in the secondary science classroom. The intent of this study was to broaden the understanding of educators on the impact of digital games that use student response systems in secondary science by looking at three research questions. Digital games have the potential to have a positive impact on vocabulary development in science classes. As students engage in digital games, they have the opportunity to play the game multiple times. Each time a student plays the game they have the potential to improve their performance which could lead to a better understanding of the vocabulary and content (Chen et. al., 2019; Icard, 2014). If this research demonstrates a positive impact, teachers could use this information to make decisions about using digital games as part of their curriculum to increase the success of their students.

To be successful during the course of using digital games students need to use their previous experiences to make progress within the game. Students without realizing it provides scaffolding for their new experiences by activating their prior knowledge and experiences and applying it to the new experiences within the game. This study could potentially demonstrate that teachers could use digital games to help students review their previous knowledge before the introduction of new content to facilitate the scaffolding of learning.

Research has shown that higher levels of self-efficacy can lead to students being more engaged in classroom activities which can lead to greater academic success (Mikropoulos & Natsis, 2012). Students' experiences with digital games can help them gain confidence in their content knowledge because digital games are known to support student learning through repetition and immediate feedback (Annetta et al., 2014; Clark & Ernst, 2009). If this study determines that digital games can lead to higher levels of self-efficacy in students, then educators can justify the use of digital games as part of the science curriculum.

Digital games have the potential to have an immense impact in the secondary science classroom. Educators could integrate the digital games into their curriculum to increase student vocabulary knowledge, scaffold the learning of new content, and develop higher levels of self-efficacy. Digital games could be a technological tool that addressed three instructional concerns of teachers using only one instructional strategy which would benefit student learning experience and increase their success in science class.

Rationale for Methodology

An explanatory sequential mixed method design was chosen for this study for the ability it provides the researcher to integrate quantitative data and qualitative data and apply the data analysis to the research questions. The goal of using mixed methods research was to use the strengths of quantitative and qualitative research while minimizing any potential weaknesses from either of the methodologies (Johnson & Onwuegbuzie, 2004). When researchers use the combination of both methodologies it creates a more powerful analysis of the data and the conclusions drawn from it (Ivankova, Creswell, & Stick, 2006).

One of the advantages of using an explanatory sequential mixed-method design is that the quantitative data is collected and then the qualitative data is collected to help explain or elaborate on the quantitative results (Creswell, 2014). The reasoning behind this approach is that quantitative data provides a general picture of the research questions and then qualitative data collection is used to explain the general picture (Creswell, 2014; Lund, 2012). By using both quantitative and qualitative research methods, it allowed for overlapping data collection that provided different facets for the same research questions which enhances the understanding of the data (Greene, Caracellie, & Graham, 1989). By using the explanatory sequential mixed methods design, it presented the researcher with a complete understanding of the impact of digital games on teachers' and students' perception of vocabulary development, the scaffolding of student learning, and the level of a student's self-efficacy in science content areas.

Assumptions of the Study

The researcher assumed that each of the teachers involved in the study was following the school district provided curriculum to guide their instructional strategies. By following the provided curriculum teachers engage students similarly when covering the topics within the content area. This provided students with the same opportunity to master the content while engaging in digital games.

It was also assumed that the teachers followed the guidelines provided by the researcher on the administration of the survey to the students during the first phase of quantitative data collection. It was important for the teachers to administer the survey according to guidelines to help reduce any discrepancies within the data collection and analysis process. By following the same procedures, it increased the validity of the results.

During the second phase of qualitative data collection, it was assumed that teachers and the students were provided an adequate amount of time to complete the open-ended survey questions during the interviews. This will potentially improve the quality of the responses received during this phase of data collection. High-quality responses provided the researcher with an opportunity to conduct an in-depth analysis of the responses.

Definition of Terms

Activating Prior Knowledge. Teachers use the process of activating prior knowledge to determine what students may already know about the content being presented before they begin to learn about it (Alexander-Shea, 2011; Spires & Donley, 1998)

Digital Game. A digital game such as Kahoot! and Quizlet is an interactive program that enables one or multiple players to engage in the content primarily for entertainment purposes using technology such as computers and mobile devices (All, Castellar, & Van Looy, 2016).

Scaffolding. Scaffolding is the support that is meant to provide the assistance necessary to allow learners to accomplish tasks and develop new understandings that they would not otherwise be able to accomplish on their own (Hammond & Gibbons, 2001).

Self-Efficacy. Self-efficacy is a person's perception of their ability to complete tasks or goals that they have set for themselves (Bandura, 1997).

Vocabulary Development. Vocabulary development is described as learning activities that center around vocabulary instruction that help students focus on how words and concepts connect to each other within the context of the content area (Alexander-Shea, 2011).

Summary

As teachers use more and more technology to engage their students research must support the instructional strategies choices being made as part of the science curriculum. Digital games are well suited for use in science classrooms because they support the science curriculum by helping students develop their science skills and knowledge (An, Haynes, D'Alba, & Chumney, 2016). Teachers can use digital games to demonstrate to students that they are more than just entertainment for students and that digital games can be used to help students learn content knowledge and master science-specific vocabulary.

By researching the impact digital games that use student response systems have on teachers' and students' perceptions of vocabulary development and activating prior knowledge, it will provide educators with an understanding of the potential connection between digital games, vocabulary acquisition, and scaffolding of learning. As students use digital games in the science classroom, this technology has the capability to increase a student's level of self-efficacy which can lead to a greater positive perception of learning in the content area (Berger, Ketelhut, Liang, Natarajan, & Karakus, 2015). The connection between digital games and science content knowledge will have been better understood through the research provided in this study.

CHAPTER II: LITERATURE REVIEW

Digital games have the potential to provide students with a bridge that is necessary between their success in acquiring science content and their personal experiences with technology. Research into the use of digital games by Korucu and Alkan (2011) demonstrates that students feel empowered by the choice that digital games provide them in their learning experiences. Teachers can use digital games to help create a learning environment that connects students' prior knowledge to new content in a way that is familiar to the student (Wouters et al., 2013). Digital games can contribute to student success by developing and reinforcing vocabulary knowledge which is essential to learning science content (Tan et al., 2018). Student's confidence levels can be improved by the use of digital games which can benefit them in academic areas (Ketelhut, 2007). The ability to use digital games as part of the learning process can increase vocabulary knowledge and can support student's acquiring new content knowledge by activating prior knowledge which leads to increased self-efficacy.

Theoretical Framewor

Researchers have used theories such as metacognitive, behavioral, constructivism, and self-efficacy to ground their research into how digital games affect student learning. Research shows that the use of digital games has the potential to promote both the cognitive and motivational processes of learning (Ke, 2016; Wouters, et al, 2013). Digital games can be used by teachers to change how students are learning new content and to create new learning behaviors. This can occur while playing digital games since they promote interactivity which is conducive to promoting mastery of new knowledge (Lee, 2015). A students' confidence, motivation, engagement, and persistence while engaged in learning can be measured based on students' level of self-efficacy and an educator's use of scaffolding to support learning.

Scaffolding and Technology Supported Learning

Teachers use scaffolding to help bridge the gap between what learners want to achieve and what they are capable of achieving themselves without any outside assistance (Luckin, 2008). Scaffolding is based on Vygotsky's (1978) zone of proximal development (ZPD) theory. There is a zone in which new learning can occur where learning is not too challenging nor is it too easy for the students to learn (Hammond & Gibbons, 2001). The ZPD theory provides teachers with a strategic framework that can be used for selecting and implementing a plan to support student learning (Sharma & Hannafin, 2007). Scaffolding provides the necessary support to assist learning in completing tasks successfully.

Technology-supported learning can provide teachers with an approach to scaffolding student learning to increase academic achievement (Huang & Huang, 2015). Teachers must provide students with clear goals and learning activities that allow students to extend their current level of understanding of the content (Hammond & Gibbons, 2001). Technology enhances scaffolding interactions by offering a varied means for students to explore content (Saye & Brush, 2002) and provides a link for students between available resources and their environment (Luckin, 2008). Teachers' use of technology as part of the curriculum can support students' efforts to help themselves meet their learning needs and their understanding of the content (Sharma &

Hannafin, 2007). Using technology to scaffold learning can provide students with increased opportunities to be successful within a content area.

Self-Efficacy and Digital Games

Self-efficacy is a persons' perception of their ability to complete tasks or goals that they have set for themselves (Bandura, 1997) and the success of an individual has to complete their tasks or goals can be measured by their level of self-efficacy (Eccles & Wigfield, 2002). Self-efficacy can be a learned process and can be used to provide students with the opportunity to practice goal setting, encourage effort investment, and learn to work through problems and setbacks that occur while they are working to achieve their goals (Ahmad & Safaria, 2013). If students have a high level of self-efficacy, they are more confident in their ability to understand direct instruction, solve problems, and are more likely to challenge themselves academically (Zimmerman, Bandura, & Poons, 1992). The more opportunities that students are provided to complete educational tasks or learning goals that they set for themselves, the greater the chance students will achieve their goals and be academically successful.

Student success in a science class depends on the student being able to use prior knowledge to help scaffold the new content and increase their vocabulary knowledge as they learn the content. Aurah's (2017) research demonstrated a significant correlation between self-efficacy and achievement in science class and it is recommended that teachers assess student's levels of self-efficacy early to determine what interventions may be necessary to increase student's self-efficacy. Teachers can use this insight to determine the best methods to help every student be successful in science class. Students who have high levels of self-efficacy can succeed in science tasks by working hard to complete those tasks (Britner & Pajares, 2006) and do not need as much support compared to student with lower levels of self-efficacy. In contrast, students who believe that they can't be successful in science class avoid any science related work and put forth the minimal effort necessary to complete any science related task (Britner & Pajares, 2006). Self-efficacy is a learning theory that can be applied to how students can use digital games to accomplish what they need to be successful in science class.

Research has shown that self-efficacy can impact a students' choice of learning and the amount of effort exerted in classroom activities (Mikropolous & Natsis, 2012). If students have a high level of self-efficacy, they will be engaged in classroom activities and that can increase their academic success. Digital games empower students with the choice of when and where they can learn which allows them the freedom to learn at their own pace (Korucu and Alkan, 2011), and this freedom in learning can be leveraged to help improve student's self-efficacy in academic settings. Students benefit from the option to repeat levels of digital games and the practice provided by games can increase confidence in the content and self-efficacy which leads to greater success in academic areas (Ketelhut, 2007). Student learning is supported in digital games since immediate feedback is provided as they work through the games (Annetta et al., 2014; Clark & Ernst, 2009). This can create a feedback loop that allows students to check their understanding of the content and make adjustments as needed. As students perceive themselves as being successful in science their self-efficacy increases which therefore provides them with a positive perception of the learning (Berger et al., 2015). This cycle of positive perceptions and increased self-efficacy becomes a self-fulfilling cycle for student learning and academic success.

Influence of Technology in the Classroom

In today's digital age, the Internet gives teachers and students access to an enormous and ever-growing selection of online content and resources. For students in today's society, technology is an essential part of their lifestyle and needs to be an integral part of the learning process since they are particularly receptive to learning activities mediated by these tools (Hayes & Ohrnberger, 2013). The current generation has spent their entire lives using different types of technology and digital media. Despite students' familiarity with technology and that educational games have been available for several decades, there is not widespread use of digital games in the classroom by teachers. Research shows that 78% of teachers say they use digital games in the classroom, but the teachers using games in their classrooms are using games to motivate and reward over 50% of the time and not as part of their learning strategies (Korbey, 2014). Digital games need to be seen as more than games or entertainment by teachers. In the science classroom, technology such as probeware and Chromebooks, are being used to collect and analyze data for students during experiments. However, frequently technology is not being used as more than a tool in the science classroom and therefore not engaging students and enriching their learning experiences. When students take a science class, they need for the learning experience to be an active, experiential, and problem-based process that reflects how science occurs in real world settings and that can be provided through digital games (Oblinger, 2004). Students need the experience of viewing digital games as a tool for learning content knowledge and not just as an entertainment source.

One of the emerging technologies available for teachers is digital games which allow students to be part of an active learning process. The students in our classrooms tend to be experiential learners and prefer active learning to passive learning due to their interactions within their digital environments (Oblinger, 2004) and view traditional learning methods as boring and it doesn't inspire them to want to learn (Mayo, 2007). Students' familiarity with games and digital media makes them responsive to learning using web-based games since they are not just familiar with the technology but use it constantly as part of their daily lives (Siew, 2018; Hayes & Ohrnberger, 2013). Teachers need to leverage students' interest in technology to generate motivation for students to learn.

Besides being a platform that students are familiar with digital games can provide students with competition to help them excel in their learning and create opportunities for discussion and collaboration to increase their understanding of new content. The benefit of using digital games is that learning can occur organically without the student necessarily being aware that learning is occurring (Tan et al., 2018.) The use of digital games doesn't camouflage that learning is occurring, it makes learning through digital games occur seamlessly. When teachers use games to provide students with interactive learning environments, they do more than just teach the content to the students. Using digital games as part of game-based learning is known to increase students' motivation to learn (Sung & Hwang, 2013). By motivating students to learn, teachers create ownership of learning. When students have ownership of their learning, they value it more.

Teachers need to learn how to harness the power of technology to enrich the educational process for their students. Teachers can use technology to enhance learning, but can also use it to support active, meaningful learning environments that are driven by students (An & Williams, 2010). Students prefer to work on their own without having the teacher constantly supervise them (Giannakas et al., 2018). Students want the opportunity to demonstrate that they can accomplish learning goals without always needing the teacher present. Freedom to learn without direct supervision or instruction can increase motivation to learn and potentially create lifelong learners (Clark & Ernst, 2009). Technology can be used to empower students to have more control over their education (Rahimi, van den Berg, and Veen, 2015) and by giving students more control over their learning experiences, the content that students are learning becomes more valuable to them.

By their nature, digital games are not just a one-time use as a learning activity. Digital games can be used multiple times by the teacher and the students. Games can be used to teach a specific skill or to elaborate upon a content area in an environment that allows students to play, make mistakes, try again, and learn from each they play the game (Siew, 2018). As students play the game multiple times, they are more likely to improve their performance within the game, which would ultimately contribute to the improvement of their understanding of the content area and provide students with experience using problem-solving skills (Chen et al., 2019; Icard, 2014). Repetition can provide increased success and confidence in a specific content area. Games can be competitive in nature for students because they can entice students to play again to improve their previous scores or to compete against fellow students to move up the leaderboard. Every time a student plays a game it does not guarantee the student will be successful at it. According to Icard (2014), students can use their experiences in digital games to learn how to handle success and failure in a low-risk environment.

