THE EFFECTS OF DIGITAL STORYTELLING ON ASTRONOMY MISCONCEPTIONS
HELD BY FOURTH GRADE STUDENTS

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Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

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ABSTRACT

For students to be successful in the Knowledge Age, they need a deep understanding of subject area content. When students develop misconceptions of science concepts, it limits their ability to progress in this area. Misconceptions are very resistant to change and interfere with student mastery of accepted science theory (Stamp & O'Brien, 2005; Wendt & Rockinson-Szapkiw, 2014). The purpose of this study was to examine the effectiveness of student-produced digital stories in reducing the number of misconceptions held by students. This quasi-experimental study involved 118 fourth grade students in a small elementary school in the southeastern United States. The MOSART Astronomy and Space Science Concepts Inventory (ASSCI), a multiple-choice test employing common student misconceptions as distractors, was used as both the pretest and posttest to measure changes in student understanding. The resulting data was analyzed using ANCOVA with the pretest scores from the ASSCI serving as the covariate. The analysis of the data found a statistically significant difference in the scores of students who produced digital stories when compared to students who produced digital informational writing, the type of writing traditionally used in science classrooms. The results of this study supported the used of digital storytelling in science classrooms to help reduce student misconceptions of science concepts. One recommendation for future studies would be to examine the effectiveness of digital storytelling on specific subgroups. Another recommendation would be to examine the effectiveness of digital storytelling after teachers had received additional professional development on the use of digital storytelling as a pedagogical tool that integrates technology and content acquisition.

Keywords: astronomy, digital storytelling, digital narratives, elementary science

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List of Abbreviations

American Association for the Advancement of Science (AAAS)

American Association of School Librarians (AASL)

Common Core State Standards (CCSS)

Council of Chief State School Officers (CCSSO)

English Language Arts (ELA)

Georgia Department of Education (GaDOE)

Georgia Standards of Excellence (GSE)

International Society for Technology in Education (ISTE)

MOSART Astronomy and Space Science Concepts Inventory (ASSCI)

National Governors Association Center for Best Practices (NGA)

National Science Foundation (NSF)

Organization for Economic Cooperation and Development (OECD)

Partnership for 21st Century Learning (P21)

President's Council of Advisors on Science and Technology (PCAST)

Science, Technology, Engineering, and Mathematics (STEM)

Technological Pedagogical Content Knowledge (TPCK)

Write to Learn (WTL)

CHAPTER ONE: INTRODUCTION

Overview

Chapter One provides a summary of the proposed study. It gives a brief rationale for why the study was needed, the theoretical underpinning of the study, and a short explanation of how the study was conducted.

Background

In 1991, expenditures for information and communication products exceeded those for industrial products, marking the United States' transition into the Knowledge Age (Trilling & Fadel, 2009). Two schools of thought define this age; one school, seemingly supported by United States' expenditures, describes a society where knowledge is a tool or product that brings about economic growth while the other school of thought is that knowledge is freely shared and developed within a democratic society (Biesta, 2014). Discussions of how this Knowledge Age will evolve continue but several characteristics have emerged. Successful citizens in this Knowledge Age society will be lifelong learners who can adapt and change as new technologies develop. These citizens will not only possess knowledge but also the ability to use knowledge innovatively and collaboratively to address global issues (Biesta, 2014; Griffin, McGaw, & Care, 2012). The changes in ways through which society communicates and share information also brought changes in instructional practices in classroom settings (Niemi et al., 2014). Among these changes, digital storytelling has been proposed as an effective way to teach knowledge and skills students will need in this new age (Czarnecki, 2009; Niemi et al., 2014)

To facilitate society's movement into the Knowledge Age, a coalition of business, governmental, educational, and community leaders formed the Partnership for 21st Century Skills

(P21). The coalition worked to identify and promote knowledge and skills students would need in order to be successful in this new age (Partnership for 21st Century Skills [P21], n.d.). Although the majority of knowledge and skills identified by the coalition were not new, their importance was. No longer were these knowledge and skills just for advanced students, as in the Industrial Age, now all students would need these skills in order to be successful in the 21st century (Claymier, 2014; Kivunja, 2014).

P21 organized identified knowledge and skills into the Framework for 21st Century Learning which influenced development of numerous educational initiatives including Common Core State Standards Initiative (Beriswill, Bracey, Sherman-Morris, Huang, & Lee, 2016; P21, 2011). The Framework for 21st Century Learning consists of four domains which should be integrated across the curriculum and instruction. The first domain calls for mastery of content knowledge in key content areas such as reading and writing, foreign language, mathematics, science, geography, history, and government. The second domain consists of learning and innovation skills which includes creativity, innovation, critical thinking and problem-solving, and communication and collaborative skills. The third domain contains information, media, and technology skills which allow students to create, evaluate and utilize information, media, and technology. The fourth domain involves life and career skills which includes the social and emotional competencies necessary to succeed in a constantly changing world (P21, 2015). This study examined the effectiveness of student-produced digital storytelling, a WriteTo Learn (WTL) instructional strategy that integrates these four domains, in decreasing the number of misconceptions of astronomy concepts held by fourth grade students.

Not only does transition into the Knowledge Age require changes in what students are taught, it also calls for changes in how students are taught. Researchers and scholars have started

focusing on how technology is used to improve teaching and learning instead of the technology itself (Aslan & Reigeluth, 2013; Hechter, Phyfe, & Vermette, 2012; Jimoyiannis, Tsiotakis, Roussinos, & Siorenta, 2013; Maddin, 2012).

The Technology Pedagogical Content Knowledge (TPCK) framework, proposed by Mishra and Koehler (2006), addresses this need for a change in focus and provided a theoretical underpinning for the current study. The TPCK framework examines the interrelationship between technological knowledge, pedagogical knowledge, and subject area content knowledge as opposed to each entity existing as a separate body.

One component of the TPCK framework is teachers' pedagogical knowledge. Many current pedagogical practices recommended for better teaching and learning are in line with constructivist learning theory (Arce, Bodner, & Hutchinson, 2014). This theory encompasses two main views. The first is that learning is an active process that requires the learner to construct knowledge as opposed to acquiring knowledge. The second is that instruction should support the construction of knowledge instead of the transmission of knowledge (Cunningham & Duffy, 1996). Writing strategies integrated into the instructional process become a unique form of learning that facilitates the construction of knowledge (Atasoy, 2013; Tomas & Ritchie, 2015; Waters, 2014). Writing is an active process, requiring the evaluation and revision of meanings; organizing and sequencing of ideas; and identification of relationships between diverse strands of thought, leading to better recall and increased understanding (Atasoy, 2013; Czarnecki, 2009; Sanchez & Lewis, 2014; Waters, 2014). Incorporating writing activities specifically to promote student understanding of content material is considered as a Writing to Learn (WTL) strategy (Sampson, Enderle, Grooms, & Witte, 2013). This study incorporated two WTL strategies, explanatory writing and narrative writing. Explanatory writing uses facts and supporting details

to expound on a topic (Culham, 2016). Explanatory writing acted as the control for the study. Narrative writing uses characters involved in events presented in a logical order to tell a story (Culham, 2016; Kulla-Abbott & Polman, 2008). Narrative writing served as the independent variable in this study.

The technology component of TPCK addresses the need for technology skills while maintaining effective pedagogical strategies. Educational organizations such as The International Society for Technology in Education (ISTE) and CCSS Initiative support this integration of technology and pedagogical strategy. The ISTE standards, updated summer of 2016, still acknowledge that students need to know how to use technology tools, but the focus of the standards has changed to how students use technology tools to support learner-driven attainment of deeper content knowledge (International Society for Technology in Education [ISTE], 2016). CCSS focus on the learner-driven task, such as writing, but stress the integration of technology tools (Ray, Graham, Houston, & Harris, 2016). Although CCSS emphasize writing integrated with technology, a survey of middle school teachers across the United States found these strategies were the ones least used (Ray et al., 2016). Digital storytelling can address this concern because it integrates effective pedagogical strategies and technology skills. In digital storytelling, focus is on the writing process, not the technology tools. The story should be able to stand independent of the technology but the technology would be meaningless without the story (Luke, Tracy, & Bricker, 2015). Digital storytelling has numerous synonyms, including computer-based narratives, digital documentaries, digital essays, digital narrative, electronic memoirs, and interactive storytelling (Robin, 2014). However, for the purpose of this study, the terms digital storytelling and digital narratives were used. Digital storytelling was defined as a

short 2-10 minute story incorporating some mixture of still images, video clips, text, recorded audio narration, and/or music (Robin, 2014).