When teachers include digital games in their lessons, it supports student learning that can occur anywhere for their students (An & Williams, 2010). The use of mobile devices to participate in digital games supports learning in the right moment and the right place for the student since it can be used to allow students to have immediate access to the content and create a collaborative learning environment (Korucu and Alkan, 2011). Students do not have to learn only in the traditional classroom setting. Learning can occur whenever the student has the opportunity to engage in learning. It encourages students to review and work on the material at their own pace which puts students in control and helps them manage their learning and assess their progress (Henderson, Selwyn, & Aston, 2015; Tucker, 2014). Students can be engaged with content using digital games at school, on the bus, at home, or anywhere they have access to the Internet.

Use of Digital Games as Student Response Systems

As technology changed student response systems were developed which allowed teachers to pose questions or problems to students. Digital games such as Kahoot! allows teachers to create a set of questions that can be used anytime during the lesson. Teachers can include text, images, or videos and can also adjust the number of times students can have with each question (Prieto et al., 2019). Quizlet provides users with the opportunity to create study sets that can be used as flashcards, games, collaborative activities, and quizzes to facilitate student learning (Sanosi, 2018). Students then would use computers or mobile devices to participate in the digital games. Student response systems allow for teachers and students to receive immediate feedback on their grasp of the content being taught.

Some of the common gamified quiz applications such as Kahoot and Quizlet Live can be used by teachers to foster and reinforce learning through competitive knowledge games since the digital games provide students with the opportunity to review content that has been taught in the classroom. (Tan et al., 2018). Kahoot! helped students easily recall previously covered content and achieve new perspectives that increased the knowledge (Toth, Logo, & Logo, 2019; Licorish, George, Owen, & Daniel, 2017). Also, students found that the variation in audio and points used in Kahoot! positively affect their concentration, engagement, enjoyment, and motivation in a significant manner (Wang & Liebroth, 2016). Students can quickly assess their knowledge of the content through the feedback provided by digital games such as Kahoot!

Student response systems can provide students with more than a competitive environment to review content knowledge. Digital games such as Quizlet and Quizlet Live support students' vocabulary development through interactive flashcards, individual games, and competitive collaborative games. The use of student response systems creates an atmosphere that is more exciting for students, motivates them to learn, and allows them to use their mobile devices constructively in an educational environment (Wolff, 2016). Students found that using Quizlet made it easy for them to study new vocabulary and helped them master content vocabulary with the use of the digital game (Dizon, 2016; Wolff, 2016). The integration of digital games into the curriculum created a positive influence on students’ academic performance and gave them ownership over the learning of the vocabulary through the use of technology (Setiawan & Wiedarti, 2020;

Lander, 2016). Digital games that incorporate the use of student response systems create a learning environment that motivates students to interact with the content vocabulary and assists them in the acquisition of new vocabulary.

Significance of Activating Prior Knowledge to Student Success

By the time students reach a high school science class, teachers expect students to be able to read the content provided whether it is the textbook, journal articles, or experiment instructions. The actual reading of science content is not a problem for students. The problem that students are encountering is when they are trying to comprehend what they are reading, learning, and discussing in science class. “Reading science text is perhaps most challenging because of its many new concepts and words” (Kroeger, Burton, & Preson, 2009, p.6). Science classes use vocabulary that students do not encounter in their daily language experiences and therefore students do not have as much practice with using science vocabulary. According to Young (2005), if students do not have a clear understanding of the language or content in their science classes, they will experience difficulty with the material and will start to lose interest in science classes. So, students can have difficulties making connections between their prior knowledge and the new science content because of the vocabulary used in the classroom and then can potentially end up struggling academically.

Kroeger et al. (2009) explained that there is a gap between what students already know about science content and what they are learning about in their current science class. Students are not learning to use and apply the science content knowledge taught through various classroom activities. They then become lost in a learning gap because they are attempting to learn new science content without the support or skills to connect the previous learning with the new learning (Rasinski, Padak, & Newton, 2017). The difficulty of the course intensifies if students are struggling with the content and compound the problem that students encounter when they have not developed the skills needed to cope with the intensity of the coursework. Over time students' motivation to learn and engagement levels will suffer because of the gap in their content knowledge.

The process of activating prior knowledge is described as a reading strategy that students use to determine what they already know about the content being presented before they begin to learn about it (Alexander-Shea, 2011; Spires & Donley, 1998). Using prior knowledge as a reading strategy is associated with an increase in the level of reading comprehension for students (Barth & Elleman, 2017). Increased reading comprehension provides students with deepened content knowledge and confidence in the material being learned. When students use prior knowledge as they read through texts, they create inferences that help them fill in any potential gaps in the text (Barth & Elleman, 2017). Using prior knowledge to create inferences to help fill in the gaps in students' comprehension is a reading strategy that can be applied in any content area.

If students do not have the opportunity to activate their prior knowledge before they read then comprehending new content can be difficult for students (Kostons & ver der Werf, 2015). This can put students at an immediate disadvantage in the learning process. Use of activating prior knowledge can be used by teachers to help students more effectively learn new information and provide meaningfulness to the information while it is being learned (Swiderski, 2011). Making connections in content knowledge helps scaffold the learning experience for students. This learning strategy helps students understand how their background knowledge can be used to make connections with what is being currently taught that they might not be able to otherwise make with the content (Willingham & Price, 2009). When learning is scaffolded for the student by using reading strategies such as activating prior knowledge, it can make the content more accessible for students.

Activating prior knowledge is more than just for students' success. When teachers engage students in discussions about their prior knowledge, it provides the teacher with information that can be used to develop lessons that meet the students learning needs and can help dispel any misconceptions that students have about the content (Swiderski, 2011). Teachers can assess students' prior knowledge to determine what students are ready to learn and differentiate the curriculum to meet the students where they are ready to learn.

Use of Digital Games to Connect Prior Knowledge to New Content

Since the current generation of students has been operating in the digital world for the majority of their life, they tend to experience a disconnect between their daily life and their learning environment at school (Oblinger, 2004; Prensky, 2003). Digital games provide a method to reach students using a learning mechanism that are familiar to them. Digital games can be used to help teachers scaffold learning by building on a student's previous experiences and knowledge that keeps students engaged and fosters interest in the content for extended periods (Hamari et al., 2016; Huang & Huang, 2015; Escheverri & Sadler, 2011). This can provide teachers with a tool to connect the curriculum to the students' learning experiences.

For students to be successful while playing games they must use their prior knowledge and leverage it to learn new ideas to be able to advance in the game

(Oblinger, 2004). This method of scaffolding student learning as they progress through the game covertly aids students as they acquire content knowledge. Digital games can be used to involve students in the review of previous learning before the introduction of new content to help create a bridge between prior learning and the new learning (Iten & Petko, 2016). When students are actively engaged in their learning, they are more motivated to retain the content knowledge being taught to them (Tan, Ganapathy, & Kaur, 2018; Cagiltay, 2007). The use of digital games as an instructional strategy lends itself to the use of well-structured prior knowledge since it requires students to build upon their prior knowledge during their learning experiences (Wouters et al., 2013). Students benefit from activating their prior knowledge before learning new material and digital games provide teachers with a method to accomplish this goal.

Clark and Ernst (2009) believe that games are a valuable tool that can be used to encourage student learning at all grade levels. They based their premise on The Federation of American Scientists who have taken the position that gaming increases the student's ability to think analytically and increase their problem-solving skills (Clark & Ernst, 2009). Digital games create active learning experiences that involve them in the problem-solving process which builds their investigative skills (Oblinger, 2004). The capacity to think analytically and use problem-solving skills allows students to make connections between previous science classes and what they are currently learning.

Importance of Vocabulary in Reading in Science Content

Science lessons are rich in vocabulary and require students to interpret what they read and hear in class. Students need to become better readers of informational text, so they can improve their understanding of science. When students find out they are doing an experiment they get excited about the science concepts, but they can have difficulty explaining the scientific principle that they just learned about in the experiment (Harper, 2018). Students can understand the concept being taught in the experiment but have difficulty explaining it since they lack the vocabulary needed to describe what they are learning. Understanding content area vocabulary is an essential part of learning about science, but it can be problematic for students since they are learning about new words and ideas that are not part of their daily language (Rasinski et al., 2017). Learning activities that center around vocabulary instruction help students focus on how words and concepts connect to each other within the context of the content area (Alexander-Shea, 2011). Teachers need to incorporate vocabulary lessons into the science curriculum. The more connections that students make between the vocabulary and the science concepts, the more likely they are to transfer knowledge to other parts of their life (Billmeyer & Burton, 2002). The integration of reading strategies, such as vocabulary instruction, into the science curriculum is important to the comprehension of science concepts and the students' ability to demonstrate their understanding of science.

Science teachers consider their content area a hands-on, active learning process and do not perceive reading in the same light and do not always feel comfortable including vocabulary instruction in their lessons (Singletary, 2010). Vocabulary instruction should be included in all aspects of learning including experiments, informational texts, and review activities which can make it part of the hands-on, active learning process. By providing students with multiple opportunities to use science vocabulary, it increases students' confidence in how they are using their science knowledge (Harper, 2018). It is not enough for students to understand the science content, they need to be able to discuss and explain what they are learning in class.

In addition, teachers become concerned because they do not know if they have the time to teach reading strategies in an already packed content area (Singletary, 2010). Teaching vocabulary can be challenging because there is no perfect instructional method that teachers can use, but what is a necessary part of vocabulary instruction is providing multiple exposures to the vocabulary to increase the success of students (National Institute for Literacy, 2007). When teachers take the time to use explicit vocabulary instruction it encourages students to make the connection between reading strategies and learning in science class (Radcliffe, Cacerly, Hand, & Franke, 2008), and part of vocabulary instruction includes encouraging students to explain scientific concepts to help them learn the content (Harper, 2018). Teachers need to take every opportunity to infuse vocabulary instruction into every part of their lessons.

Digital Games as a Tool for Vocabulary Development

Science can be a difficult subject for students to learn because the vocabulary taught with the content is not part of their daily language. Mastering the vocabulary used in science class is essential for the success of a student but the traditional method of rote memorization can be boring for students (Huang & Huang, 2015). Students need to do more than look up definitions in a textbook and create flashcards to learn new vocabulary. One of the reasons digital games are successful in the classroom is that they keep students' attention and promote knowledge retention because of the elements of play that are involved (Tan et al., 2018). Students become involved in the learning process since digital games can provide a balance of learning and play through the game elements (Nussbaum & Beserra, 2014). Digital games provide a learning experience that students have a positive reaction to the content when used as part of the curriculum.

A benefit of using technology is that it is not static and is constantly evolving. Students benefit from using technology for vocabulary instruction since online resources are regularly updated and respond to students through their interactions within the game (Abrams & Walsh, 2014). Additionally, digital games can provide teachers with access to updates that reflect the most recent changes in science research. These updates and interactions provide students with the most recent information available and that could never be achieved with traditional teaching methods.

Students have to interact with potential new vocabulary to make progress within the game since they need to constantly analyze the content to be successful with the game (Ebrahimzadeh & Alavi, 2017). Learning becomes a fluid process as students use their content knowledge to successfully navigate the game. Students attribute their success in learning the vocabulary with how digital games gave them the ability to interact with the words in a multitude of contexts and it required them to apply their knowledge immediately (Abrams & Walsh, 2014). Digital games can be used to reinforce vocabulary knowledge which helps students focus on the essential content knowledge (Tan et al., 2018). In Toth, Logo, and Logo's (2019) research on the effectiveness of digital games, students reported that it was easier to remember the content since the digital games had exposed them to the vocabulary previously. It helped students be successful with the content because it built upon their prior knowledge. Students who used digital games to facilitate learning new vocabulary also develop group decision-making skills and improve on their scientific literacy as they work through the game levels (Harper, 2018; Sardone & Develin-Scherer, 2010) which are essential skills for their continued success in science courses.

Watson, Mong, and Harris (2011) explained that digital games help move the curriculum away from a teacher-centered approach to learning to more of a student-centered approach to learning which allows for students to have the opportunity to control how often, when, and where they can use the digital game for practice. When students had the opportunity to use digital games to help them learn vocabulary, they achieved greater knowledge gains because digital vocabulary games strengthened students' self-directed learning (Yip & Kwan, 2006). By handing over the control of the learning environment, it gives students the freedom to take ownership of their learning. The ability to choose the time, place, and frequency of gameplay increased students' interaction and enjoyment which resulted in gains in their academic achievement (Abrams & Walsh, 2014). Since students have control of how they use the digital vocabulary game, it allows students to play the game as many times as they want. Digital vocabulary games allow students to learn through repetition and within the context of the reading needed within the game. It created a structure that helped them with their vocabulary development (Yip & Kwan, 2006). Digital games provide students with feedback and interactive learning, but the most important part of vocabulary instruction is the interactions that happen in the classroom and that online resources should not be used in isolation (Abrams & Walsh, 2014). Teachers need to understand the impact of digital games on vocabulary development and how they should be integrated into their science curriculum.

Summary

One of the reasons that science class can be intimidating to students is that they struggle with the new science terms that they encounter (Ferrell, 2007). Students have difficulty with science terms since they are only using them during science class. Students are unable to build their science knowledge using these new vocabulary terms because their prior knowledge is insufficient (Gillis & MacDougall, 2007). This lack of prior knowledge creates a problem that must be addressed by teachers. A student's success in science education depends on students' level of literacy. Students must have the skills to be able to read critically and write clearly about what they are learning in class (Singletary, 2010). Teachers can enhance the learning experience by taking the time to effectively teach the vocabulary using multiple methods that include the use of digital games as part of the curriculum.

Students who are engaged in digital games are acquiring science knowledge and achieving learning objects (Chen, Law, & Huong, 2019; Giannakas, Kambourakis, Papasalouros, & Gritzalis, 2018). When digital games are used in science classes it creates higher levels of student effort, engagement, and persistence that leads to increased student success and self-efficacy (Pajares, 2002). Students who use digital games in their science classes have shown an increase in their self-esteem as learners and academic success (Meluso, Zheng, Spries, & Lester, 2012) which can be explained by the self-efficacy theory. Self-efficacy as a learning theory can be applied to explain the impact that digital games have on students in the science classroom.

Science teachers need to comprehend the impact that digital games can have in their classrooms. Digital games have the capability to influence student's success by providing them an opportunity to connect their prior knowledge with new content. They can support student's acquisition of vocabulary knowledge through repetition and the feedback that can be incorporated into digital games. Once a student increases their vocabulary and content knowledge it could lead to higher levels of self-efficacy which would boost their success in science class.

CHAPTER III: RESEARCH METHODOLOGY

Digital games are seen in almost every content area and educational level. It is crucial for educators to understand how digital games that use student response systems can be integrated into their curriculum. Student success in high school science classes hinges on their ability to connect their previous experiences to what they are learning, comprehend the vast amount of content related vocabulary, and have a well-developed sense of self-efficacy. If any of these three items are missing for a student, they struggle to flourish in science classrooms. Digital games have the capacity to help students successfully progress through science content by addressing these concerns.

The purpose of this explanatory sequential mixed methods research was concentrated on the perceived impact digital games that use student response systems such as Kahoot and Quizlet have in high school science classrooms on vocabulary development, connection previous knowledge and experiences to new content, and self-efficacy. By using mixed methods research, the data collection and data analysis has the advantages of both types of research and was able to reduce any disadvantages that come from using a single method of research (Johnson & Onwuegbuzie, 2004). This provided a comprehensive analysis of the research questions.

Research Questions

Based on the purpose of this study, three research questions were analyzed to determine the perceived impact that digital games that use student response systems have in the science classroom. The study was used to answer the following research questions:

1. How do students and teachers perceive the use of digital games on their vocabulary development in high school science classes?
2. How do students and teachers perceive the use of digital games to scaffold learning by activating prior knowledge in high school science classes?
3. What is the impact of digital games on a student's self-efficacy in the science classroom?

It is hypothesized that the use of digital games as part of the science curriculum will have had a positive impact on the perception of vocabulary development, scaffolding of learning by activating prior knowledge, and self-efficacy. This positive perception will occur because students will have increased exposure and experience with the science vocabulary and content knowledge through the use of digital games. Digital games provided educators an instructional strategy to research students using technology that they were familiar with and comfortable using as part of their daily life. Student's self-efficacy will be positively impacted since digital games provide students with multiple opportunities to practice science vocabulary and review content knowledge. The increase in practice enhanced student's confidence in the science content which led to higher levels of self-efficacy.

The research involved multiple high school science classrooms with different teachers which introduced several variables that needed to be taken into account during the data analysis phase of the study. The first variable was the familiarity of the teachers and students with the digital game being used. To provide the teachers and students with time to become acquainted with the digital game, data was not collected before the end of the first quarter of school. By providing time for the participants to become familiar with the digital game, it lessened the impact of this variable in the data analysis. Another variable that could impact the data analysis phase was how the content was being taught in the classroom. Each teacher had their own instructional strategies that they used to deliver content knowledge to their students. The significance of this variable was potentially minimized since all science teachers in the county follow the curriculum developed by the school district. The school district's curriculum laid out a timeline for content delivery and provided well-developed lessons and content resources for teachers to use in their science classrooms. This provided the researcher with insight into the content that was being taught in the class at any given time during the school year and ensured that every student had covered the same content before data was collected about the use of digital games in science classrooms.

Research Design

The process of using explanatory sequential mixed method design provided the researcher with the opportunity to integrate both quantitative data and qualitative data in the research process (Figure 1). The reason for using this type of mixed method approach is that the quantitative and qualitative data and their analysis clarify those statistical results by exploring the participants' views in more depth (Subedi, 2016). This design method provided a more complete understanding than either quantitative research or qualitative research can in isolation because explaining how the variables interact with each other creates a stronger design method (Creswell, 2014). Mixed methods research studies, such as explanatory sequential, provided the researcher with the ability to describe what is being used in practice in the classroom (Johnson & Onwuegbuzie, 2004) and allows for a more thorough analysis by taking advantage of the strengths of both quantitative and qualitative research methods which will lessen the impact of any disadvantages of either research method (Ivankova et al., 2006).

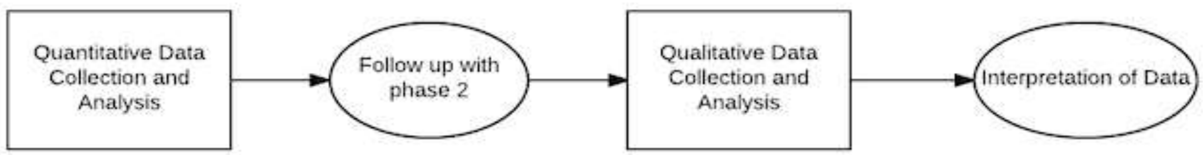


Figure 1. Explanatory Sequential Mixed Methods Design. Adapted from Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (p. 220), J. W. Creswell, 2014, Thousands Oak, CA: Sage Publications, Inc.

This study included two phases of data collection. During phase 1 of the study, quantitative data was collected from teachers and students using Likert scale surveys to determine the significance of using digital games in the science classroom on vocabulary knowledge, use of prior knowledge to facilitate learning new content, and building self-efficacy. In the second phase of the study, qualitative data was collected by incorporating the perspectives of the science teachers and their students through open-ended questions (Creswell, 2014). The qualitative data collected provided a more in-depth understanding by exploring participants' views of digital games in the science classroom in greater detail (Subedi, 2016). The use of qualitative data to support quantitative data was critical to creating a more comprehensive study since it seeks to elaborate upon the results found during phase 1 (Doyle, Brady, & Byrne, 2009; Creswell & Plano Clark, 2007; Johnson & Onwuegbuzie, 2004).

By incorporating both qualitative research and quantitative research into the design of the research, it provided the researcher with a more complete picture of the perceived impact of digital games on vocabulary development, scaffolding learning, and student's self-efficacy in science classrooms. The results could be considered to be more comprehensive since the validity of the inferences and conclusions will increase when there is more convergence between the quantitative and qualitative data analysis (Lund, 2012; Bryman, 2006). The mixed methods research design provided the study with the validity of both types of traditional research methods.

By using an explanatory sequential mixed-methods study, the researcher sought to find triangulation between the findings generated by using both traditional methods of research. Triangulation is essential to the study since it provides a method to determine if the findings generated in phase 1 can be corroborated by the findings of phase 2 (Bryman, 2006; Johnson & Onwuegbuzie, 2004). When the data is corroborated through triangulation it will generate greater validity of the data analysis (Doyle et al., 2009). The use of quantitative and qualitative data created an in-depth analysis of the impact digital games can have on vocabulary knowledge, the scaffolding of prior knowledge while learning new content, and increased levels of self-efficacy in science classrooms.

Participants

The research was conducted in a rural school district in Maryland. The school district has a population of approximately 15,000 students. The school district has 16 elementary schools, 6 middle schools, and 5 high schools. The focus of the research was on how digital games impact high school science classes and there are approximately 4,500 students enrolled in the five high schools. In this school district, the high schools include grades 9 - 12 with an age range of 14 to 19 for the students. Overall the high schools in the school district have a graduation rate of 93.3% based on the 2019 Maryland Report Card which is generated by the Maryland State Department of Education annually.

High school science teachers that indicate that they use digital games as part of their curriculum were invited to participate in the study. Of the 37 high school science teachers invited to participate in phase one of the study, 19 teachers chose to participate. Each teacher was responsible for teaching five to six science classes during the course of the school year when the research was conducted. All of the teachers that participated in phase 1 were asked to participate in phase two since it was anticipated that not all the teachers would potentially want to participate in phase 2. Of the 19 teachers that were invited to participate in phase 2 of the study, only 5 responded to the open-ended questions.

The students of the teachers that chose to participate in the study were invited to participate in the study as well. These students were chosen for the first phase because their teachers indicated that they used digital games as part of the curriculum. It was essential to the data collection that the students that participated in the study had experience using digital games in their science classes. Most of the science classes in the county have 20-30 students enrolled in each class. A total of 105 students responded to the Likert-scale survey used in phase 1 of the study. During phase two of the study 15% of the students were asked to participate in the open-ended questions using purposeful sampling. 15% of students were chosen using maximum variation sampling. This method of purposeful sampling focuses on documenting a diverse variety of individuals (Creswell & Poth, 2018). Students were chosen based on their responses to the Likert scale survey in phase 1 and included students from both ends of the spectrum (strongly disagree to strongly agree) as well as students that had neutral responses. This helped reduce bias and increased the validity of the data analysis since participants were sought out that represented a variety of beliefs about using digital games in science class. A total of 12 students responded to the open-ended questions in phase 2 of the study. By allowing any high school science teachers and students that are interested in participating in the study, the researcher intended to generate a large and diverse sample of participants to collect data from during both phases of the research.

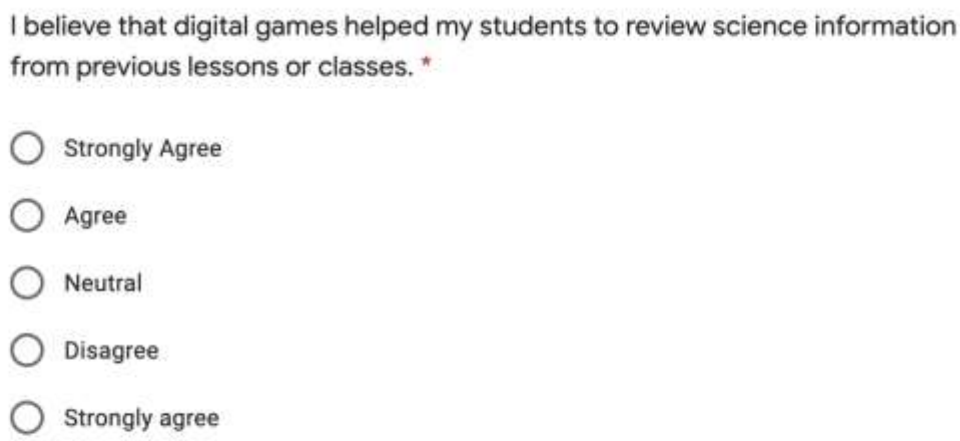
Research Tools

Phase 1 – Likert Scale Survey

Quantitative data for all three research questions were collected from high school science teachers and the students in their classrooms using a Likert scale survey. The Likert scale was a five-point scale using the terms strongly agree, agree, neutral, disagree, and strongly disagree. Likert scale surveys are frequently used to gather data on people's attitudes, beliefs, and opinions on a given topic (Ruel, Wagner, & Gillespie, 2016). A five-point Likert scale does not force people to choose either extreme since it provides neutral as an option for the participants which will help increase the validity of the data analysis (Ruel et al.,2016). To prevent any potential confusion for the participants a definition and examples of digital games were provided to the participants to clarify what is considered a digital game when referring to the survey questions. Participants were told that digital games were an interactive program that enables one or multiple players to engage in the content primarily for entertainment purposes using technology such as computers and mobiles devices like Kahoot! and Quizlet. The use of the definition helped the participants better understand what was being asked about digital games in the survey questions. This should have prevented any ambiguity in the responses to the teacher and student questions.

During the first phase of the study, quantitative data were collected in two different categories from teachers (Appendix B). The survey questions on teachers' perception of digital games impact on vocabulary development and activating prior knowledge were developed based on the relevant literature (An et al., 2016; Sardone & Devlin-Scherer, 2010; Ray & Coulter, 2010). Content validity was ensured by having three different teachers organize and group the Likert-survey questions into perceived categories. This feedback determined if the survey questions measured the intended research areas and were adjusted based on the feedback from the teachers. This same method was used to ensure content validity for the student Likert-survey questions.

The Likert scale survey have five questions about science teachers' perceptions of the impact of digital games on vocabulary development and five questions about science teachers' perception of the impact of digital games on scaffold learning by activating prior knowledge. The Likert scale survey only included statements that pertained to research questions 1 and 2 since teachers can only receive feedback from the students during the use of digital games on these two questions. Teachers can receive feedback from the data collected within the digital games based on the student's performance with the content. The data generated by the digital games did not give teachers any information on a student's level of self-efficacy and therefore the study did not collect teachers' perceptions on students' level of self-efficacy.


I believe that digital games helped my students to review science information from previous lessons or classes. *

Strongly Agree

Agree

Neutral

Disagree

Strongly agree

Figure 2. Sample question from the Likert-scale survey for teachers

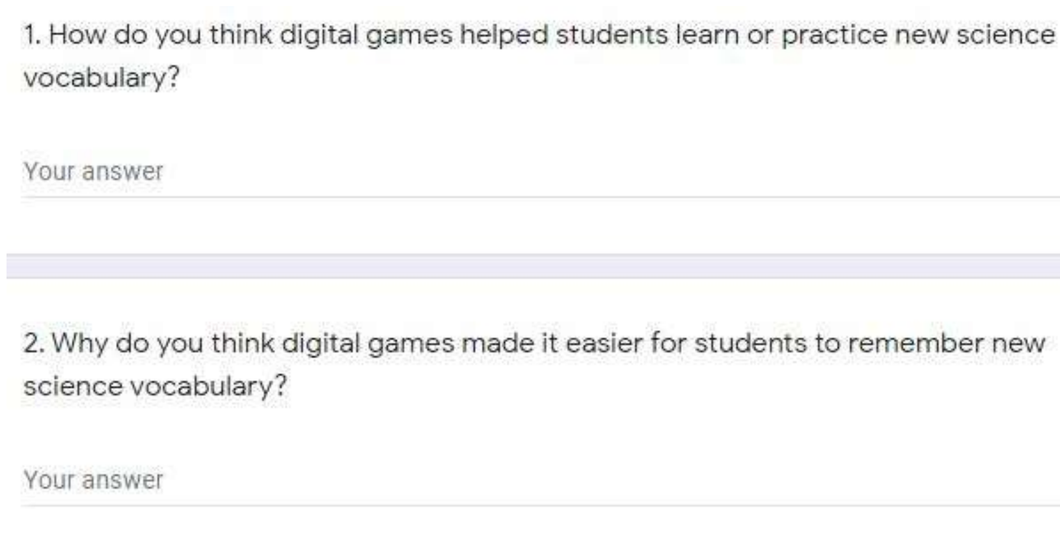
Quantitative data were collected in three different categories from students about their perception of the impact of the digital games on their vocabulary development, on their ability to make connections between prior knowledge and new content, and on their self-efficacy in the science classroom (Appendix A). The survey questions were developed based on the relevant literature (Aurah, 2017; Meluso et al., 2012; Thomas, Anderson, & Nashon, 2008; Britner & Pajares, 2006). There were five questions about the impact of digital games on students' self-efficacy, five questions about the impact of digital games on their vocabulary knowledge, and five questions on the impact of digital games about their ability to make connections between prior knowledge and new content.

Figure 3. Sample questions from the Likert-scale survey for students

Phase 2 – Open-Ended Questions Survey

Qualitative data was collected on all three research questions during phase 2. The data was collected using open-ended survey questions. The data collected during phase 1 were analyzed using descriptive statistics and Pearson correlation. The results of the analysis were used to adjust the scope of the open-ended questions for the teachers and the students. The focus of the questions was to gain information to better understand the responses to the teacher and student surveys in phase one. The open-ended questions were structured so that the same set of questions was asked of each participant in the same sequence. This made it easier to analyze the data within the two groups of participants (teachers and students). The qualitative data was used to build upon the results from the quantitative data. The focus of the qualitative data was to determine the reasons behind the teacher and student responses on the Likert scale surveys. The qualitative data were collected from the same pool of individuals as the quantitative phase of the study because the purpose of the explanatory sequential mixed methods design was to explore the results reported during the first phase of the study in more depth (Creswell, 2014).

The data collected from the corresponding Likert scale surveys were used to develop open-ended questions for teachers (Appendix D) and students (Appendix C) for Phase 2 of the study. The open-ended questions for teachers was divided into two categories, vocabulary development and activating prior knowledge. Teachers were not asked to answer questions about students' level of self-efficacy since teachers are unable to speak with certainty about a students' level of self-efficacy based on the interactions that occur during the use of digital games within the science classroom setting.