The third component of TPCK involves content knowledge. It is not only important that teachers have a deep understanding of the content, they must also know how to develop knowledge in their students (Koehler, Mishra, & Cain, 2013). For example, research in science education shows that children come into science classrooms with theories they have developed through their interaction and observation of the world around them. Theories that differ from theories accepted by the scientific community are known as misconceptions. Effective science teachers must have deep understanding of the science content students need to acquire but also know to challenge student misconceptions so that they can be reduced or eliminated. Without this reduction of misconceptions, students cannot master new concepts (Stamp & O'Brien, 2005; Wendt & Rockinson-Szapkiw, 2014). Table 1 lists the fourth grade astronomy concepts and their common misconceptions found in the state of Georgia's science curriculum. However, identification of students' misconceptions can be a time-consuming process involving individual interviews or lengthy, open-ended question assessments. Need for an easier, more efficient method for determining these misconceptions was needed. The MOSART Astronomy and Space Science Concept Inventory (ASSCI) was developed to help teachers identify student misconceptions and to evaluate the effectiveness of interventions designed to help change these misconceptions. This inventory uses a multiple choice format and includes misconceptions identified in science education research literature as the distractors (Sadler et al., 2009). These misconceptions appear to be quite similar across different cultures and over long periods of time so students with misconceptions will choose the distractor comparable to their own belief.

Table 1

Astronomy Concepts and Common Misconceptions

Concepts	Common Misconceptions
1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun.	1. Our solar system is an Earth-centered solar system in which the sun and planets revolve around Earth.
2. Day and night occur because the Earth rotates on its axis. Half of Earth, which faces the sun, has day; at the same time, the other half of the Earth has night. As the Earth rotates, the locations of Earth having day and night change.	2. The sun moves around the Earth, i.e. it rises in the East and sets in the West, to form day and night.
3. The change of seasons is caused by the tilt of the Earth and its position in relation to the sun as the Earth orbits the sun in almost perfect circles. For example, when the northern half of the Earth tilts toward the sun, summer occurs in the northern hemisphere and winter occurs in the southern hemisphere.	3. The change of seasons occurs because the Earth revolves around the sun in an elliptical (oval-shaped) orbit. When Earth nears the sun, summer occurs; and when the Earth is farthest from the sun, winter occurs.
4. Planets and stars are different in their appearance and motion.	4. Planets and stars are alike.
5. Stars vary according to size and color.	5. All stars are alike.
6. The sun is a medium-sized star, but it appears larger than other stars because it is so close to Earth.	6. The sun is the largest star in the sky.
7. Changes in the locations of constellations during the night are due to the rotation of Earth on its axis.	7. Constellations move across the sky at night.
8. Earth's moon reflects the light of the sun.	8. Earth's moon produces its own light.
9. Different phases of the moon are observed because of the relative positions of the moon to the Earth.	9. Lunar phases are caused by Earth's shadow being cast on the moon.
10. Different stars can be seen during different seasons.	10. The same stars can be seen during the entire year.
11. There is just one star in our solar system, i.e. the sun.	11. There are thousands of stars in our solar system

From "The Stars and Our Solar System by Georgia Department of Education (GaDOE), 2007 (https://www.georgiastandards.org/Frameworks/GSO%20Frameworks/4%20Science%20Framework%20The%20Stars%20and%20Our%20Solar%20System.pdf). Copyright 2007 by GaDOE. Reprinted with permission.

Just as the Knowledge Age is leading to changes in what students are taught and how they are taught, it is also leading to changes in how students are assessed. Analysis of standardized state assessments considered to be rigorous found less than ten percent of questions required higher order thinking skills; the vast majority of questions only required factual recall and basic application (Herman & Linn, 2014). However, newly developed assessments are moving away from multiple choice tests that measure recall to multistep, multicomponent tests embedded with technology tools such as word processors, audio and visual information, and simulated search engines (Educational Testing Service, 2016). These assessments are aligned with college and career readiness standards which require conceptual understanding of content; ability to communicate effectively; and capable use technology and media (McLaughlin & Overturf, 2012). Teachers align instruction to ensure students are successful on high-stakes assessments (Griffin et al., 2012; Herman & Linn, 2014; A. Schoenfeld & Törner, 2014) so instructional strategies that can increase conceptual understanding as well as improve communication skills are needed (Sinaga & Feranie, 2017).

Problem Statement

Digital storytelling has been proposed as an effective instructional strategy to increase student learning (Crane, 2008; Morgan, 2014). Articles such as that by Morgan (2014) outlined the numerous advantages of using digital storytelling in the classroom to support instruction. Other educators, such as Angay-Crowder, Jayoung, and Youngjoo (2013) and Cole, Street, and Felt (2012) provided examples of how digital storytelling can be integrated into classroom instruction. However, these articles are based on anecdotal experience, not empirical studies. For digital storytelling to be accepted as a best practice, it needs a strong research base to support it (Roney, 2009). Unfortunately, research studies involving digital storytelling in educational

settings are limited (Duveskog, Tedre, Carolina Islas, & Sutinen, 2012) and current studies in the literature lack sufficient controls such as comparison groups or pretest and posttest data (Fry & Villagomez, 2012).

Another concern with current studies in the literature is that few address academic content in classroom settings. For example, a study by Niemi et al. (2014) discussed what students learned after participating in a digital storytelling project. Student surveys reflected an improvement in technology skills related to the creation of a digital story while teacher surveys reported use of 21st century skills such as critical thinking but evaluation of academic content was not included in this study. Other studies, such as that by Campbell (2012), examined the effects of digital storytelling on writing quality, a major focus of CCSS, but not at specific content area achievement. However, if students are to become scientifically literate citizens, science content must be introduced at an early age (President's Council of Advisors on Science and Technology [PCAST], 2010; Sahin et al., 2015) and instructional practices must help overcome student misconceptions (Stamp & O'Brien, 2005; Wendt & Rockinson-Szapkiw, 2014). Although digital storytelling has been proposed as an effective instructional strategy, additional research is needed to determine its effect on content understanding and academic achievement (Tan, Lee, & Hung, 2014), especially within elementary grades (Dalton et al., 2015).

Purpose Statement

The purpose of this quantitative, quasi-experimental study was to address a gap in the literature regarding the effect of digital storytelling on content understanding in elementary grades. Digital storytelling has been proposed as an effective way to enhance learner's understanding (Crane, 2008; Elwood, 2010; Kilic, 2014) and integrate technology into classroom

instruction to boost student engagement and motivation (Alqarawi, Dundeni, & Ouyang, 2013; Crane, 2008; Santos Green & Chassereau, 2014). However, there were few research studies to support these claims (Robin & McNeil, 2012). Researchers (e.g., Foley, 2013; Normann, 2011) identified a need for research based on the use of digital storytelling in elementary classrooms.

This study added to the current body of knowledge that can be used to help educators determine the effectiveness of digital storytelling in reducing misconceptions, thus improving astronomy understanding of fourth grade students. The study occurred in an elementary school in the southeastern United States. Fifty-one percent of the school's families qualified for the federally assisted lunch program giving the school Title 1 status. The population was 72% Caucasian, 38% African-American, and 6% of the population identified as another race. The study sample consisted of fourth grade students. There were 72 boys and 46 girls that participated in this study. Of the 118 students that participated, 74 identified as Caucasian, 39 identified as African-American, and 5 identified as another race. The independent variable for the study was the type of writing strategy used during an astronomy unit. Explanatory writing served as the control. Explanatory writing, also known as informational writing, uses facts and details to expound on a topic (Culham, 2016). Narrative writing served as the experimental condition. Narrative writing produces a story in which characters are introduced and developed as events occur, usually in a logical sequence (Culham, 2016; Kulla-Abbott & Polman, 2008). The dependent variable was misconceptions about astronomy concepts held by the students. Misconceptions occur when a student's understanding of a scientific phenomenon differs from the explanation accepted by the scientific community (Gurel, Eryılmaz, & McDermott, 2015). Misconceptions were identified through the MOSART ASSCI.

Significance of the Study

This study presented merits for empirical research on the effectiveness of digital storytelling to reduce misunderstanding of astronomy content. Roney (2009) discussed the need for both a strong theoretical and a strong research base for storytelling. He stated there was a strong theoretical basis for storytelling but not a comprehensive research base to support this theoretical base. Empirical research was needed to either provide support or disprove this theoretical base.