1. How do you think digital games helped students learn or practice new science vocabulary?

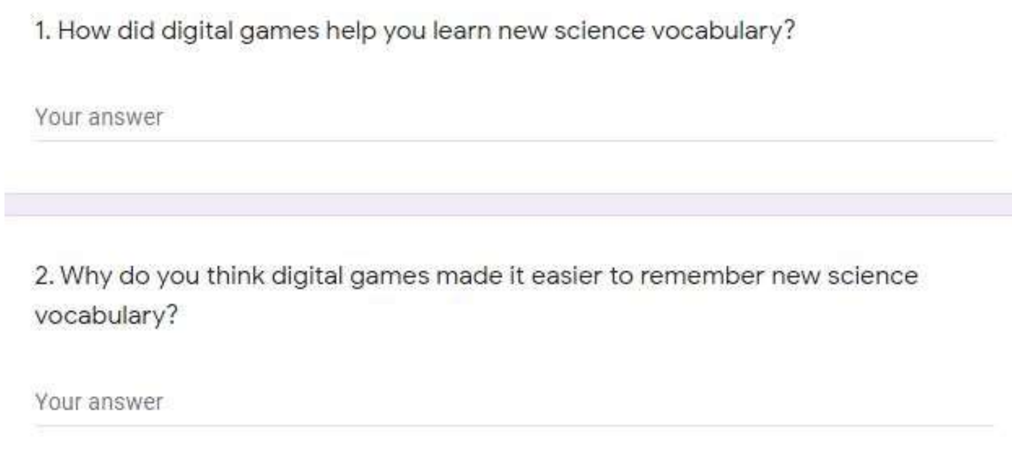
Your answer

2. Why do you think digital games made it easier for students to remember new science vocabulary?

Your answer

Figure 4. Sample questions from the open-ended questions survey for teachers

The interview questions for students were divided into three categories, vocabulary development, activating prior knowledge, and self-efficacy along the same lines of inquiry used in the phase 1 quantitative research. Each set of open-ended questions was used to help the researcher better interpret the results of quantitative data in phase one.


1. How did digital games help you learn new science vocabulary?

Your answer

2. Why do you think digital games made it easier to remember new science vocabulary?

Your answer

Figure 5. Sample questions for the open-ended questions survey for students

Data Collection and Management

The Likert scale survey was sent out to 37 high school science teachers in the school district. The teachers were given three weeks to complete the Likert scale survey and were sent one reminder one week before the due date. After the teachers completed the Likert scale survey, they were asked to send the student Likert scale survey to all the students in their high school science classes. The students were given three weeks to complete the Likert scale survey and were reminded by their teachers to complete the survey one week before the deadline.

The teachers and students were asked to complete the Likert scale survey after the use of digital games that use student response systems such as Kahoot! and Quizlet in their science classes. The method for collecting the quantitative data was a Google Form since the school district provides teachers and students with Google accounts. Teachers and students have experience using Google Forms so it was a familiar tool to them which will lessen any potential negative impact of using technology as part of the data collection process. The use of Google Forms facilitated the gathering of data quickly and efficiently since it can be downloaded in multiple formats. This provided the researcher with an effective method to collect the data to be exported to statistics software for data analysis.

Qualitative data were collected during the second phase of the study which was composed of open-ended questions in a survey. Google Forms was used to collect data from the participants during this phase of the study as well. Five high school science teachers and fifteen students were asked to participate in open-ended follow-up questions. The teachers and students chosen to participate in phase 2 of the study were based on their responses to the Likert-survey questions. Participants with typical experiences as well as atypical experiences were sought so the entire range of experiences with digital games was understood by the researcher (Coyne, 1997).

Data Analysis and Procedures

Each phase of the research was analyzed separately from each other. This was essential to the research method because the explanatory sequential mixed method design allowed for the quantitative results to drive the design of the qualitative data research tools (Creswell, 2014). In the quantitative phase, the data were evaluated using descriptive statistics to determine the nature of the results and if there were any patterns in teachers' responses about the perceived impact of digital games on vocabulary development and if teachers perceived that digital games scaffold learning by activating prior knowledge. Specifically, the data were evaluated for central tendency (mean) to determine the most typical score and standard deviation to determine the extent of the typical score from the mean (Hatcher, 2013).

The quantitative data were also analyzed using the Cronbach alpha coefficient to determine the reliability within a set of scores since multiple-item scales were being used for each research question. Cronbach alpha is a measure used to assess the reliability or internal consistency of a set of scale or test items (Hatcher, 2013). This provided the researcher with a measurement of how well the questions in the Likert scale surveys consistently and reliably measured each of the research questions.

The in-depth analysis of the qualitative data in the second phase was used to determine the reasons behind the participants' responses found in the quantitative research. To increase consistency in the data analysis, it was decided to use a single coder for the phase 2 qualitative research. Interrater reliability between coders was not a concern since only one coder was used to analyze the qualitative data (Ruel et al., 2016). It was possible to have a single coder since there were a small number of responses and categories generated for the phase 2 qualitative data analysis.

The participants' responses were initially analyzed using an open coding method which has the researcher recording instances of recurring words and phrases. Open coding allowed for the researcher to analyze the data without having preconceived categories for the responses (Creswell & Poth, 2018). The participants responses were read and re-read for familiarization and to identify initial codes based on surface level semantics in the data rather than any preconceptions about the research questions and the data (Braun & Clarke, 2006). Once the open coding was completed, axial coding occurred to draw connections and condense the initial codes developed during the open coding (Creswell, 2014). Major categories of information were created based on the emerging trends in the data and reanalyzed to reduce the major categories into themes (Ruel, Wagner, & Gillespie, 2016) axial coding.

The results of the research were interpreted following the explanatory sequential mixed method design in the discussion section. The quantitative data was interpreted using descriptive statistics and the qualitative data were analyzed for major themes found in the participants' responses. The discussion of the results from the quantitative research was reported independent of qualitative research data to allow for each set of data to be analyzed objectively. The last part of the discussion examined how the results of the qualitative data are used to explain the quantitative results (Creswell, 2014). It is essential to interpret the results of both phases of research independently and together to provide a clear discussion of how the research questions have been answered with the study.

Ethical Considerations

Before conducting the study, IRB approval was obtained from Boise State University. The appropriate protocol was followed at the local level to obtain permission from the school district to conduct the study in the high schools. Administrators and teachers potentially involved in the study were informed of the purpose of the study and were notified that participation in the study is completely voluntary.

At the beginning of the study written consent was obtained from the high school administrator and teachers who voluntarily agree to participate in the study. Additionally, since the research involved children, parents had to give permission for the students to be included in the study. It was explained to parents that participation in the study is completely voluntary and that parents could choose not to have their students included in the study. All participants were provided with information about the purpose of the study and how it was conducted. Teachers, parents, and students were made aware that the data collected during the course of the study or the outcome of the research did not impact a student's grade in the class.

All students received the same content and teaching methods during the course of the study whether they chose to participate in the study or not. The collection of the data was noninvasive and did not intend to disrupt classroom learning. While collecting the data all the personal and identifying information was withheld from the study and changed when needed to protect the privacy of the individuals participating in the study. Students that chose not to participate in the study did not have the data collected that would have been associated with them. Likert scale survey results and open-ended questions responses were collected using an electronic method such as Google Forms. Names and identifying information were changed to protect the privacy of the individuals when they were provided as part of a survey.

All research materials were original or appropriate authorship were cited throughout the study. The quantitative and qualitative data collected during the course of the study was not stored at the same site as where the research was being conducted and access was limited to the author in the study. All the materials used for the study and the raw data collected over the course of the study will be kept for a period of three years and then will be destroyed.

Validity of Data Collection

When data was being collected during the quantitative phase, it was essential to have a large sample size that can be used to develop the qualitative phase of the research. Every opportunity was given to the science teachers and the students in their classrooms to participate in the Likert scale survey to increase the sample size. All results from the quantitative data analysis were considered when creating the interview questions and open-ended questions. Teachers were chosen randomly for phase 2 of the research to remove any potential bias during the qualitative phase of research. Every attempt was made to consider all aspects of the research process throughout the quantitative and qualitative phases of the study to increase the validity of the study.

Summary

This study used explanatory sequential mixed methods research to examine the perceived impact digital games have in high school science classrooms on vocabulary development, scaffolding by activating prior knowledge, and students' self-efficacy. In the first phase, quantitative data were collected using a Likert scale survey to examine teachers' and students' perceptions about the influence digital games have on students' vocabulary development and if digital games provide scaffolding to help students connect prior knowledge to the new content. Additionally, students' perceptions of self-efficacy while using digital games was measured using the Likert scale survey. The quantitative data collected during the first phase was used to develop open-ended questions to be asked of the teachers and students during the qualitative data collection. The qualitative data were examined to determine any major themes found in the participants' responses.

CHAPTER IV: RESULTS

The purpose of this study was to focus on the perceived impact that digital games, such as Kahoot! and Quizlet that uses a student response system, have in high school science classrooms on vocabulary development, scaffolding learning by activating prior knowledge, and self-efficacy of the students. Digital games, such as Kahoot!, have shown that they can be used to help students recall previously covered content and achieve a greater understanding of the content (Toth, Logo, & Logo, 2019; Licorish et al., 2017). The use of digital games as part of the curriculum helps provide students with ownership over their learning through the use of technology (Setiawan & Wiedarti, 2020; Lander, 2016). Digital games can provide students the opportunity to take control of their learning (Korucu & Alkan, 2011) and can be used to help improve their self-efficacy in the classroom. The connection between digital games, science classrooms, and student's self-efficacy was better understood through the research conducted in this study.

The teachers were asked to complete a ten question Likert scale survey (Appendix B) during phase 1 and 10 opened-ended survey questions (Appendix D) during phase 2 of the study on the impact digital games have on students' vocabulary development and on the scaffold learning by activating prior knowledge in their high school science classes. The students were asked to complete a 15 question Likert scale survey (Appendix A) and 17 open-ended survey questions (Appendix C) on the impact digital games have on students' vocabulary development, use of prior knowledge to facilitate learning new content, and building self-efficacy in their high school science class.

The Likert scale surveys used a five-point scale using the terms strongly agree, agree, neutral, disagree, and strongly disagree. The responses to the survey were converted into numerical values with five being used for strongly agree down to one being used for strongly disagree. The conversion was done to facilitate the analysis of the quantitative data. The data were analyzed using descriptive statistics to describe the results of the survey and to determine if there were any patterns in the teachers' and students' responses. More specifically, the data were evaluated for central tendency (mean) to determine the most typical response from the teachers for each of the questions and standard deviation to determine the extent of the typical score from the mean (Hatcher, 2013).

The goal of phase 2 of the study was to use qualitative data to build upon the results of the quantitative data collected during phase 1. By collecting two types of data, it allowed for overlapping data collection that created a more complete picture and provided increased validity in the data (Lund, 2012; Greene et al., 1989). The data generated during phase 2 provided the researcher with the opportunity to better understand the results from the quantitative data analysis.

Phase 1 Quantitative Data

Vocabulary Development - Teacher Responses

The first five questions (Q1 - Q5) on the teachers' Likert scale survey (Appendix B) examined research question 1 about the teachers' perceptions of the impact digital games have on the vocabulary development of the students in high school science classes

(Table 1). These five questions focused on three areas of vocabulary development. First on teachers' perception of a student's ability to learn new science vocabulary using digital games (Q1, Q2, and Q3). Next if using digital games made learning new science vocabulary fun for students (Q4). Lastly, if the use of digital games motivated students to learn new vocabulary (Q5).

Table 1 Descriptive Statistics for Vocabulary Development by Question - Teachers

	N	Min	Max	Mean	Std. Deviation	Neutral (3)	Agree (4)	Strongly Agree (5)
Q1: Digital games helped my students learn new science vocabulary	19	3	5	3.95	.524	15.8%	73.7%	10.5%
Q2: Digital games made it easier for students to remember new science vocabulary.	19	3	5	3.95	.524	15.8%	73.7%	10.5%
Q3: Digital games allowed students to practice e new science vocabulary until the students better understand the vocabulary.	19	3	5	4.32	.582	5.3%	57.9%	36.8%
Q4: Digital games made learning new science vocabulary fun for my students.	19	4	5	4.53	.513	0%	47.4%	52.6%
Q5: Digital games motivated my students to learn new vocabulary.	19	3	5	4.05	.848	31.6%	31.6%	36.8%
Valid N (listwise)	19							

For all five questions about vocabulary development teachers perceived a positive impact on students' learning while using digital games. For Q1 and Q2, teachers agreed or strongly agreed that digital games helped and made it easier for their students to learn new vocabulary (84.2). 94.7% of teachers agreed or strongly agreed that digital games allowed their students to practice new vocabulary (Q3). All teachers agreed or strongly agreed that digital games made it fun for students to learn new science vocabulary (Q4 = 100%). While only 68.4% of teachers agreed or strongly agreed that digital games motivated their students to learn new science vocabulary (Q5).

Table 2 Reliability Statistics for Vocabulary Development - Teachers

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.788	.789	5

The data generated from the first five questions (Q1-Q5) was also analyzed using the Cronbach alpha coefficient to determine the reliability level since multiple-item scale were used to determine teachers' perceptions of the impact of digital games on students' vocabulary development. The Likert scale survey used in this study has an acceptable internal consistency with a Cronbach alpha coefficient reported of 0.788 (Table 2).

Vocabulary Development – Student Responses

The first five questions (Q1 - Q5) on the students' Likert scale survey (Appendix A) examined research question 1 about the students' perceptions of the impact digital games have on their vocabulary development in their science classes (Table 3). These five questions focused on three areas of vocabulary development using digital games. First, the questions focused on students' perception of learning new vocabulary using digital games (Q1, Q2, and Q3). Next, if digital games made learning science vocabulary fun for students (Q4). Lastly, did students believe using digital games made them more successful in science class (Q5).

Table 3 Descriptive Statistics for Vocabulary Development by Question - Students

	N	Min	Max	Mean	Std. Deviation	Neutral (3)	Agree (4)	Strongly Agree (5)
Q1: Digital games helped me learn new science vocabulary.	105	1	5	3.99	.995	9.5%	55.2%	28.6%
Q2: Digital games made it easier for me to remember and use new science vocabulary	105	1	5	4.09	.774	14.3%	55.2%	28.6%
Q3: Digital games allowed me to practice new science vocabulary until I better understood it.	105	1	5	4.01	.956	7.6%	50.5%	31.4%
Q4: Digital games made learning new science vocabulary fun.	105	1	5	4.19	1.057	13.3%	27.6%	51.4%
Q5: Using digital games to learn vocabulary has made me more successful on assignments and quizzes in science class.	105	1	5	4.10	.950	5.7%	51.4%	35.2%
Valid N (listwise)	105							

For all five questions about vocabulary development students perceived a positive impact on their learning while using digital games. For Q1 and Q2, students agreed or strongly agreed that digital games helped and made it easier for them to learn new vocabulary (83.8%). 83.9% of students agreed or strongly agreed that digital games allowed them to practice new vocabulary (Q3). Students agreed or strongly agreed that digital games helped make them more successful on their assignments in science class (Q5 = 86.6%). While 79% of students agreed or strongly agreed that digital games made learning new science vocabulary fun (Q4).