Hung, Hwang, and Huang (2012) contended that digital storytelling has been identified as an effective method to promote knowledge construction but that its effect on student achievement has not been researched. Dalton et al. (2015) noted that available research is especially dearth when addressing elementary grades. Rebmann (2012) agreed in that the effectiveness of digital storytelling to develop new literacies was documented but noted that the majority of studies exploring this were qualitative. Qualitative studies involve small numbers of participants causing debate over the applicability of findings to other situations (Gall, Gall, & Borg, 2007).

This study can assist educators and policy makers concerned with developing students' deeper understanding of content. It is of particular interest to classroom teachers concerned with developing a deeper understanding of science concepts in their students. Deeper understanding of science concepts can only by achieved when student misconceptions are removed (Wendt & Rockinson-Szapkiw, 2014). Although digital storytelling has been proposed as effective instructional method, teachers need to know if digital storytelling is effective specifically in removing misconceptions. This study provided insights in the effectiveness of student-produced

digital storytelling in removing science misconceptions, specifically within the field of astronomy.

Research Question

RQ1: Is there a difference between the number of astronomy misconceptions held by students that participate in digital narrative writing tasks and the number of astronomy misconceptions held by students participating in digital explanatory writing tasks while controlling for pretest scores?

Definitions

1. *Constructivism* – a theory of learning which maintains that a learner constructs meaning based on prior knowledge and experience as opposed to simply receiving knowledge from others (Collins & O'Brien, 2003).

2. *Digital Storytelling* - stories that contain some mixture of computer-based images, text, recorded audio narration, video clips, and/or music. Digital stories can vary in length, but most of the stories used in education typically last between 2 and 10 minutes (Robin, 2014).

3. *Explanatory Writing* – writing meant to explain or provide information. It uses details to expound on a topic. Also referred to as expository or informational writing. (Culham, 2016).

4. *Misconception* – a student's understanding of a scientific phenomenon which differs from the explanation accepted by the scientific community (Gurel, Eryılmaz, & McDermott, 2015)

5. *Narrative Writing* – writing meant to tell a story. Characters are introduced and developed as events occur, usually in a logical sequence (Culham, 2016; Kulla-Abbott & Polman, 2008).

6. *Technological Pedagogical Content Knowledge* – a theoretical framework which accentuates the complex interaction among and between technology, subject content, and pedagogical practices. It differs from other works by emphasizing the advantages and constraints of these interactions instead of considering each domain separately (Mishra & Koehler, 2006).

CHAPTER TWO: LITERATURE REVIEW

Overview

Chapter two explores the current research related to this study. It includes the rationale for the theories used to guide the study, and a review of other studies relevant to the proposed study.

The Knowledge Age is placing new demands on its citizens. Recall of facts will not sufficiently prepare a person to be a productive, contributing member of society. Successful citizens have a deep understanding of key concepts in major content areas along with the ability to be self-directed, life-long learners. In addition, educators must adopt teaching practices that will promote deeper understanding and 21st century skills in students. This literature review explores these areas. It begins with the theoretical frameworks which guides this study. It continues with a review of skills students will need in order to be successful in the 21st century's Knowledge Age. Finally, it discusses digital storytelling as a teaching practice promoting deeper content understanding and its uses for improving needed 21st century skills.

Theoretical Framework

Two theories, constructivism and Technology Pedagogical Content Knowledge (TPCK) model, provide the framework for this study.

Constructivism Theory

Constructivism combines elements from the work of Piaget, Bruner, Vygotsky and other early psychologists into an overarching theory of learning (Juvova, Chudy, Neueister, Plischke, & Kvintova, 2015). Although there are several strands, one highlighting the works of Piaget with another based on Vygotsky's work, the strands agree in two major areas. The first area of agreement is that an individual develops new knowledge based on past experiences and prior

knowledge. Knowledge is constructed by the individual, not transferred from one person to another. The second area of agreement is that effective instruction requires active participation of the learner. The teacher's role is to act as a facilitator, helping the learner internalize new knowledge (Liu & Chen, 2010)

This study was underpinned by social constructivism, the strand of constructivism based on Russian psychologist Vygotsky's sociocultural theory. Sociocultural theory specifically identifies storytelling as one of the types of interactions that occurs between learner and environment to promote cognitive development (Miller, 2011). Social constructivism adopts Vygotsky's concept that cognitive development is based in social interactions and cultural environment (Liu & Chen, 2010). However, there is an interdependence between individuals and environment, resulting in adaptations to both environment and learner as interactions occur. These interactions are not limited to human beings but also include interactions with material and psychological tools. In the Knowledge Age, material tools include electronic devices such as computers, mobile phones, and the Internet while Niemi et al. (2014) specifically identified creating stories as one possible psychological tool.

An important aspect of sociocultural theory is the zone of proximal development which refers to differences in what a student can do independently and what he or she can do when provided assistance. Digital storytelling addresses this zone in several different ways. Digital stories can be created by others to provide support within a student's zone of proximal development (Kildan & Incikabi, 2015). Students can watch digital stories, providing them with information in a format that combines audio and visual thus addressing multiple learning styles. Digital storytelling also allows students to view information numerous times, providing support for students struggling with reading. Additionally, students' learning is fostered as digital

formats allow them process information at their own pace. Examples of using digital storytelling as support within a student's zone of proximal development by producing videos for student viewing can be seen in studies by Incikabi and Kildan (2013) and Niemi et al. (2014). However, as students create their own stories, technology can also provide support, allowing students to accomplish more than they could working independently. Emert's (2014) work with refugee children provides an example of technology providing this type of assistance by removing complications imposed by grammar, spelling, and punctuation required when writing. Nilsson's (2010) work with a special needs student reported similar results. Nilsson's student was able to complete complex stories when technologies overcome barriers caused by his physical limitations. However, a literature review by Bruce et al. (2013) cautioned that technology, regardless of the type or how it is used, never replaces good teaching. Teachers must understand how content knowledge is best conveyed to students and how technology can best support student learning of that content knowledge (Mishra & Koehler, 2006).

Technological Pedagogical Content Knowledge (TPCK)

Studies and reports about the effectiveness of technology integration from a decade ago noted that despite monies devoted to technology integration in schools, little effect on student achievement resulted (Sadik, 2008). Numerous reasons for this lack of effectiveness have been identified. These include lack of access to reliable technology, lack of teacher belief in the importance of technology integration, and lack of training on effective methods of integration (Mishra & Koehler, 2006; Polly, 2011; Vu, 2014). As the lack of access issue has been addressed, the issue of effective methods of integration remains. Hechter and Vermette (2013) discussed this issue, describing various types of usage being observed. One type of usage was considered instructional. Technology was used by teachers for presenting and sharing lessons

with students. Jimoyiannis et al. (2013) found this to be the most common practice, adding that

when technology was used by students it was for low-level tasks such as worksheets or

assessments. The second type of usage described by Hechter and Vermette (2013) was

considered educational. In this case, technology was in the hands of students who were

completing inquiry or problem-based assignments. This is the type of technology use recognized

as needed for active learning, promotion of deeper understanding of content, and college and

career readiness (Jimoyiannis et al., 2013; Jones, 2014; Kenna & Russell, 2014; Luther, 2015;

Polly, 2011). Effectively integrating technology to promote deep understanding of content

requires that teachers not only understand the content they are presenting, the best teaching

practices to use while presenting this content, and how to use technology, but also how these

three domains interact.

Mishra and Koehler (2006) presented a framework to help guide educators as they work

toward effective integration of technology. This framework built on Shulman's 1986 work

which proposed that content knowledge and pedagogical knowledge should not be considered

separately, as was common practice, but that best practices occurred when the two areas

overlapped, providing the best instructional methods to use when presenting various students

with a specific knowledge set. Mishra and Koehler proposed that technology was being

considered as a separate domain just as content and pedagogy were considered separate prior to

Shulman's work. Just as effective teaching must search for how content and pedagogy overlap

to find best practices, to find effective practices for technology integration, educators must

evaluate how the three domains interact. Best practices for technology integration occur when

technology is used in support of the best pedagogical methods available to present specific

content. Mishra and Koehler described this triple overlap as technological pedagogical content knowledge.