Table 4 Reliability Statistics for Vocabulary Development - Students

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.808	.818	5

The data generated from the first five questions (Q1-Q5) was also analyzed using the Cronbach alpha coefficient to determine the reliability level since multiple- item scales were used to determine students' perceptions of the impact of digital games on their vocabulary development in science class. The Likert scale survey used in this study has an acceptable internal consistency with a Cronbach alpha coefficient reported of 0.808 (Table 4).

<u>Activating Prior Knowledge – Teacher Responses</u>

The last five questions (Q6 - Q10) on the teachers' Likert scale survey (Appendix B) examined research question 2 about the teachers' perception of the impact digital games have on scaffolding learning by activating prior knowledge in high school science classes (Table 5). These five questions focused on three areas of teachers' perceptions for activating prior knowledge using digital games. First, did digital games help students remember and review information from previous science lessons (Q6 and Q8). Next, did the use of digital games make it easier for students to activate prior knowledge from previous lessons (Q7 and Q10). Lastly, did using digital games provide students with the opportunity to practice new information (Q9).

Table 5 Descriptive Statistics for Activating Prior Knowledge by Question - Teachers

	N	Min	Max	Mean	Std. Deviation	Neutral (3)	Agree (4)	Strongly Agree (5)
Q6: Digital games helped my students remember what they had learned in previous science lessons or classes.	19	3	5	4.21	.918	31.6%	15.8%	52.6%
Q7: Digital games made it easier for my students to use what they had learned in previous science lessons to help them learn new science information.	19	2	4	3.37	.684	42.1%	47.4%	0%
Q8: Digital games helped my students to review science information from previous science lessons or classes.	19	4	5	4.42	.507	0%	57.9%	42.1%
Q9: Digital games provided my students with the chance to practice the new information that they learned in science class.	19	3	5	4.37	.761	15.8%	31.6%	52.6%
Q10: Digital games made it easier for my students to use their knowledge from previous science classes in their current science class.	19	3	5	3.74	.733	42.1%	42.1%	15.8%
Valid N (listwise)	19							

In four of the five questions about activating prior knowledge, teachers perceived a positive impact on using digital games in science class. All teachers agreed or strongly agreed that digital games helped their students review what they learned in previous lesson (Q8). 84.2% of teachers agreed or strongly agreed that digital games allowed their students to practice new science information (Q9). 68.4% of teachers agreed or strongly agreed that digital games helped their students remember what they had learned in previous lessons (Q6). A little of half (57.9%) of teachers agreed or strongly agreed that digital games made it easier for their students to use their knowledge from previous lesson (Q10). Lastly, only 47.4% of teachers agreed that using digital games made it easier for students to use their prior knowledge to learn new science information (Q7).

Table 6 Reliability Statistics for Activating Prior Knowledge - Teachers

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.719	.724	5

The data generated from the last five questions (Q6 - Q10) was also analyzed using the Cronbach alpha coefficient to determine the reliability level since multiple-item scales were used to determine teachers' perceptions of the impact of digital games on scaffolding learning by activating prior knowledge. The Likert scale survey used in this study has an acceptable internal consistency with a Cronbach alpha coefficient reported of 0.719 (Table 6).

Activating Prior Knowledge – Student Responses

The next five questions (Q6 - Q10) on the students' Likert scale survey (Appendix A) examined research question 2 about the students' perception of how digital games impacted the use of prior knowledge and facilitated learning new science content (Table 7). These five questions focused on three areas about students' perceptions of activating prior knowledge using digital games. First, did digital games help students remember and review science information from previous lessons (Q6 and Q8). Next, did digital games make it easier for students to use what they had learned in previous science lessons (Q7 and Q10). Lastly, did digital games help students practice new science information (Q9).

Table 7 Descriptive Statistics for Activating Prior Knowledge by Question - Students

	N	Min	Max	Mean	Std. Deviation	Neutral (3)	Agree (4)	Strongly Agree (5)
Q6: Digital games helped me remember what I have learned in my previous science lessons or classes.	105	1	5	3.91	1.048	16.2%	37.1%	34.3%
Q7: Digital games made it easier to use what I have learned in my previous science lessons to help me learn new science information.	105	1	5	3.93	.824	14.3%	59.0%	21.0%
Q8: Digital games helped me to review science information from previous lessons or classes.	105	1	5	4.12	.906	12.4%	43.8%	38.1%
Q9: Digital games provided me the chance to practice the new information that I learned in science class.	105	1	5	4.18	.896	9.5%	43.8%	41.0%
Q10: Digital games made it easier to use my knowledge from previous science classes in my current science class.	105	1	5	3.90	.854	19.0%	53.3%	21.9%

Valid N (listwise)	105	

For all five questions about activating prior knowledge, students perceived a positive impact on their learning when using digital games in science class. Students agreed or strongly agreed that digital games helped and made it easier for them practice the new information they learned in science class (Q9 = 84.8% and Q8 = 81.9%). 80.0% of students agreed or strongly agreed that using digital games made it easier for them to use what they had learned in previous science class to learn new science information (Q7). Students agreed or strongly agreed that digital games helped them remember and use their previous science knowledge in their science classes (Q10 = 75.2% and Q6 = 71.4%)

Table 8 Reliability Statistics for Activating Prior Knowledge - Students

Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**N of Items**
.877	.889	5

The data generated from the second group of questions (Q5 - Q10) was also analyzed using the Cronbach alpha coefficient to determine the reliability level since multiple-item scales were used to determine students' perceptions of the impact of digital games on the use of prior knowledge and facilitate learning new content. The Likert scale survey used in this study has an acceptable internal consistency with a Cronbach alpha coefficient reported of 0.887 (Table 8).

<u>Self-efficacy – Student Responses</u>

The last five questions (Q11 - Q15) on the students' Likert scale survey (Appendix A) examined research question 3 about the students' perception of self-efficacy in the science classroom (Table 9). These five questions focused on three areas about students' self-efficacy and digital games. First, did the use of digital games increase student's confidence about learning basic concepts and doing a good job on assignments (Q11 and Q14). Next, did students believe that they could understand any science material and receive an excellent grade on an assignment since they were using digital games in science class (Q13 and Q15). Lastly, did using digital games make it easier for students to understand the most difficult material in science class (Q12).

Table 9 Descriptive Statistics for Self-Efficacy by Question - Students

	N	Min	Max	Mean	Std. Deviation	Neutral (3)	Agree (4)	Strongly Agree (5)
Q11: Using digital games during science class has increased my confidence that I can understand the basic concepts being taught in this class.	105	1	5	4.07	.983	13.3%	39.0%	39.0%
Q12: Using digital games during science class has made it easier for me to understand the most difficult material presented in this class.	105	1	5	3.93	.912	10.5%	55.2%	24.8%
Q13: Using digital games during science class has made it easier for me to believe that I can understand any topic taught in class if I try hard enough.	105	1	5	3.90	.929	14.3%	51.4%	24.8%
Q14: Using digital games during science class has helped me be confident that I can do a good job on the assignments and tests in this class.	105	1	5	3.95	.944	11.0%	50.0%	29.0%
Q15: Using digital games during science class has helped me believe that I can get an	105	1	5	3.85	1.026	21.0%	41.0%	28.6%

excellent grade in science class.								
Valid N (listwise)	105							

For all five questions about self-efficacy, digital games had a positive impact on students' levels of self-efficacy. 83.2% of students agreed or strongly agreed that digital games made it easier for them to understand difficult concepts presented in science class (Q12). Students agreed or strongly agreed that using digital games in science class made them confident in their ability to understand basic concepts and do a good job on assignments (Q11 = 78% and Q14 = 79%). 76.2% of students agreed or strongly agreed that using digital games made it easier for them to understand any science concept if they tried hard enough (Q13). Lastly, 69.9% of students agreed or strongly agreed that using digital games could help them earn an excellent grade in science class (Q15).

Table 10 Reliability Statistics for Self-Efficacy - Students

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.919	.919	5

The data generated from the last five questions (Q11 - Q15) was also analyzed using the Cronbach alpha coefficient to determine the reliability level since multiple-item scales were used to determine students' perceptions of the impact of digital games had on their self-efficacy in the science classroom. The Likert scale survey used in this study has an acceptable internal consistency with a Cronbach alpha coefficient reported of 0.919 (Table 10).

Phase 2 Qualitative Data

Vocabulary Development – Teacher Responses

Four major themes emerged from the analysis of the teachers' responses to the open-ended questions related to the perceived impact of digital games had on students' vocabulary knowledge in science class. The themes discovered during the qualitative data analysis were that teachers believed digital games are fun for students, increased student engagement, provided repetition, and increased students' motivation to learn (Table 11). All five teachers remarked upon how they believe that students had fun and enjoyed using digital games to help them learn new science vocabulary. One teacher remarked that "I think that students remember better when they are having fun, so a game brings out some of the concepts in a more memorable way." The qualitative data collected was supported by the quantitative data (Q4) collected in phase 1 with a mean of 4.53 reflected that most teachers agreed that digital games made learning fun for their students.

Table 11 Themes from Vocabulary Development Data Analysis - Teachers

Theme	Number of Teachers that Mentioned Theme	Corresponding Question in Likert Scale Survey
Fun	5	Q4
Student Engagement	5	-
Repetition	4	Q3
Student Motivation	3	Q5

It was mentioned by all five of the teachers that digital games created high levels of engagement for their students as they learned new vocabulary. It was explained by one teacher that "In this virtual world, ANY engagement helps tremendously!!! Games definitely draw them in more and keep them more awake. Especially competitive games." Another teacher remarked that using digital games helped the lower level students learn new vocabulary in the class, "I think that they definitely helped my lower level students who struggle with vocabulary because they are not just forced to read them. It lets them interact with the material and other people." When the students can interact with each other and learn new vocabulary it increases their level of engagement. As one teacher stated, "They always get excited when I say we are going to play a game." Digital games are making students excited to learn and when they are excited to learn they are engaged in the learning process.

Four of the teachers mentioned that digital games provided students with the ability to practice the new vocabulary multiple times. This repetition helped the students remember and learn new vocabulary associated with the science content. "Games allow students repeated exposure to the new terms and additional opportunities to practice using them." explained one of the teachers. The data collected from teachers in phase 2 was supported by the teacher responses from phase 1. Specifically, question 3 (mean = 4.32) indicated that most teachers agreed with the statement that digital games allowed students to practice the new science vocabulary until the students better understood.

Students can be motivated to learn when teachers are using digital games to help build students' vocabulary knowledge in the content area. Three of the teachers explained that they believed that digital games motivated students to learn because it was different from the traditional method of lecture and notes since "they definitely prefer it to me just lecturing and telling them about it." One teacher even stated that, "I think they (digital games) allow students to interact with the vocabulary in a different fun way. It lets them do more than just write or read the terms." Students can be motivated to learn when they have the chance to compete. One teacher explained it by saying, "The competition aspect of many games encourages students to learn the vocabulary so they can perform better and beat their classmates or their own high score." The qualitative data collected was supported by the quantitative data (Q5) collected in phase 1 with a mean of 4.05 reflected that teachers agreed that digital games motivated students to learn new science vocabulary. Digital games can provide teachers with the opportunity to motivate their students to learn new vocabulary whether it is because it is a new way to learn, a more interactive way to learn than traditional lecture, or just provides students with the chance to become better at the game.

Vocabulary Development – Student Responses

Five major themes emerged from the data analysis of the open-ended questions (Appendix D) that examined if digital games impacted the students' perception of their vocabulary development in their high school science class. The themes discovered in the qualitative data analysis were that digital games made learning vocabulary fun, created competition, created more options for learning the vocabulary, increased student engagement, and provided feedback (Table 12). All 12 of the students indicated that using digital games provided a fun and easy way to learn new science vocabulary. This reinforced the findings from the survey for Q4 (Appendix A) which had a mean of 4.19 that demonstrated that students agreed with the statement that digital games made learning new science vocabulary fun. One student explained by saying "using digital games is fun and helps with preparing for the test." Another student stated that "It made it more fun to learn the vocabulary, so in turn it made it easier for me to remember it." A student pointed out that" It was more fun because you weren't just listening to someone talk about the terms, you were playing them with yourself." Digital games provided students with a method for learning new vocabulary that they found interesting and enjoyable compared to just learning it by completing reading and writing activities since they "enjoyed studying using digital games rather than plain flashcards." The students' responses to the open-ended questions clearly showed that they had fun using digital games to learn new science vocabulary.

Table 12 Themes from Vocabulary Development Data Analysis - Students

Theme	**Number of Students that Mentioned Theme**	**Corresponding Question in Likert Scale Survey**
Fun	12	Q4
Competition	9	-
Options	9	Q3
Engagement	6	-
Feedback	5	-

Nine of the students brought up that using digital games created competitions with their classmates and allowed them to compete against themselves as well. When digital games are used as part of the lesson "a sense of competition is brought into the mix and as a high school student, I crave that friendly competition every now and then." One student explained that in this digital environment it provided an outlet for their competitive spirit, "I am very competitive so games where I get to compete against others made it more fun and challenging for me." The competition that digital games created provided students with the ability to connect virtually and "these games additionally offer competition between all the students which is extremely fun no matter the material that's being learned." For some students it was more than just competing against their peers, it was about being able to compete against themselves to increase their learning of the new vocabulary. "It was fun and interesting because I was competing against myself and other classmates so I really cared about memorizing them," described one student and another student explained " you can replay the games to try to get a higher score," on why using digital games helped them learn new science vocabulary. Digital games provided students with a method for learning new science vocabulary that appealed to their competitive nature.

Nine of the students mentioned in their responses that they appreciated how digital games provided them a variety of methods and multiple opportunities to learn science vocabulary. "It provides more hands on and personal experience, and it gives a lot of different options for what you can do," explained one student on how digital games helped them learn new vocabulary. Digital games helped students because it allowed them to see the vocabulary in different forms. After all, students could use matching games, multiple-choice activities, and live against other students. It was described by a student who said, "Games like Kahoot and Quizlet helped students through repetition of seeing the words paired with their definitions." and another student explained that digital games "help me because there interactive." By having the opportunity to use the digital games multiple times, it made it easier for students to learn science vocabulary because "seeing specific words and phrases over and over again really helps to sear needed class materials into the minds of students," explained one student. These students' responses reflected the quantitative data analysis of Q3 (Appendix A) which had a mean of 4.01 that indicated that students agreed with the statement that digital games allowed students to practice new science vocabulary until they better understand it. Students appreciated that digital games gave them the chance to learn new science vocabulary using a variety of methods and provided them with multiple opportunities to be successful with the vocabulary.

Six students indicated that digital games helped them be better engaged in the learning process. One student believed that "it's felt by many students that games are needed to bring us into what we are learning" and kept them involved during lessons. Since digital games were more engaging than just completing assignments one student felt "If you win or lose in a digital game it's more memorable than just writing the words down on a sheet of paper." Another student explained that "Digital games are more memorable to me so when I use the study vocab I usually remember them better." When students were involved with and enjoyed the learning process through the use of digital games it created more engagement in science classes which helped them learn the vocabulary.

Five of the students indicated that digital games provided them with feedback during the learning process and this made it easier for them to learn new science vocabulary. One student explained why the feedback was important to help them learn "If I got it wrong it showed me the correct answer so I could try to understand why that was correct." Unlike assignments that get turned in to the teacher and need to be graded, digital games gave students immediate feedback and let them know how successful they were with learning the vocabulary. "It helps when you get really into the game and you're bound and determined to win, so it helps you remember what you got right and wrong, "explained one of the students. The feedback digital games provided students gave them the information they needed to help them understand where they were at in the learning process and "feel rewarded and confident in your skills."

Although all 12 students indicated that they believed that digital games were fun and could help them learn new science vocabulary, three students made it clear that digital games were not always the best way for them to learn and be successful in science class. For one student using digital games was about memorization and didn't feel like it helped them understand the content since "Sometimes I memorized the questions on the digital games and when a test or quiz comes the questions are different and I find myself struggling to answer the questions." and another student stated "Digital games help with memory and review, not so much understanding the why and how." of what they were learning in class. Lastly, one student felt that digital games could only help them learn certain information since "Games might be fun, but they have their limitations on what they can cover in class." Even though each of these students enjoyed using digital games, it wasn't the best way for them to learn new science vocabulary.

Activating Prior Knowledge – Teacher Responses

Three major themes emerged from the data analysis of the open-ended questions (Appendix D) that examined if digital games impacted teachers' perceptions of scaffolding learning by activating prior knowledge in their science classes. The themes discovered during the qualitative data analysis of the teachers' responses were that digital games help scaffold learning, provide feedback for students and teachers, and helped build community (Table 13). All five of the teachers indicated that they believed that using digital games helped scaffold learning for their students. Teachers described how the digital games helped them introduce content, review content, and differentiate the content.

"You can use them to introduce a topic, engage at the beginning level, or pull it together in a review. Sometimes in the middle to break up or summarize some things just taught to help cement stuff in their brains."

Another teacher described how digital games helped differentiate learning for students, "It allows me to have lower kids interact with vocabulary by matching definitions while higher level students can do higher level activities." Teachers used digital games as part of their science curriculum to help scaffold learning at all stages of the learning process.

Table 13 Themes from Activating Prior Knowledge Data Analysis - Teachers

Theme	**Number of Teachers that Mentioned Theme**	**Corresponding Question in Likert Scale Survey**
Scaffolding	5	-
Feedback	4	-
Build Community	2	-

Four of the teachers described how digital games provided both the teachers and students with feedback on learning. One teacher explained how they used the results to make informed decisions while planning their lessons, "I will use the results of the game to determine what I need to review and reteach before a summative assessment." Another teacher described how the digital games provided immediate feedback for teachers because "They (digital games) can also highlight misconceptions that students may have." The prompt feedback gave the teacher the chance to address misconceptions immediately with students to help them understand the science content before moving on. More than just teachers benefited from the feedback that digital games provide, students were able to use the feedback to determine how well they understood what they were learning in science class. A teacher explained why feedback is essential to student learning, "I think games provide students with opportunities to feel successful with the content by answering questions correctly." Students need to assess their learning and digital games help students determine where they are at in the learning process. "When I use games for review in class, it gives students a better understanding of what they have learned and what they need to review before an assessment," stated one teacher. The use of digital games in science class provided teachers and students with valuable information about what has been learned in science class.

Two teachers believed that an additional benefit of using digital games in their science classrooms was that it helped them build community. One teacher explained that "I think the friendly competition involved in games has helped me build a classroom community despite the disconnect and relative isolation of each student due to virtual learning." With the majority of students being part of the virtual classroom and not in person it has made developing relationships much more difficult. "Not having the students in the classroom has made it much harder to build relationships that normally would help facilitate learning," explained one teacher about how it is essential to get to know your students so you can understand how they learn. "When you have strong relationships with your students it makes it easier for a teacher to differentiate and scaffold their learning," stated a teacher. In some cases, using digital games in science classrooms helped build a bridge between the students, the teacher, and the content.

Activating Prior Knowledge – Student Responses

Four major themes emerged from the data analysis of the open-ended questions (Appendix C) that examined if digital games impacted students' perceptions of the scaffolding of learning by activating prior knowledge in their science classes. The four themes that were identified were that digital games provided students the opportunity to practice, focused their learning, allowed students to access the content using multiple methods, and helped students make connections with the content (Table 14). Eight of the students mentioned how digital games gave them the chance to practice and review what they were learning in science class. Students found that when they used digital games they "practiced more" and "they're a fun way to study." Digital games "made me retain more info than I usually would" because of how digital games presented information. It was explained by a student that "it's better for reviewing things that have already been taught in class" and that it helped "through means of repetition." Students used digital games to "go back and over that material again" and "it mainly reinforced, elaborated or reviewed science information" since it could show students what they needed to improve on. The quantitative data analysis of Q8 with a mean of 4.12 and Q9 with a mean of 4.18 demonstrated that students agreed with statements that digital games helped them practice new information and review information from previous science classes and are reflective of their responses to the open-ended questions. Students found that digital games helped them practice and review what they were learning in the science class.

Table 14 Themes from Activating Prior Knowledge Data Analysis - Students

Theme	**Number of Students that Mentioned Theme**	**Corresponding Question in Likert Scale Survey**
Practice	8	Q8 and Q9
Focus	6	-
Increased Access	4	-
Connection	4	-

Six students indicated that using digital games helped them focus on important content in their science classes. It was explained by one student that "it did make it easier because they helped me focus more on the important things I needed to know versus everything that we have learned which is overwhelming." Digital games helped to take broad topics in science and helped narrow students focus since students "knew what material to focus on if I were to study for a test" and "not all of it (science content) needs to be completely understood" in depth at the high school science level. Another student found that it helped them focus because "it takes what we need to know and compacts it into a fun game." Students used digital games to help them organize and prioritize what they needed to learn for their science classes.

Four of the students discussed how digital games helped them learn new science content because it helped them access the content in multiple ways. "Seeing things in a different form makes it stick better in my mind,' explained one of the students. Using digital games "helped me review science information from previous lessons because it was much easier to access than anything that was on paper" stated one student. Since most digital games can be accessed using different types of technology, it made it an easy format for students to use. A student stated

> "I was able to access the digital games from anywhere so if I was on the go or traveling I could be studying on my phone in the car versus having to bring my binders and notebooks in the car to study."

Students were able to use the different types of technology and formats that digital games provided to help them expand their science knowledge.

Four students described how using digital games helped them make connections between what they already learned about the science content and new information being presented in class. Students found that "digital games bring a great new way of learning both new and old class information" and that "the old vocabulary links with new a lot, so you do need to know the old stuff to play with the new." Students found with the digital games that used multiple choice questions that it helped because "it gives you a starting point for previous material" and "it helps our brain narrow down between the 4 choices in Kahoot so it helps us remember those 4 choices and which one is right" Students saw digital games as method to help them remember what they had learned and built upon it with their new knowledge.

Additionally, two students mentioned that they did not believe that digital games helped them make the connections between previous science knowledge and what they were learning in the current science class. One student felt that digital games "mainly helped me on the week of the test and I didn't remember much after that" since it didn't help them commit the knowledge to their long term memory. Another student explained that "digital games use the exact same medium" and didn't prepare them for any other type of question format that could be potentially found on the assignment. Students found that these limitations made digital games less than ideal for learning new science content.

Self-efficacy – Student Responses

Three major themes emerged from the data analysis of the open-ended questions (Appendix C) that examined the impact of digital games on a student's perception of self-efficacy in the science classroom. The three themes that were identified were that digital games provided students with confidence about their science knowledge, engaged students in the science curriculum, and provided necessary feedback for students in the learning process (Table 15). Ten students responded that digital gave them confidence and helped support their morale as they were learning new science concepts. The quantitative data analysis results of Q11 (Appendix B) with a mean of 4.07 reflected these results since students agreed that using digital games in science class has increased their confidence that they can understand the basic concepts taught in their science class. Students explained that some of the digital games they played provided them with a score when they were finished with the game. Being able to "physically see a high score helped reaffirm that I know the concept" and "reinforced my self-confidence and I feel good about the test" which increased their level of confidence in their knowledge and skills. For some students using digital games in their science class did more than just improve their self-confidence, it improved their morale for the science class.

> "If you do well in games, not only does it increase your confidence, but it also increases your morale for the class in its entirety with the idea that "hey, maybe I'm not too bad at this" and there's an overall greater sense of self worth the better you do."

One student explained that digital games “have helped me strive to do better and have made me try harder.” Digital games gave students a method to control their success in science class and by controlling their success it increased their self-confidence in their knowledge and skills in the content area.

Table 15 Themes from Self-Efficacy Data Analysis - Students

Theme	**Number of Students that Mentioned Theme**	**Corresponding Question in Likert Scale Survey**
Confidence	10	Q11
Engagement	7	-
Feedback	6	-

Seven students indicated that their levels of engagement were increased by the use of digital games in science class. One of the reasons that digital games increased engagement was because of the competition that digital games provided students. If students wanted to be successful while playing digital games, it made it easier “because it keeps my attention to the class and forces me to remember, it's like a pop quiz” and “it has made me want to learn the stuff.” One student explained that digital games made them feel better prepared to be successful because “It’s great knowing that a little bit of friendly competition has bettered my education through means of repetition.” For another student digital games helped them set goals and accomplish them because “Anything with competition pushes me to strive to do the best that I can do.” When students had higher levels of engagement in science class, they became more involved in their learning which impacted their perceptions of their self-efficacy.

Six students explain that the feedback digital games provided them made it easier for them to understand what was being taught in science classes. Teachers use digital games to provide feedback to their students and to help them make adjustments to the curriculum. Students find that "The teacher is more likely to go over the difficult material if they see how everyone does on it." and this benefits every student because "most teachers will go over why something is the right answer." When a student can understand their mistakes it "helps me learn and grow from my mistakes" and then "you start to understand things you didn't before." The feedback students receive is valuable to help them access their science knowledge and skills, but it can be more than that for them. "It helped me understand if I put in the work, I can understand the most difficult things because I see a difference in how much I know the material after playing the games." explained one student. Digital games provided students with the opportunity to improve the science knowledge and skills since it supports their learning through the feedback given during the game.

Three students believed that using digital games in science class did not increase their perceptions of self-efficacy since it helped only with general science knowledge and not with the more difficult material presented in class. One student explained that digital games "only taught me how to learn what was being presented in them" and didn't expand their knowledge outside of what was in the game. For one student, digital games just helped them learn the facts, and "I tend to understand things better when I understand why things work and not all digital games do that." Digital games can help students improve their knowledge but not the depth that students need to be completely confident and successful in their science class.

Summary

When examining all the qualitative data, two major themes emerged throughout the research questions, feedback and engagement. Students found that the feedback that digital games provided was essential to helping them learn new science vocabulary and supported their self-efficacy in science classes. Digital games are capable of providing instant feedback in ways that teachers are unable to for students and this allowed students to learn from their mistakes (Oblinger, 2004). This assisted students in taking ownership of their learning and allowed them to practice and improve their science knowledge and skills (Sharma & Hannafin, 2007). Teachers found the feedback that digital games provided about their students' science knowledge was important because it helped them adjust and differentiate their lessons to meet the needs of their students. Teachers knew immediately what science topics their students had mastered and what information needed to be retaught to improve their students' success with the content area.

When digital games are being used as part of the science curriculum, students found their levels of engagement increased in science classes. Students benefited from being engaged in their learning in science class because it helped them learn science vocabulary. Teachers noticed the higher levels of engagement of students while using digital games and the benefits it provided students. The higher levels of engagement helped to create student ownership of learning (Sung & Hwang, 2013). Building students' confidence in their knowledge and skills in science was not observed by teachers in the data generated by the digital games. Students explained that when teachers used digital games in science class it improved their self-efficacy. This improvement in self-efficacy, students attributed to improving their learning and academic success in science (Berger et al., 2015).

CHAPTER V: DISCUSSIONS AND CONCLUSIONS

Before teachers integrate digital games into the science curriculum, they must understand the impact that digital games have on their students' acquisition of the necessary knowledge and skills in their science classes. Digital games have the potential to create a learning environment that contributes to the success of high school science students on multiple levels. For teachers to effectively use digital games in their classrooms, it needs to be understood how digital games can be used as an instructional strategy that helps them implement the best practices in their science classrooms.

The purpose of this study was to broaden the understanding of the perceived impact of digital games that used student response systems in secondary science classrooms in developing students' vocabulary knowledge, scaffolding learning by activating prior knowledge, and students' perception of self-efficacy. An explanatory sequential mixed methods design was chosen for this study because it provided the researcher with the ability to integrate quantitative data and qualitative data to answer the research questions. This combination of both types of methodologies can create a powerful understanding of the phenomenon being examined since it combines the assets of both research methods while reducing the potential deficiencies in using either of the methodologies on their own (Ivankova et al., 2006; Johnson & Onwuegbuzie, 2004). This increased the validity and reliability of the findings.

The first research question evaluated if digital games impacted students' and teachers' perceptions of vocabulary development in high school science classes. The study determined that teachers perceived that digital games positively impacted student vocabulary development because it was fun and engaging for students when they used it and its increased student motivation and engagement in the learning process. The findings also indicated that students perceived that digital games positively impacted their vocabulary development because using digital games were fun and engaging for students, created competition, and provided them with feedback about their learning. This supports previous research that demonstrated that digital games are successful as part of the classroom curriculum because it keeps students engaged and helps them remember what is being learned while playing the digital game (Tan et al., 2018; Nussbaum & Beserra, 2014). Although all the students enjoyed using digital games to help them improve their vocabulary knowledge some students believed it only helped them with memorization.

The data analysis of the Likert scale survey results indicated that teachers and students agreed that digital games impacted their students' level of vocabulary knowledge in science class. The data analysis of the open-ended questions survey revealed two major themes that were found in common between the teachers' responses and the students' responses. Both teachers and students considered that digital games made learning science vocabulary fun and increased the levels of student engagement in the content. Teachers knew that students enjoyed using digital games since "They always get excited when I say we are going to play a game" and it was fun and engaging for students "because we weren't just sitting down and copying notes, we were doing an activity." The use of digital games as an instructional strategy created a learning environment that provided a method for students to interact with the science vocabulary that was fun and engaging for students.