Digital storytelling is proposed as supporting TPCK. For example, in their case study of preservice teachers developing digital stories, Sancar-Tokmak, Surmeli, and Ozgelen (2014) identified the choice of content for a story as content knowledge, writing of the story in order to address student prior knowledge and gaps as pedagogical knowledge, and how to use various hardware and software to complete the digital story as technological knowledge. Maddin (2012) agreed that digital storytelling supports TPCK but examined it based on student production of stories. She argued that student research and evaluation of information to create their digital stories leads to deeper understanding of content while enhancing skills identified by P21 such as creativity, and innovation. Therefore, digital storytelling supports both pedagogical knowledge and content knowledge by providing teachers with a viable process to use to facilitate deeper content knowledge in their students. Technological knowledge is also supported since ability to use functions in one program usually transfer to other similar programs, helping develop technology competences.

Related Literature

The 21st Century Learner

Macionis (2007) defined education as "the social institution through which society provides its members with important knowledge, including basic facts, job skills, and cultural norms and values" (p. 410). During the Agricultural Age, families shouldered much of the responsibility for education, transferring farming and craft skills to their children in order to provide food and basic needs for the community (Trilling & Fadel, 2009). As societies moved into the Industrial Age, societal needs changed. Workers were needed to man factories and

populations shifted from rural to urban communities. Schools were established to prepare workers for these factories. Education became uniform and standardized (Trilling & Fadel, 2009), expecting all students to learn the same content within the same time frame (Aslan & Reigeluth, 2013). However, 1991 was identified as the year the United States transitioned from the Industrial Age into the Knowledge Age; it was the first year expenditures for information and communication products exceeded expenditures for industrial products.

As society continues to transition into the Knowledge Age, societal needs are once again changing. Routine manual labor and jobs requiring basic thinking skills are being replaced with jobs that require higher levels of education and complex thinking and communication skills (Annie E. Casey Foundation, 2014; Trilling & Fadel, 2009). The Partnership for 21st Century Learning (P21), a nonprofit organization consisting of government, business, and educational leaders, developed the Framework for 21st Century Learning to outline knowledge and skills students will need to be successful in this new employment environment (P21, 2015). The P21 framework identifies four areas of knowledge and skills students will need in order to meet the needs of the 21st century workplace and to be successful in life. Students need (a) a mastery of the key subjects, (b) learning and innovation skills, (c) information, media, and technology skills; and (d) life and career skills (P21, 2015).

Mastery of the key subjects. According to P21 (2015), students need to master key subjects. Employment opportunities in the Knowledge Age are vastly different from opportunities of the Industrial Age. Well-paying blue-collar jobs are being replaced with automation and remaining routine jobs do not pay decent salaries (Annie E. Casey Foundation, 2014; A. Collins & Halverson, 2009; Trilling & Fadel, 2009). New job opportunities require higher levels of knowledge creating a demand for workers with education beyond a high school

degree, especially within the science, technology, engineering, and math (STEM) fields (Trilling & Fadel, 2009).

Although advanced knowledge and skills are needed to fill higher paying employment opportunities, American students are not acquiring these. In 2015, only 33% of America's public school eighth graders scored proficient or above in mathematics (Kena et al., 2016), an essential requirement for advanced level technical skills (Annie E. Casey Foundation, 2014), and only 36% of fourth graders scored proficient or above in reading (Kena et al., 2016), an early indicator of academic success (Annie E. Casey Foundation, 2014). Deficiencies in mathematics and reading leave students ill prepared for advanced education or job training. CCSS were developed to help ensure students were ready for college coursework or career training upon high school graduation (National Governors Association Center for Best Practices (NGA) & Council of Chief State School Officers (CCSSO), 2010).

CCSS evolved from the standards based educational reform that began decades earlier (Drew, 2012; Kendall, 2011). Several factors combined to trigger standards based reform. There was a decline in SAT scores reported during the mid-1970's followed by a decline in America's standing on international measures in the 1980's (Kenna & Russell, 2014). To address these declines, local school districts, state educational departments, and national content area organizations began to develop standards outlining essential concepts and skills within each discipline (Kendall, 2011). However, the resulting standards contained more content than could be adequately covered within a given school year. This led to teachers having to rush through content without time to develop higher order thinking skills or relationships between various concepts (Jones & King, 2012; Kendall, 2011). Although these standards were being put in place, colleges saw an increase in the number of students requiring a year of remediation and a

decrease in the number of students requiring less than one year of remediation during the years between 1995 and 2000 (Kendall, 2011).

In 2009, the NGA and the CCSSO launched an effort to develop standards for language arts and mathematics (NGA & CCSSO, 2010). These two content areas were chosen because mastery of these subjects was considered necessary for success in all other content areas (Rust, 2012; Wallender, 2014). However, because of the interdisciplinary nature of learning, literacy standards for other content areas were included in the language arts standards, integrating CCSS into all content areas (Drew, 2012; Kenna & Russell, 2014).

When writing the standards, NGA and CCSSO relied on standards from high achieving states and nations along with those from professional content area organizations, data from national and international assessments, and surveys of educators and employers (Jones & King, 2012). Additionally, CCSS integrated the three other areas identified in the P21 learning framework, (a) learning and innovation skills, (b) information, media, and technology skills, and (c) life and career skills (Alismail & McGuire, 2015). CCSS also attempted to avoid problems inherent in standards produced by other organizations by reducing the number of standards so concepts could be mastered within the available time (Drew, 2012; Fuchs et al., 2015; Jones & King, 2012).

Before adoption of CCSS, students were working one to two levels below the level at which they needed to operate (Jaeger, 2014). However, CCSS did not just introduce harder materials. CCSS focused on conceptual understanding instead of recall. Students should be able to apply these deeper understandings to solve authentic, real-world problems (Jones & King, 2012; NGA & CCSSO, 2010). Students should also be able to acquire new knowledge from text and to provide arguments and ideas based on evidence from the text instead of from personal

experience or opinion, skills needed to be an independent, life-long learner (NGA & CCSSO, 2010).

Adoption of CCSS is voluntary; however, to be eligible for federal Race to the Top funding, states must implement standards common to a significant number of states (Drew, 2012). In Spring 2017, 42 states along with Washington D.C., the Department of Defense Education Activity, and four U.S. territories had adopted CCSS (NGA & CCSSO, 2010). Despite this wide-spread adoption, several major concerns have surfaced. One involves the assessment of CCSS. Teachers will teach students whatever content is necessary for those students to be successful on high-stakes standardized tests (Kenna & Russell, 2014; Schoenfeld, 2014). New standardized assessments are being developed to better align with CCSS and ensure readiness for college coursework or job training. These new assessments are multicomponent, containing some multiple choice questions but also questions requiring students to compose answers explaining their reasoning and multiple step performance tasks requiring complex thinking (Educational Testing Service, 2016). Teachers will need new instructional strategies that will prepare students for this new testing format (Griffin et al., 2012).

Learning and innovation skills. As societies continue to move into the Knowledge Age, innovative products and services that meet needs or solve problems will become major commodities (Trilling & Fadel, 2009). In order to participate in an economy stressing innovation, students must be provided opportunities which foster innovation from an early age (Phillip, 2011). P21 identifies skill sets, sometimes referred to as the 4 C's, needed to encourage innovation. These are critical thinking, communication, collaboration, and creativity (Alismail & McGuire, 2015). These skills are not new, being stressed in earlier educational reform

movements, but in this new age, attainment of these skills is essential to success (Claymier, 2014). CCSS recognizes the importance of these skills, integrating them into the standards.

However, integrating critical thinking, communication, collaboration, and creativity into content area curricula requires a change in instructional practices in classroom settings. Classroom practices must focus on involving students in higher-order thinking and real-world problem solving (Karge & Moore, 2015; Kivunja, 2014). Although teachers feel student-centered instruction integrating higher-order thinking and real-world application is the most effective instructional method (Rotherham & Willingham, 2009), the majority of instruction continues to be teacher-centered whole group instruction and seat-work (Aslan & Reigeluth, 2013; Blannin, 2015; Kenna & Russell, 2014; Rotherham & Willingham, 2009). One reason for this lack of student-centered instruction is teacher preparation (Claymier, 2014; Rotherham & Willingham, 2009; Schoenfeld, 2014). To implement student-centered instruction, teachers need extensive, sustained professional development (Kenna & Russell, 2014; Schoenfeld, 2014). It is difficult to manage numerous activities while ensuring all students are engaged with content and monitoring individual progress, all simultaneously. Teachers need instruction in how to accomplish this along with administrative support as they implement the process (Rotherham & Willingham, 2009).