The second research question evaluated if digital games impact students' and teachers' perceptions of scaffolding learning by activating prior knowledge in high school science classes. Teachers agreed that digital games could be used to scaffold learning since it provided feedback to both teachers and students and helped teachers build community in their virtual classrooms. Students also agreed that digital games helped scaffold their learning by activating prior knowledge because it allowed them to practice with science content, helped them focus and make connections to the material, and provided them with multiple methods to access and interact with the content. Previous research demonstrated that digital games helped students scaffolding their learning since digital games built upon previous knowledge by creating a bridge between the new content and the old content (Toth et al., 2019: Iten & Petko, 2016) and used their previous knowledge to be successful within the game (Oblinger, 2004). Despite how digital games helped students scaffold their learning, some students found that using digital games didn't help them make connections because it only helped them temporarily.

The data analysis of the teachers' Likert scale survey indicated that teachers agreed that digital games could be used to scaffold learning by activating prior knowledge as part of their classroom instruction. The students' Likert scale survey results indicated that students agreed that digital games helped to scaffold their learning by helping them activate their prior knowledge in science class. The data analysis of the teachers' and students' responses to the open-ended questions survey indicated one common theme between both groups of participants. Teachers and students agreed that using digital games helped students make connections and scaffold learning by activating students' prior knowledge from previous science lessons. Teachers found that when digital games were used to introduce a topic it "provided students with opportunities to be successful with the content" and this gave students "feedback about what they already knew about the topic before we went in-depth with the new content." Students appreciated the use of digital games as a way to review information from a previous lesson since "it goes through a bunch of things and it helps with seeing things a lot to get familiar with them." Digital games created opportunities for students to make the necessary connections between science content areas that they had previously learned about and what they were learning currently in their science class.

The final research question evaluated the impact digital games could have on a student's self-efficacy in the science classroom. This research question was asked only of the students since it dealt with their perception of their levels of self-efficacy and it was not something that could have been accurately measured by teachers. Students agreed that digital games impacted their levels of self-efficacy in their science classes. Digital games improved their confidence, levels of engagement, and provided feedback to help them improve their science knowledge and skills. Previous research indicated that digital games can be used to help improve self-efficacy in academic settings since digital games give students control of their learning (Korucu & Alcan, 2011). For the students that did not agree that digital games impacted their levels of self-efficacy, they thought it only helped them understand the general concepts and did not help them understand the "why" of the science content and understanding the "why" was important to them.

The quantitative data indicated that students agreed that digital games impacted their levels of self-efficacy in science class. From the qualitative data, it was found that students felt that using digital games increased their confidence in the science material, provided essential feedback on their learning, and increased their engagement levels in their science classes. Students felt that digital games "gets them more familiar with things, so I feel more confident talking about them" which helped them stay engaged in their science classes. Digital games helped create a cycle of success for students which boosted their confidence and increased their self-efficacy and that in turn impacted student learning and academic performance.

Science teachers should be using digital games as an instructional strategy in their classrooms. This study has shown that digital games can have a perceived positive impact on students' vocabulary knowledge in science, be used to scaffold learning by activating prior knowledge, and can have a positive impact on students' perceptions of self-efficacy in science classrooms. The data analysis of both the quantitative and qualitative data collected should be considered to be more comprehensive since it demonstrated a convergence between both sets of data which increased the validity of the conclusions drawn in the study (Lund, 2012; Bryman, 2006). Teachers can use this research to make informed decisions about how to integrate digital games into their science curriculum. Digital games can be an instructional strategy that helps teachers provide students with a technological tool that can benefit their learning in multiple ways.

Limitations

Several limitations potentially occurred during the study. The first potential limitation could have been the number of participants. A request for participation was sent out to all high school science teachers in the school district. Participation in the study was voluntary so this could have created a smaller sample since the number of participants were based on teachers that indicated they used digital games as part of their curriculum and were willing to take part in the study. The lack of participants was out of the researcher's control. The next limitation was the amount of students that participated in the study. The amount of students that participated in the study was directly linked to the teachers' participation since teachers invited their students to take part in the survey.

When teachers were contacted about participating in the study, it was explained that the study was looking for individuals that used digital games such as Kahoot! or Quizlet as part of their classroom instruction. Teachers were not asked how often they used digital games only if they used digital games. This is another limitation within the study since the frequency of use was not documented and could have impacted the findings of the study.

Another limitation would be the actual digital games that were used by teachers. Digital games such as Kahoot and Quizlet are created by the users. Teachers could make their own digital games or use a pre-existing digital game found in the database of the game. Teachers in the school district can share games that they have created with each other, but the use of the shared games is entirely voluntary. None of the digital games are standardized which could create inequality among the games used by teachers and the experiences students had with the games.

There were additional unanticipated limitations in this study because of the time frame when data collection occurred. The limitation that could have had the greatest impact was that the participants had to adapt to teaching and learning in a virtual environment. Teachers had to streamline their science lessons, prioritize their content, and change how instruction was being delivered to students. Using digital games as part of their science curriculum may have not been a priority for teachers this school year. This change could have impacted the frequency that science teachers used digital games as part of their classroom instruction and reduced the potential number of participants for the study. A smaller sample size could have impacted the reliability of the data collected from the participants during phase 1 and phase 2 of the study.

Another limitation of the study could have accessibility to digital games for the students. During a typical school year when a teacher uses digital games as part of their curriculum, they can make sure that they have enough devices available in the classroom so all students could participate in the digital games. Since the majority of students (50-75%) were learning from home, they could have had internet connectivity and availability issues. The lack of accessibility could have prevented students from accessing the digital games which could have affected the impact that digital games have in their science classes.

Recommendation for Future Research

The data collected from this study demonstrated that using digital games could have an impact on students' and teachers' perceptions of vocabulary development, used to scaffold learning by activating prior knowledge, and on students' perceptions of self-efficacy in the science classroom. There are several areas of additional research that could clarify the results of the study. The first recommendation would be to investigate the type and quality of professional development that science teachers receive on using digital games as part of their curriculum. Not all science teachers have had the same professional development and it could influence how and if teachers choose to incorporate digital games as an instructional strategy. By researching the professional development teachers receive, it could explain the results from this study in greater detail and provide recommendations for future professional development in using digital games in the science classroom.

It could also be beneficial to determine what digital games were being used by teachers in their science classes since not all digital games have the same purpose. Teachers could be surveyed to discover which digital games they were using and if they had a preference for a specific digital game. By asking if teachers had a preference for specific digital games, it could be determined if there were any trends in which digital games were used and the frequency that they were used as part of the science curriculum. This avenue of research could explore if the use of specific digital games could impact teacher and student perceptions on using digital games in high school science classes.

Lastly, future research could be done on how teachers are using digital games in their science classrooms. Are teachers using digital games to introduce concepts, reinforce concepts, or providing them as a review before assessments? By understanding how teachers are using digital games it could provide a more thorough analysis of the data collected. Recommendations could be made to science teachers about which method of use of digital games had the greatest impact on student learning and academic achievement and how to integrate them into their curriculum.

REFERENCES

Abrams, S. S. & Walsh, S. (2014). Gamified vocabulary: Online resources and enriched language learning. *Journal of Adolescent & Adult Literacy, 58*(1), 49-58. https://doi.org/10.1002/jaal.315

Ahmad, A., & Safaria, T. (2013). Effects of self-efficacy on students' academic performance. *Journal of Educational, Health, and Community Psychology, 2*(1), 22-29. http://dx.doi.org/10.12928/jehcp.v2i1.3740

Alexander-Shea, A. (2011). Redefining vocabulary: The new learning strategy for social studies. *The Social Studies, 102*, 95-103. https://doi.org/10.1080/00377996.2010.509371

All, A., Castellar, E. P. N., & Van Looy, J. (2016). Assessing the effectiveness of digital game-based learning: Best practices. *Computers & Education, 92-93*, 90-103. https://doi.org/10.1016/j.compedu.2015.10.007

An, Y-J., Haynes, L., D'Alba, A., & Chumney, F. (2016). Using educational computer games in the classroom: Science teachers' experiences, attitudes, perceptions, concerns, and support needs. *Contemporary Issues in Technology & Teacher Education, 16*(4), 415-433.

An, Y., & Williams, K. (2010). Teaching with Web 2.0 technologies: Benefits, barriers, and lessons learned. *International Journal of Instructional Technology and Distance Education, 7*(3), 411-418.

Annetta, L., Vallett, D., Fusarelli, B., Lamb, R., Cheng, M., Holmes, S., Folta, E., … Thurmond, B. (2014). Investigating science interest in game-based learning project. *Journal of Computers in Mathematics and Science Teaching, 33*(4), 381-407.

Aurah, C. (2017). Investigating the relationship between science self-efficacy, beliefs, gender, and academic achievement, among high school students in Kenya. *Journal of Education and Practice, 8*(8), 146-153.

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control.* New York: Freeman. Barth, A. E., & Elleman, A. (2017). Evaluating the impact of a multi-strategy inference intervention for middle-grade struggling readers. *Language, Speech, and Hearing Services in Schools, 48*(1), 31-41. 10.1044/2016_LSHSS-16-0041

Barth, A. E., & Elleman, A. (2017). Evaluating the impact of multi-strategy inference intervention for middle-grade struggling readers. *Language, Speech, and Hearing Services in Schools, 48*(1), 31-41. 10.1044/2016_LSHSS-16-0041

Berger, B. W., Ketelhut, D. J., Liang, S., Natarajan, U., & Karakus, M. (2015). Scientific inquiry self-efficacy and computer games self-efficacy as predictors and outcomes of middle school boys' and girls' performance in a science assessment in a virtual environment. *Journal of Science Education and Technology, 24*(5), 696-708. 10.1007/s10956-015-9558-4

Billmeyer, R. & Barton, M. L. (2002). *Teaching reading in the content area: If not me, then who?* Aurora. CO: ASCD.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Britner, S. L. & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*(5), 485-449. https://doi.org/10.1002/tea.20131

Bryman, A. (2006). Integrating quantitative and qualitative research: How is it done? *Qualitative Research, 6*(1), 97-113. https://doi.org/10.1177/1468794106058877

Cagility, N. E. (2007). Teaching software engineering by means of computer-game development: Challenges and opportunities. *British Journal of Educational Technology, 38*(3), 405-415. 10.1111/j.1467-8535.2007.00705.x

Chen, C-H., Law, V., & Juang, K. (2019). The roles of engagement and competition on learner's performance and motivation in game-based science learning. *Educational Technology Research and Development, 67*(3), 1003-1024. 10.1007/s11423-019-09670-7

Clark, A. C., & Ernst, J. (2009). Gaming research for technology education. *Journal of STEM Education, 10*(1 & 2), 25-30.

Coyne, I. T. (1997). Sampling in qualitative research: Purposeful and theoretical sampling; merging or clear boundaries? *Journal of Advanced Nursing, 26*, 623-630. https://doi.org/10.1046/j.1365-2648.1997.t01-25-00999.x

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods Approaches.* Thousand Oaks, California: Sage Publications, Inc.

Creswell, J. W., & Plano Clark, V. L. (2007). *Designing and Conducting Mixed Methods Research.* Thousand Oaks, California: Sage Publications, Inc.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry & research design: Choosing among five approaches.* Thousand Oaks, California: Sage Publications, Inc.

de Freitas, S. (2006). *Learning in immersive worlds: a review of game-based learning.* Bristol: Joint Information Systems Committee.

Dellos, R. (2015). Kahoot! A digital game resource for learning. *International Journal of Instructional Technology and Distance Learning, 12*(4), 49-52.

Dizon, G. (2016). Quizlet in the EFL classroom: Enhancing academic vocabulary acquisition of Japanese university students. *Teaching English with Technology, 16*(2), 40-56.

Doyle, L., Brady, A., & Byrne, G. (2009). An overview of mixed methods research. *Journal of Research in Nursing, 14*(2), 175-185. https://doi.org/10.1177/1744987108093962

Ebrahimzadeh, M., & Alavi, S. (2017). Readers, players, watchers: Short and long-term vocabulary retention through digital video games. *International Journal of Applied Linguistics & English Literature, 6*(4), 52-62. http://dx.doi.org/10.7575/aiac.ijalel.v.6n.4p.52

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109-132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Echeverri, J. F., & Sadler, T. D. (2011). Gaming as a platform for the development of innovative problem-based learning opportunities. *Science Educator, 20*(1), 44-48.

Ferrell, K. (2007). May I go to the bathroom? *Science Scope, 31*(1), 31-37.

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.

Gillis, V., & MacDougall, G. (2007). Reading to learn science as an active process. *Science Teacher, 74*(5), 45-50.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Towards a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, *11*(3), 255-274. https://doi.org/10.3102/01623737011003255

Hamari, J., Sheroff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow, and immersion in game-based learning. *Computers in Human Behavior, 54*, 170-179. https://doi.org/10.1016/j.chb.2015.07.045

Hammond, J., & Gibbons, P. (2001) What is scaffolding? In J. Hammond (Eds.) *Scaffolding: Teaching and Learning in Language and Literacy Education* (pp. 8-16). New Wales, Australia: Primary English Teaching Association.

Harper, C. J. (2018). Vocabulary instructional strategies in a middle-level science classroom. *Reading Improvement, 55*(4), 127-134.

Hatcher, L. (2013). *Advanced statistics in research: Reading, understanding, and writing up data analysis results.* Saginaw, MI: Shadow Finch Media.

Hayes, E., & Ohrnberger, M. (2013). The gamer generation teaches school: The gaming practices and attitudes towards technology of pre-service teachers. *Journal of Technology and Teacher Education, 21*(2), 153-177.

Henderson, M., Selwyn, N., & Aston, R. (2015). What works and why? Student perceptions of 'useful' digital technology in university teaching and learning. *Studies in Higher Education, 42*(8), 1567-1579. https://doi.org/10.1080/03075079.2015.1007946

Hickey, D. T., Ingram-Goble, A. A., & Jameson, E. M. (2009). Designing assessments and assessing designs in virtual educational environments. *Journal of Science Education and Technology, 18*(2), 187-208.

Huang, Y-M., & Huang, Y-M. (2015). A scaffolding strategy to develop handheld sensor-based vocabulary games for improving students' learning motivation and performance. *Educational Technology Research and Development, 63*(5), 691-708. 10.1007/s11423-015-9382-9

Icard, S. B. (2014). Educational technology best practices. *International Journal of Instructional Design and Distance Learning, 11*(3), 37-41.

Iten, N., & Petko, D. (2016). Learning with serious games: Is it fun playing the game predictor of learning success?. *British Journal of Educational Technology, 47*(1), 151-163. 10.1111/bjet.12226

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed-methods sequential explanatory design: From theory to practice. *Field Methods, 18*(1), 3-20. https://doi.org/10.1177/1525822X05282260

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26. https://doi.org/10.3102/0013189X033007014

Ke, F. (2016). Designing and integrating purposeful learning into gameplay: A systematic review. *Educational Technology Research and Development, 64*(2), 219-244.