Another argument regarding the lack of student-centered instruction is heavy emphasis on students' achievement on standardized testing (Herman & Linn, 2014; Kenna & Russell, 2014; Schoenfeld, 2014). To ensure learning and innovation skills are taught, tests need to be developed which will measure student progress in these areas (Claymier, 2014). Although Herman and Linn's (2014) analysis of test items on two recently developed tests determined that approximately one-third of items required higher-order thinking, Rotherham and Willingham

(2009) cautioned that testing higher-order thinking skills is in its infancy and should move beyond multiple choice testing. Aslan and Reigeluth (2013) suggested that assessment must go even further, evaluating individualized attainment goals instead of a specific set of content standards that are applied to everyone.

Information, media and technology skills. Today's K-12 students are considered to be "digital natives," (Beriswill et al., 2016, p.8) born into the technology-rich Knowledge Age. These students are extensive users of digital tools for social interaction and entertainment, with exposure to media reaching 12 hours a day (Redmond, 2015). Unfortunately, this exposure does not guarantee the ability to use various media sources effectively for learning. Students need skills which allow them to locate and evaluate information from a variety of sources while maintaining personal safely and protecting their online identity. Furthermore, these students need guidance in adhering to ethical and legal issues surrounding use of various media sources (Eteokleous & Pavlou, 2011; Redmond, 2015; Trilling & Fadel, 2009). CCSS recognized the importance of these skills, explicitly integrating them into the standards (P21, 2011).

Numerous national and international professional organizations work to ensure educators have resources to support building information, media, and technology skills. International Society of Technology in Education (ISTE) is one such organization, focusing on information and communication technology skills. Internationally recognized ISTE Standards, recently updated in summer of 2016, provide guidelines for administrators, educators and students on educational uses of technology (Cooper, 2015; International Society for Technology in Education, 2016; Pappas, 2008). Revised ISTE Standards have 28 performance indicators divided among seven standards. The American Association of School Librarians (AASL) has also provided standards; however, these focus more on information literacy (Cooper, 2015;

Pappas, 2008). AASL's *Standards for 21ˢᵗ Century Learners*, also in the process of being

updated for release in fall 2017, identify skills, actions, responsibilities, and self-assessment

strategies for each of four standards. Georgia, the state in which this study took place, has

formally adopted the ISTE Standards (ISTE, n.d.) and its professional school librarian

organization is an affiliate of both ISTE and AASL.

Despite differences in focus between standards from these two professional

organizations, these two sets of standards are very similar. Pappas (2008) found both sets of

standards stress inquiry processes, requiring critical thinking and problem solving. Both

recommended students develop a planned approach to acquiring and evaluating information.

Both sets of standards promoted students constructing knowledge individually and

collaboratively. Finally, both emphasized ethical use of knowledge. Although ISTE has updated

standards since Pappas' analysis, evaluation of standards shows these skill sets are still included

in the new standards.

Given the importance of information, media, and technology skills in Knowledge Age

societies, educators no longer have a choice about integrating these skills into curricula.

Students must be provided opportunities to learn and practice technology related skills (Thesen

& Kira-Soteriou, 2011). To assist educators in the integration of digital skills into content

curricula, both AASL and ISTE have produced crosswalks. These documents demonstrate how

digital standards in Standards for 21ˢᵗ Century Learners and ISTE Standards align with CCSS.

Digital storytelling is an instructional method that addresses many of these aligned standards and

is effective at promoting deeper content understanding while integrating digital standards

(Czarnecki, 2009; Sadik, 2008).

Life and career skills. Trilling and Fadel (2009) described life and career skills as those that might appear on employee performance evaluations. They divided these skills into five areas: (a) flexibility and adaptability, (b) initiative and self-direction, (c) social and cross-cultural skills, (d) productivity and accountability, and (e) leadership and responsibility. Once again, these skills are not new but have gained importance in the Knowledge Age (Kivunja, 2015; Trilling & Fadel, 2009). Unfortunately, there is little discussion in the literature of how to integrate these specific skills into curricula. For example, a database search on integration of creativity and innovation skills produced over 200 articles but the same database only produced eight about life and career skills.

Trilling and Fadel (2009) recommend student-centered learning as an effective method for integrating life and career skills into curricula but stated that these are rarely integrated into content area curricula, especially at higher educational institutions. Rotherham and Willingham (2009) argued that few educators have the training needed for effectively implementing student-centered classroom activities. They also pointed out that, although student-centered learning is advocated, there is a lack of research to identify effective ways to integrate life and career skills. Kivunja (2015) identified numerous strategies that can be implemented to teach these skills to students; however, Rotham and Willingham pointed out a problem with simply providing strategies. Skills must be integrated into content curriculum with equal importance attached to skills and content knowledge, a project which has yet to be undertaken.

Science Education

After the Russian launch of Sputnik, there was a major push for science education in the United States but it was limited to the brightest students who expressed interest in science-related careers. However, by the 1980's, the push was for science literacy for all students (Hofstein,

Eilks, & Bybee, 2011), recognizing that science literacy was needed in order to fully participate in a society where science and technology impacted the personal, social, professional, and cultural lives of everyone (Organization for Economic Cooperation and Development [OCED], 2013). Numerous organizations, such as the National Science Foundation (NSF), the National Science Teachers Association (NSTA), and the American Association for the Advancement of Science (AAAS), published reports and developed standards for American students (Breiner, Harkness, Johnson, & Koehler, 2012). Despite this push for science literacy, American students continued to lag behind their global counterparts, possibly because as with other standards reform movements, standards were too numerous to teach in the allotted time and focused on factual content with no real-life application (Hofstein et al., 2011; PCAST, 2010).

A renewed push for science and mathematics literacy began in 2001 when NSF first used the acronym STEM for science, technology, engineering, and mathematics (Sahin, Oren, Willson, Hubert, & Capraro, 2015). Since then, numerous groups have adopted the acronym, however, there is very little consensus of its meaning. According to NSF, STEM refers to mathematics, natural sciences, engineering, computer and information sciences, and social and behavioral sciences such as psychology, economics, sociology, and political science (Breiner et al., 2012). The President's Council of Advisors on Science and Technology (PCAST, 2010) mirrors this definition but excludes the social and behavioral sciences since those content areas are rarely included in K-12 educational environments. Based on these definitions, many consider STEM to refer to coursework in each of these fields taught as separate entities (Harwell et al., 2015). However, others consider STEM as a new subject that integrates science, technology, engineering, and mathematics into a single course of study (Breiner et al., 2012; Harwell et al., 2015; Mitts, 2016). Adding to the confusion is the recent movement toward

STEAM, acronym for science, technology, engineering, arts, and mathematics. Proponents of STEAM argue that integrating arts harnesses the ability to imagine and create (Wynn & Harris, 2012) , addressing the 21st Century Learner domain learning and innovation skills. Currently, there is little data to support adding arts to STEM, the available data showing mixed results.

Despite multiple definitions of STEM, there are several points of agreement. The first is that traditional instructional methods are not effective with today's students (Bevins, 2012; Breiner et al., 2012; Hofstein et al., 2011; PCAST, 2010; Wynn & Harris, 2012). Instruction must transition from a focus on disparate, low-level fact recall to deep understanding that allows knowledge to be applied in novel situations. To help students achieve this level of understanding, problem-solving approaches with hands-on activities should be utilized (Bevins, 2012; Jones, 2014; Mitts, 2016). Problems should be authentic, real-world problems that emphasize relationships between STEM and society (Bevins, 2012; Breiner et al., 2012; Harwell et al., 2015; Hofstein et al., 2011; OECD, 2013). This complements calls for changes in instructional methods made by proponents of 21st Century Learning and CCSS.

A second point of agreement is that all citizens need to be scientifically literate. Citizens need an understanding of broad topics, such as energy consumption and health, so they can participate in discussions and make informed decisions about critical issues facing individuals, societies, and the planet (Hofstein et al., 2011; OECD, 2013; PCAST, 2010). To ensure a scientifically literate citizenry, STEM coursework should begin in early childhood. Early exposure to STEM topics increases interest and performance abilities (PCAST, 2010; Sahin et al., 2015) and Harwell et al. (2015) state that early evidence suggests exposure to STEM education is promising improvements in science and mathematics achievement.

However, before students can develop a deeper understanding of science concepts and become scientifically literate, students' misconceptions will need to be addressed (Wendt & Rockinson-Szapkiw, 2014). Science education researchers found children begin developing an understanding of science phenomena during infancy (Wind & Gale, 2015). As children observe the world around them, they develop theories to explain these phenomena. When these theories, based on incomplete data and lack of experience, do not align with accepted scientific theories they are considered misconceptions (Elliott & Pillman, 2016; Gurel et al., 2015; Wendt & Rockinson-Szapkiw, 2014). Misconceptions have been shown to be very to resistant to change and hinder mastery of science concepts. Instructional practices that challenge misconceptions and give students the opportunity to reconstruct and build on these previous ideas are needed (Stamp & O'Brien, 2005; Wendt & Rockinson-Szapkiw, 2014).