Ketelhut, D. J. (2007) The impact of student self-efficacy on scientific inquiry skills: An exploratory investigation in River City, a multi-user virtual environment. *Journal of Science Education and Technology, 16*(1), 99-111.

Korbey, H. (2014, June 10). *Surprising insights: How teachers use games in the classroom.* https://ww2.kqed.org/mindshift/2014/06/09/surprising-insights-how-teachers-use-games-in-the-classroom/

Korucu, A. T., & Alkan, A. (2011). Differences between m-learning (mobile learning) and e-Learning, basic terminology and usage of m-Learning in education. *Procedia-Social and Behavioral Sciences, 15*, 1925-1930. ttps://doi.org/10.1016/j.sbspro.2011.04.029

Kostons, D., & van der Werf, G. (2015). The effects of activating prior topic and metacognitive knowledge on text comprehension scores. *British Journal of Educational Psychology, 85*, 264-275. 10.1111/bjep.12069

Kroeger, S. D., Burton, C., & Preston, C. (2009). Integrating evidence-based practices in middle science reading. *Teaching Exceptional Children, 41*(3), 6-15. DOI: 10.1177/004005990904100301

Lander, B. (2016). Quizlet: What students think - a qualitative data analysis. *EURO CALL, 12*(3), 254-259.

Lee, Y.-H. (2015). Does digital game interactivity always promote self-efficacy? *Cyberpsychology, Behavior, and Social Networking, 18*(1), 669-673. DOI: 10.1089/cyber.2015.0165

Licorish, S. A., George, J. L., Owen, H. E., & Daniel, B. (2017). “Go Kahoot!” Enriching classroom engagement, motivation, and learning experience with games. Chen, W. et al (Eds). Proceedings of the 25th International conference on Computers in Education. New Zealand: Asia-Pacific Society for Computers in Education.

Liu, M., Rosenblum, J. A., Horton, L., & Kang, J. (2014). Designing science learning with game-based approaches. *Computers in the Schools, 31*(1-2), 84-102. https://doi.org/10.1080/07380569.2014.879776

Luckin, R. (2008). The learner centric ecology of resources: a framework for using Technology to scaffold learning. *Computers & Education*, *50*, 449-462. https://doi.org/10.1016/j.compedu.2007.09.018

Lund, T. (2012). Combining qualitative and quantitative approaches: Some arguments for mixed methods research. *Scandinavian Journal of Educational Research, 56*(2), 155-165. https://doi.org/10.1080/00313831.2011.568674

Mayo, M. J. (2007). Games for science and engineering education. *Communication of the ACM, 50*(70), 30-35. 10.1145/1272516.1272536

Meluso, A., Zheng, M., Spires, H. A., & Lester, J. (2012). Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. *Computers & Education*, *59*, 487-504. 10.1016/j.compedu.2011.12.019

Mikropolous, T. A., & Natsis, A. (2011). Educational virtual environment: A ten-year review of empirical research. *Computers & Education*, *56*(3), 769-780. https://doi.org/10.1016/j.compedu.2010.10.020

National Institute for Literacy. (2007). What content-area teachers should know about adolescent literacy. http://www.nifl.gov.

Nussbaum, M., & Beserra, V. d. S. (2014, July). Educational video game design. Paper presented at IEEE 14th International Conference on Advanced Learning Technologies, Greece.

Oblinger, D. (2004). The next generation of educational engagement. *Journal of Interactive Media in Education, 8*, 1-18. http://doi.org/10.5334/2004-8-oblinger

Pajares, F. (2002). Gender and perceived self-efficacy in self-regulated learning. *Theory into Practice, 41*(2), 116-125. https://doi.org/10.1207/s15430421tip4102_8

Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment*, *1*(1), 21-21. https://doi.org/10.1145/950566.950596

Prieto, M. C., Palma, L. O., Tobias, P. J. B., & Leon, F. J. M. (2019). Student assessment of the use of Kahoot in the learning process of science and mathematics. *Education Sciences, 55*(9), 1-13. doi:10.3390/edusci9010055.

Radcliffe, R., Caverly, D., Hand, J., & Franke, D. (2008). Improving reading in a middle school science classroom. *Journal of Adolescent & Adult Literacy, 51*(5), 398-408. DOI: 10.1598/JAAL.51.5.3

Rahimi, E., van den Berg, J., & Veen, W. (2015). Facilitating student-driven construction of learning environments using Web 2.0 personal learning environments. *Computers & Education, 81*, 235-246. https://doi.org/10.1016/j.compedu.2014.10.012

Rasinski, T., Padak, N., & Newton, J. (2017). The roots of comprehension. *Educational Leadership, 74*(5), 41-45.

Ray, B. & Coulter, G. A. (2010). Perceptions of value of digital mini-games: Implications for middle school classrooms. *Journal of Research on Technology in Education, 26*(3), 92-100.

Ruel, E., Wagner, W. E., & Gillespie, B. J. (2016). *The practice of survey research: Theory and application.* Thousand Oaks, CA: Sage Publications, Inc.

Sanosi, A. B. (2018). The effect of Quizlet on vocabulary acquisition. *Asian Journal of Education and e-Learning, 6*(4), 71-77.

Sardone, N. B., & Devlin-Scherer, R. (2010). Teacher candidate responses to digital games: 21st century skills development. *Journal of Research on Technology in Education, 43*(4), 409-425. https://doi.org/10.1080/15391523.2010.10782558

Saye, J. W., & Brush, T. (2002). Scaffolding critical reasoning about history and social issues in multimedia-supported learning environments. *Educational Technology Research and Development, 50*(3), 77-96.

Setiawan, M. R., & Wiedarti, P. (2020). The effectiveness of Quizlet application towards students' motivation to learn vocabulary. *Studies in English Language and Education, 7*(1), 83-95. 10.24815/siele.v7i1.15359

Sharma, P., & Hannafin, M. J. (2007). Scaffolding in technology-enhanced learning environments. *Interactive Learning Environments, 15*(1), 27-46. https://doi.org/10.1080/10494820600996972

Siew, P. H. (2018). Pedagogical change in mathematics learning: Harnessing the power of digital game-based learning. *Educational Technology & Society, 21*(4), 259-276.

Singletary, J. (2010). Idea bank. *Science Teacher, 77*(1), 56-58.

Spires, H. A., & Donley, J. (1998). Prior knowledge activation: Inducing engagement with informational texts. *Journal of Educational Psychology, 90*(2), 249-260. https://doi.org/10.1037/0022-0663.90.2.249

Stieler-Hunt, C., & Jones, C. M. (2015). Educators who believe: Understanding the enthusiasm of teachers who use digital games in the classroom. *Research in Learning Technology, 23*(1), 1-14. 10.3402/rlt.v23.26155

Subedi, D. (2016). Explanatory sequential mixed methods design as the third research community of knowledge claim. *American Journal of Educational Research, 4*(7), 570-577. 10.12691/education-4-7-10

Sung, H., & Hwang, G. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & Education, 43,* 43-51. https://doi.org/10.1016/j.compedu.2012.11.019

Swiderski, S. M. (2011). Transforming principles into practice: Using cognitive active learning strategies in the high school classroom. *The Clearing House: A Journal of Educational Strategies, Issues, and Ideas, 84*(6), 239-243. https://doi.org/10.1080/00098655.2011.590549

Tan, D., Ganapathy, M., & Kaur, M. (2018). Kahoot! It: Gamification in higher education. *Pertankia Journal of Social Science and Humanities, 26*(1), 565-582.

Thomas, G., Anderson, D., & Nashon, S. (2008). Development of an instrument designed to investigate elements of science students' metacognition, self-efficacy and learning processes: The SEMLI-S. *International Journal of Science Education, 30*(13), 1701-1724. DOI: 10.1080/09500690701482493

Toth, A., Logo, P., & Logo, E. (2019). The effect of the Kahoot quiz on the student's results in the exam. *Periodica Polytechnica Social and Management Sciences, 27*(2), 1-7. https://doi.org/10.3311/PPso.12464

Tucker, S. Y. (2014). Transforming pedagogies: Integrating 21st century skills and Web 2.0 technology. *Turkish Online Journal of Distance Education, 15*(1), 166-173. 10.17718/tojde.32300

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* M. Cole et al. (Eds). Cambridge, MA: Harvard University Press.

Wang, A. I., & Lieberoth, A. (2016). The effect of points and audio concentration, engagement, enjoyment, learning, motivation, and classroom dynamics using Kahoot!. *Reading: Academic Conferences International Limited* (Oct 2016), 738-746

Watson, W. R., Mong, C. J., & Harris, C. A. (2011). A case study of the in-class use of a video game for teaching high school history. *Computers & Education, 56*(2), 466-474. https://doi.org/10.1016/j.compedu.2010.09.007

Willingham, D., & Price, D. (2009). Theory to practice vocabulary instruction in community college developmental education reading classes: What research tells us. *Journal of College Reading and Learning, 40*(1), 91-106. 10.1080/10790195.2009.10850326

Wolff, G. (2016). Quizlet Live: The classroom game now taking the world by storm. *The Language Teacher, 40*(6), 25-27.

Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology, 105*(2), 249-265. https://doi.org/10.1037/a0031311

Yip, F. W. M., & Kwan, A. C. M. (2006). Online vocabulary games as a tool for teaching and learning English vocabulary. *Educational Media International, 43*(3), 233-249. https://doi.org/10.1080/09523980600641445

Young, E. (2005). The language of science, the language of students: Bridging the gap with engaged learning vocabulary strategies. *Science Activities, 42*(2), 12-17. https://doi.org/10.3200/SATS.42.2.12-17

Zimmerman, B. J., Bandura, A., & Poon, M. (1992). Self-motivation for academic attainment: The role of self-efficacy belief and personal goal setting. *American Educational Research Journal, 29*, 663-676. https://doi.org/10.3102/00028312029003663

APPENDIX A

Student Survey - Phase 1 Qualitative Data

Impact of Digital Games in Science Classrooms

The questions in the survey will be answered using a 5-point Likert-type response scale (strongly agree to strongly disagree).

Vocabulary Knowledge:

1. I believe that digital games helped me learn new science vocabulary.

2. I think that digital games made it easier for me to remember and use new science vocabulary.

3. I believe that digital games allowed me to practice new science vocabulary until I better understood it.

4. I think that digital games made learning new science vocabulary fun.

5. I believe that using digital games to learn vocabulary has made me more successful on assignments and quizzes in science class.

Activating Prior Knowledge:

1. I believe that digital games helped me remember what I have learned in my previous science lessons or classes.

2. I think that digital games made it easier to use what I have learned in my previous science lessons to help me learn new science information.

3. I believe that digital games helped me to review science information from previous lessons or classes.

4. I think that digital games provided me the chance to practice the new information that I learned in science class.

5. I think that digital games made it easier to use my knowledge from previous science classes in my current science class.

Students' Self-Efficacy:

1. Using digital games during science class has increased my confidence that I can understand the basic concepts taught in this class.

2. Using digital games during science class has made it easier for me to understand the most difficult material presented in this class.

3. Using digital games during science class has made it easier for me to believe that I can understand any topic taught in class if I try hard enough.

4. Using digital games during science class has helped me be confident that I can do a good job on the assignments and tests in this science class.

5. Using digital games during science class has helped me believe that I can get an excellent grade in science class.

APPENDIX B

Teacher Survey - Phase 1 Quantitative Data

Impact of Digital Games In Science Classrooms

The questions in the survey will be answered using a 5-point Likert-type response scale (strongly agree to strongly disagree).

Vocabulary Knowledge:

1. I believe that digital games helped my students learn new student vocabulary.
2. I think that digital games made it easier for students to remember new science vocabulary.
3. I believe that digital games allowed students to practice new science vocabulary until the students better understand the vocabulary.
4. I think that digital games made learning new science vocabulary fun for my students.
5. I think that digital games motivate my students to learn new science vocabulary.

Activating Prior Knowledge:

1. I believe that digital games helped my students remember what they had learned in previous science lessons or classes.
2. I think that digital games made it easier for my students to use what they had learned in previous science lessons to help them learn new science information.
3. I believe that digital games helped my students to review science information from previous lessons or classes.
4. I think that digital games provided my students with the chance to practice the new information that they learned in science class.
5. I think that digital games made it easier for my students to use their knowledge from previous science classes in their current science class.

APPENDIX C

Open-Ended Student Questions - Phase 2 Qualitative Data

Impact of Digital Games in High School Science Classrooms

The questions listed below are potential questions to be asked during the qualitative phase 2 of the research.

Vocabulary Knowledge:

1. How did digital games help you learn new science vocabulary?

2. Why do you think digital games made it easier to remember new science vocabulary?

3. How did you use digital games to help you practice new science vocabulary?

4. Do you think being able to practice new science vocabulary using digital games made you better understand the vocabulary you learned? Why or why not?

5. Why did playing digital games make learning new science vocabulary fun?

6. Are there any other ways that digital games helped you learn science vocabulary? Please explain.

7. What would you want teachers to know about how digital games impacted helped you with science vocabulary?

Activating Prior Knowledge:

8. How did digital games help you remember what you learned in your previous science lessons or classes?

9. Did digital games make it easier for you to learn new science information? Why or why not?

10. Do you think digital games helped you review science information from previous lessons or classes? Why or why not?

11. How do you think playing digital games in science class helped you practice the new information that you learned in science class?

12. Are there any other ways that digital games helped you understand what you were learning in science class? Please explain.

Students' Self-Efficacy:

13. How has using digital games increased your confidence that you understand the basic concepts being taught in science class?

14. Why has using digital games in science class made it easier for you to learn the most difficult material presented in this class?

15. Has using digital games during science class made it easier for you to believe that you can understand any topic taught in class if I try hard enough? Explain your answer.

16. Have digital games helped you set goals and accomplish them in science class? Explain your answer.

17. Do you think that digital games have made you feel better prepared to be successful in science class?

APPENDIX D

Open- Ended Teacher Questions – Phase 2 Qualitative Data

Impact of Digital Games in High School Science Classrooms

The questions listed below are potential questions to be asked during the qualitative phase 2 of the research.

Vocabulary Knowledge:

1. How do you think digital games helped students learn or practice new science vocabulary?

2. Why do you think digital games made it easier for students to remember new science vocabulary?

3. What benefits do you see as a teacher for using digital games to learn new science vocabulary?

4. Do you think the students enjoyed using digital games to learn science vocabulary? Why or why not?

5. Were there any unexpected problems or benefits to using digital games to help students learn new vocabulary?

6. What would you want other science teachers to know about using digital games as part of their instruction?

Activating Prior Knowledge:

7. How did you use digital games as part of your classroom instruction?

8. Do you think that digital games help your students remember what they learned in their previous science lessons or classes?

9. Did digital games help you scaffold student learning? Why or why not?

10. Are there any other ways that digital games helped your students understand what they were learning in science class? Please explain.