Write to Learn

Write to Learn (WTL) is a pedagogical approach that emerged in the late 1960's. Studies involving WTL strategies report consistent positive effects on learning (Ray et al., 2016; Sanchez & Lewis, 2014; Waters, 2014). Although WTL strategies are older, they are receiving renewed interest. One reason for this renewed interest is the number of students having to take remedial writing courses when entering higher education (Sanchez & Lewis, 2014; Waters, 2014). A second reason is the focus on writing in CCSS and the new standardized assessments which embed writing tasks (Griffin et al., 2012; Teuscher, Kullinna, & Crooker, 2015).

Although WTL strategies produce positive benefits, different types of tasks will produce different results. Researchers have identified 43 different writing strategies that can be divided into four categories. Mechanical writing strategies, such as note-taking and worksheets, work with short text passages. Informational writing strategies, such as reports and abstracts, share

information or opinions with others. Personal writing strategies, such as journals and letters,

involve experiences and personal connections. Narrative writing strategies, such as stories and

blogs, incorporate literary genres (Ray et al., 2016).   Mechanical writing strategies and

informational writing strategies are considered to be traditional writing tasks. Traditional tasks

are used in communication, such as taking notes during a lecture, and evaluation, such as a report

submitted to the instructor. These types of tasks promote passive learning. Personal writing

strategies and narrative writing strategies are considered to be non-traditional writing tasks.

These tasks are considered a learning strategy and are used to promote active learning (Sinaga &

Feranie, 2017). Waters (2014) stated that when writing is used as a means of learning instead of

an evaluation tool, it becomes a unique form of learning. This type of writing causes the learner

to clarify knowledge; organize and reflect on ideas; and integrate different strands of thought

(Atasoy, 2013).   It also provides the learner with immediate visual feedback (Waters, 2014).

Research into the use of non-traditional writing tasks during science coursework is

developing. In their study with college students, Sinaga and Feranie (2017) found that

mechanical and informational writing tasks helped students apply concepts but did not lead to

increased conceptual understanding as the non-traditional writing tasks did. Sampson et al.

(2013) achieved similar results when working with middle and high school students. They

reported small gains when students participated in traditional tasks such as reports and abstracts.

Deeper understanding was gained when students had to explain, reflect, or elaborate in their

writing tasks. Studies by Chen, Hand, and McDowell (2013) and Lee and Maerz (2015) also

supported the use of non-traditional writing tasks in science classrooms, citing writing for an

audience other than the instructor as a factor. When writing for a teacher, students may include

terms the teacher used without fully understanding the meaning. However, writing for a

different audience requires students to translate scientific terms into terms they personally understand and then translate from those terms to terms their intended audience would understand (Chen et al., 2013; Lee & Maerz, 2015).

Although these studies support the integration of non-traditional writing tasks into the curriculum to support learning, a recent survey of middle school teachers across the United States found that most WTL strategies used in those classrooms were traditional, involving short writing tasks that did not require any analysis, interpretation, or composition. Additionally, the least frequently used tasks were ones that integrated technology (Ray et al., 2016). WTL strategies, as other pedagogical strategies, must adapt and incorporate changing technologies (Hilton & Hilton, 2013). However, before these adapted strategies will become permanent options, their influence on academic achievement must be documented (Yang & Wu, 2012).

Digital Storytelling

Storytelling is a universal practice occurring among all cultures (Dawkins & O'Neill, 2011). It is considered one of the oldest methods of transferring information from one person to another (Crane, 2008). For example, because of details describing a geological event, Earth Science Australia (n.d.) has dated an aboriginal story as having occurring over 12,000 years ago, about 2,000 years before writing appeared. Cultures have used storytelling to transfer information, traditions, morals, values, and ethics from one generation to the next. In their position paper on storytelling, the National Council of Teachers of English (1992) stated that storytelling made factual information more memorable, making stories one on the best ways to transfer information. Lee and Maerz (2015) suggested stories are effective because people are accustomed to the transfer of information through this format. Stories help people relate past experience to the present and help them understand how and why decisions were made. Anu,

Jorma, and Sinikka (2014) expanded the role of storytelling stating that developing a story constructs meaning while sociocultural psychologists have identified storytelling as one of the activities in which individuals participate as they create knowledge (Miller, 2011).

Although storytelling is recognized for its importance in the transfer of knowledge, as the United States continues transitioning into the Knowledge Age, new concerns over the reliance on technology to communicate are surfacing (Waters, 2014). Digital storytelling provides a way to integrate new technologies into traditional learning strategies. Digital storytelling began in the 1990's when new technologies allowed lay persons to produce quality projects. With the introduction of interactive websites, these stories could be shared with an authentic audience and educators began exploring the use of digital storytelling in educational settings (Robin, 2014). Digital storytelling is being recognized as a robust instructional method applicable to numerous content areas and incorporating numerous 21st century skills (Barnes, Gachago, & Ivala, 2015; Cole et al., 2012; Emert, 2014).

Although the definition of digital storytelling varies, it is generally accepted to be a short, 3-5 minute story that combines pictures, video, music, and audio to tell a story. Robin (2008) expanded the definition by identifying three different categories of digital stories. These are personal narratives, historical stories, and stories that are used to inform or instruct.

Yuksel, Robin, and McNeil (2010) conducted a study to determine the use of digital storytelling around the world. In a survey of 154 participants, they found that digital storytelling has been used in 26 different countries and in a variety of situations. It has been used in multiple academic subject areas but also in the areas of health education and mental health. The majority of respondents to the survey agreed that digital storytelling improved students' content knowledge, along with writing, technology, and presentation skills. They also felt digital

storytelling improved research skills, reflection skills, language skills, social skills, and higher order thinking skills, all skills identified by P21 as skills needed to be successful in the 21st century. This study was limited to participants who had expressed an interest in digital storytelling, limiting the generalization of the results. Additionally, the survey asked for perceptions so the resulting data was based on these perceptions and not on measured changes in student achievement.

Despite the 2007 report by the U.S. Department of Education that found technology had not improved student achievement, educators continue to advocate the use of technology in the classroom (Robin, 2008). The challenge is to find effective ways to integrate that technology into the curriculum (Alqarawi et al., 2013; Dreon, Kerper, & Jon, 2011; Robin, 2008). Proponents of digital storytelling argue that this is an effective method of technology integration because it increases student engagement and motivation while simultaneously addressing the majority of skills identified by P21 for 21st Century Learners (Robin, 2008).

In the Knowledge Age, students must master academic content (P21, 2015). One way digital storytelling promotes mastery of academic content is by presenting content in a digital format as opposed to print. Dreon et al. (2011) and Pence (2010) felt that information presented in this manner reflected how students encounter information in their daily lives outside of formal educational environments thus improving understanding. Rebmann (2012) agreed with this but added that digital storytelling presented information in a manner that reached kinesthetic, auditory, and visual learners while Robin (2008) stated this integration of visual and audio enhanced and accelerated comprehension.

Although there is strong theoretical support for digital storytelling's positive effect on deep, meaningful acquisition of content, there is little empirical research to verify this (Nilsson,

2010). Rebmann (2012) noted that the majority of empirical studies represented in the literature are qualitative. For example, a study by Niemi et al. (2014) interviewed focus groups from three different classrooms after participation in a digital storytelling project. Researchers found that during the project, students sought new knowledge, modifying it to make it meaningful. Students described this as an active process and teachers confirmed that students integrated experiences and content from various contexts. Studies such as these are important in describing how digital storytelling activities evolve and to verify the development of competencies and literacies; however, before digital storytelling will become an accepted practice, more data on digital storytelling's effect on academic achievement is needed (Elwood, 2010).

There is also theoretical support for digital storytelling encouraging development of learning and innovation skills. Creativity and innovation are used as students convert information from one format into another to create a coherent message for a specific, intended audience (Czarnecki, 2009). Critical thinking skills are also used in multiple steps of the digital storytelling process. Students must find and evaluate information from multiple sources. The limited time element of digital stories requires students to select which information best conveys desired messages to audiences. Then students employ mental imagery to represent concepts as they determine which images and audio would best enhance the story (Czarnecki, 2009; Elwood, 2010; Kearney, 2011; Nilsson, 2010; Pence, 2010; Royer & Richards, 2008; Sylvester & Greenidge, 2010).

Even though empirical studies involving digital storytelling are sparse, one study conducted in Tanzania does support claims that digital storytelling has a positive effect on learning and innovation skills. In a case study involving 17 students aged 11-15years, researchers Duveskog, Tedre, Sedano, and Sutinen (2012) concluded storytelling encouraged

creativity and the use of imagination. These researchers also concluded that student creativity was enhanced as students developed strategies to overcome presented problems and imagined resulting consequences of each strategy. A qualitative study conducted by Morris (2013), observed critical thinking activities as students edited stories and added multimedia components. Additionally, Morris noted that students changed roles throughout the editing process, moving from audience perspective to creator perspective, critically evaluating information presented when acting as an audience member and then fashioning changes to improve presentation when in creator mode. Although studies such as these verify use of creativity, innovation and critical thinking skills, these studies do not offer any measure of these skills. Without such measures, it is unclear if digital storytelling helps develop these skills or if digital storytelling only provides practice in these skills.

Proponents of digital storytelling also recommend digital storytelling because it addresses information, media, and technology literacy (Emert, 2014; Kilic, 2014; Morris, 2013; Niemi et al., 2014). Traditionally, literacy refers to the ability to not only read but to write using the media format of the time. Although this definition continues to hold, formats available during the Knowledge Age have greatly expanded (Ohler, 2009). To be literate, a student must be able to manipulate digital, video, and audio in addition to traditional print (Cole et al., 2012). But literacy extends beyond just knowing how to use the technologies, students must know how to find and evaluate media created by others, and how to apply various technologies to create their own learning, and guidelines for responsible use (Cole et al., 2012; Ohler, 2009). Production of a digital story requires students to demonstrate mastery of an impressive range of these skills (Emert, 2014).

Once again there is limited empirical support for arguments proposing digital storytelling as a means of addressing information, media, and technology literacy skills. One such study was conducted by Gyabak and Godina (2011). This case study provided eight laptop computers to a school in rural Bhutan which had no previous technology. Researchers concluded digital storytelling provided a practical platform for introduction of technology skills. Niemi et al. (2014) supported findings of Gyabak and Godina. This case study occurred in three different classrooms, one in Finland, one in Germany, and one in the United States. Participants were not required to have extensive technology experience but were required to have access to mobile technologies. Based on self-reporting, students had little to no experience with digital storytelling or applications commonly used in digital storytelling such as video or audio editing at the beginning of the study. At the conclusion of the study, students had learned to use editing software but also how to use technologies to find information they needed.

As with studies supporting other 21st century skills, studies supporting the acquisition of information, media, and technology skills are based on observations and perceptions. These verify the acquisition of skills but do not measure any degree of acquisition. Additionally, proponents of digital storytelling argue that digital storytelling helps develop digital citizenship (Czarnecki, 2009); however, this claim is not supported in study results. Digital citizenship, as information gathering and communication skills, is addressed in both ISTE and AASL standards. Proponents of digital storytelling recommend digital storytelling activities as an excellent platform for teaching these skills (Fries-Gaither, 2010) but integration of these skills is dependent on the instructor (Kearney, 2011; Maddin, 2012). Simply infusing digital storytelling into the curriculum will not help students develop these skills unless intentional instruction of these skills is also incorporated.

The fourth area of 21st century skills addressed by digital storytelling is life and career skills. There are five elements within this domain, one being flexibility and adaptability (Kivunja, 2015). Kivunja (2015) suggested these skills be taught through the use of feedback loops. Feedback loops occur when information is given with the purpose of influencing next occurring steps in order to reach a goal. Feedback loops have been documented in many of the case studies describing digital storytelling production. For example, Morris (2013) found numerous occurrences of feedback which was then used to improve production in her case study involving fourth through seventh graders. Documented feedback loops included students self-evaluating their work as they switched from audience to creator, critique of peers, input from small peer groups, and responses from teachers. In their study involving students from three different countries, Niemi et al. (2014) also observed feedback loops but found students considered giving and getting feedback to be the most challenging aspect of the digital storytelling process.

In addition to the effectiveness of digital storytelling in promoting 21st century skills, it has also proven effective for developing educational communities to support learning (Aslan & Reigeluth, 2013). Anu and Jorma (2014) conducted a case study in which 32 students, aged 6-12 years old, produced digital stories about winter fishing. The students were divided into seven small groups of mixed ages and abilities. The groups were allowed to choose their own perspective from which to examine the theme and to design their research from that perspective. The researchers found that the groups included contributions from every member of the group and noted two astute observations. First, although the students tended to describe how they collected their data, they did not mention the actual technology used to record the digital story. Although the researchers mentioned that the groups did not discuss which technology was used

in the making of the digital story, they did not provide any explanation of why they considered that important. One reason for that could be the familiarity that today's students have with video and communication technologies. They would not consider these tools needed explanation, assuming others would be equally familiar with them. Secondly, Anu and Jorma (2014) remarked that the collection tools are changing. The main tool in this study was digital cameras but smart phones and other technologies may possibly be used in the future. Although other researchers also note the rapid change in technology tools (Blannin, 2015; Dalton et al., 2015; Dotson & Dotson-Blake, 2015; Koehler et al., 2013), Craig (2013) stated, "In preparing digital stories, how digital media is used is considered less important than the story itself" (p.6)

The case study by Anu and Jorma (2014) occurred in a fairly unique setting. It was conducted in a very small rural school in Finland which allowed students to be arranged into mixed age groups. Additionally, the project allowed students to design their own research around a specific topic based on the community in which the school was located instead of requiring specific content standards be addressed. When unique settings such as the one in this study are used, generalization of study results is limited as is the ability of other researchers or educators to replicate the study.

Figg and McCartney (2010) also used digital storytelling for the purpose of building an educational community among teachers, students, and parents. This study addressed underachieving middle school students during a summer enrichment program. In this study, teacher candidates acted as facilitators as middle school students learned how to use the technology tools. The middle school students then became the experts and taught a significant person in their life about the technology as they produced a family history digital story. The project was a positive experience for the teacher candidates, providing them with experience in

facilitation as opposed to direct teaching. It was a positive experience for the significant person as most of these people had negative experiences with educational institutions. But it was especially positive for the middle school students. These students gained content skills as they worked to write the stories they recorded but more importantly, they gained confidence when they became the expert teaching their significant person how to use the technology.

Figg and McCartney's (2010) case study contributed to the literature because participants were middle school students. However, this study also occurred in a unique setting that would be difficult to duplicate in a regular classroom setting. In this situation, there was one adult facilitator for each middle school student while in a regular classroom teacher-student ratio would be closer to one adult for 25 or more students. Additionally, as in the study by Anu and Jorma (2014), the researchers were not tied to specific content standards that had to be taught. Regular classroom teachers would not have that freedom, having to follow a set curriculum.

In contrast to these studies which involved unique settings, Sadik (2008) conducted a mixed methods study in a traditional classroom setting in Egypt. This study involved four classrooms in two different private schools that were specifically chosen because the teachers expressed a willingness to integrate technology into their lessons. Participating teachers attended workshops to learn technologies, such as Photo Story 3, digital cameras, and scanners, which would be used during digital story creation. Teachers became facilitators in their classrooms as students produced digital stories. At the conclusion of the study, researchers evaluated the quality of the digital stories produced along with the technology integration practiced by the teachers. Unlike the studies discussed above which occurred in unique settings, Sadik's (2008) study occurred in a traditional classroom setting but, like the other studies, student achievement of curriculum content standards was not evaluated. Stories in this study were evaluated based on

technical merits such as quality of images, sound, and transitions, not on student understanding of curriculum content. During interviews with participating teachers at the end of the study, Sadik found the effectiveness of digital stories in increasing student understanding of curriculum standards to be a concern; however, teachers believed digital storytelling projects would increase student understanding.

Hung et al. (2012) conducted a pretest, post-test quasi-experimental study which examined the effect of digital storytelling on the motivation, problem-solving competence, and content acquisition of fifth grade students in Taiwan. In this study, both the control group and the experimental group experienced a project-based learning approach. However, the experimental group participated in digital storytelling as the project produced while the control group participated in conventional projects. Pre-tests determined that there was not a statistically significant difference between the control and experimental groups. However, analysis of the post-test results shows a statistically significant difference in the two groups with the experimental group scoring higher on the motivation, problem-solving competence and science learning achievement tests. This study occurred within the normal school year as part of the regularly scheduled science class. It compared the difference in scores of students participating in a digital story project to those of students participating in conventional projects. However, the researchers do not explain what is considered to be conventional projects. It is unknown if these conventional projects involve any type of technology. If the conventional projects involved technology but not digital storytelling, it would strongly support other arguments in the literature that state simply putting technology into the classroom is not effective (Adcock & Bolick, 2011; Burke, 2012; Bush & Hall, 2011; Flanagan & Shoffner, 2013).

In a similar study, Yang and Wu (2012) explored the impact of digital storytelling on motivation, critical thinking, and academic achievement in an English as a Second Language class. This study also employed a pre-test, post-test quasi-experimental design. The control group participated in the traditional presentation of the curriculum while the experimental group received the same curriculum but were tasked with collaboratively creating digital stories. In contrast to the study by Hung et al. (2012), Yang and Wu did not find a statistically significant difference in the academic achievement between the experimental group and the control group. However, as Hung et al., they did find that the experimental group scored higher on motivation and critical thinking.

Although in the study by Hung et al., the use of technology with the control group was unclear, in Yang and Wu's study, the use of technology in the control group was explained. In the control group, the teacher used technology in the presentation of the content. Based on this integration, Yang and Wu's study supports the argument that simply inserting technology does not improve student achievement. They suggest that technology used to present content only supports teacher-centered instruction instead of the type of student-centered learning environments that produce improved student achievement.

Although studies on digital storytelling tend to support the positive effects of digital storytelling on motivation and critical thinking skills, there are mixed results on its effectiveness on student achievement. This conflict in results is reflected in a study by Clarke and Adam (2010). Clarke and Adam conducted a case study examining the use of digital storytelling as a pedagogical tool. Based on two case studies and six additional interviews, they found that the participants in their study had views similar to participants in other studies. The participants strongly felt that digital storytelling has positive benefits for students. However, Clarke and

Adam also concluded that there several issues surrounding the use of digital storytelling. One of these issues was the definition of digital storytelling. The original digital stories were autobiographical in nature following the example set by Daniel Meadows who produced the model aired by the BBC. This definition is very narrow and excludes work which conveys instruction or academic content.

Another issue Clarke and Adam (2010) discovered was the need for method to fit with the content. The participants in their study expressed the need to ensure that technology was not being used just to be used but that it actually addressed student needs. Participants saw digital storytelling as an alternate way of demonstrating understanding. However, they also recognized the fact that digital storytelling promoted communication and collaborative skills that could not be achieved through traditional instruction. They also considered digital storytelling to be student-centered as opposed to teacher-centered.

The issue of the instructional method fitting the content that Clarke and Adam identified was supported by the work of Tan et al. (2014). Tan et al. argued that certain types of knowledge could be conveyed through digital storytelling but that digital storytelling was not effective with other types of knowledge. They proposed that content which could be examined from multiple points of view could easily be conveyed through digital storytelling. Content from humanities or social sciences fit this criteria. Content which had an accepted knowledge base students needed to learn in depth did not translate well into digital stories. Science content, especially curricula taught in schools, fell into this second category. To address this problem, Tan et al. proposed changing the digital story to an edu-tainment narrative in which a problem is encountered and the characters in the story find the answer, thus explaining the content. The researchers felt this was an acceptable method because of its use in children's video

programming. To accomplish this type narrative, the students were exposed to the desired

content and then tasked with designing a problem that could be used to explain the concept to

their peers. At the conclusion of their study the researchers reiterated their belief that not all

knowledge can be conveyed through digital stories and the content to be conveyed should be

closely considered to determine alignment to the digital story method.

The work by Tan et al. (2014) in turn supported that of Clarke and Adam (2010). Clarke

and Adam raised the issue of a lack of a single definition of digital storytelling. When Tan et al.

discussed the stories that were produced in their study, they used the term edu-tainment.

However, Clarke and Adam stated that other educators considered the definition of digital stories

in education settings should change from a strictly narrative view to one that expresses a point of

view based on research. Consideration of this alternate definition of digital storytelling could

possibly have allowed Tan et al. to employ a different research design.

Another issue identified by Clarke and Adam (2010) was the amount of time required for

digital storytelling. Because of the additional time needed for content delivered through this

approach, strong administrative support was needed. This issue was also identified in the study

by Yuksel et al. (2010). One of the participants in this study stated, "I suspect that the small

amount of improvement is not worth the time spent" (Yuksel et al., 2010, p. 1268). Additional

studies that quantify the effects of digital storytelling are needed before this determination can be

made with any sense of accuracy.

Roney (2009) discussed the need for both a strong theoretical and a strong research base

for storytelling. He offered support for reading aloud to children as an example. Reading aloud

to children has a strong theoretical basis for the impact of this practice but it also has been

empirically researched, providing research based support for the theoretical base. Similarly,

storytelling, whether oral, written or digital, has a strong theoretical basis. There are numerous articles on how to incorporate digital storytelling into the classroom and why this instructional strategy should be adopted. However, the majority of these articles are not based on research studies. Empirical research is needed to either provide support or disprove this theoretical base.

Analysis of research-based articles on storytelling revealed that of many of these are qualitative. Qualitative studies contribute to an understanding of how digital storytelling as an instructional method develops various skills and how it is perceived by teachers and students. However, qualitative studies are based on small numbers of participants, limiting their generalization to other populations (Gall et al., 2007). Furthermore, these studies do not examine the effectiveness of digital storytelling on student achievement, a necessary component in light of P21's focus on mastery of content (Elwood, 2010). This study attempted to address this gap in the literature. It was a quantitative study that examined the effects of digital storytelling on student understanding by comparing the number of misconceptions of students producing digital stories with levels of students producing digital informational projects.

Summary

Review of the literature revealed noticeable gaps regarding digital storytelling. The coverage of this topic did not provide a comprehensive picture of digital storytelling. Most notable was the fact that there was little empirical evidence to support or reject the use of digital storytelling. The majority of articles were either theoretical, explaining how digital storytelling met the needs of the 21st century learner, or anecdotal, discussing experienced results and providing the reader with information on how to implement digital storytelling in his or her own situation. In most of the studies where empirical evidence was presented, the studies did not consider academic content in regular classroom settings. Digital storytelling will not become an

accepted instructional strategy unless it is proven to be effective in helping students acquire

content knowledge. This study addressed this issue by providing empirical evidence of the

effectiveness of digital storytelling in student acquisition of content knowledge in a regular

classroom setting.

CHAPTER THREE: METHODS

Overview

Chapter Three provides a detailed explanation of the procedures for this study. It describes the steps taken by the researcher to procure the study site and needed permissions. Then it explains the responsibilities of the teachers and the activities completed by the students. It concludes with the collection and analysis of the data.

Design

This study adopted a quasi-experimental nonequivalent control-group design. Quasi-experimental designs are used when a single variable is manipulated so that its effects can be observed; however, participants cannot be randomly placed into groups and existing groups are used instead (Campbell & Stanley, 1963). One advantage of this design is the group's behavior will more closely mimic natural behaviors since participants are not in an artificial environment created by randomization (Gall et al., 2007).

In this design, pretests and posttests were administered to both control and experimental groups (Gall et al., 2007). Since the participants in this study were not randomly assigned to the control or experimental group, pretests allowed the researcher to determine preexisting differences between groups and address existing differences during statistical analysis. Although there could be an issue with pretest sensitization, it was found that this effect was stronger when the pretest and posttest were different (Gall et al., 2007). To help minimize this, the MOSART ASSCI posttest is a duplicate of the pretest. The developers of the test have published two versions of the test with the only difference in the two versions being the order of the questions. Campbell and Stanley (1963) also stated that pretest sensitization is less likely to occur when testing is a normal procedure within that environment, such as within a classroom.

The independent variable for this study was the type of writing task assigned to students during a Writing to Learn (WTL) activity on space. Students in the control group produced explanatory text while students in the experimental group produced narrative text. In explanatory text, a topic is explained through the use of facts, details, definitions, and examples which are organized so that related information is gathered into sections. Precise language and domain specific vocabulary are used and a concluding statement is provided. In contrast, narratives demonstrate story elements. Stories establish a situation and introduce characters or a narrator, and dialogue or descriptions are used to advance the plot. The conclusion of the story follows logically from the events presented. Both groups integrated technology to produce a digital rendition of their writing task. Digital renditions were between 3-10 minutes in length, the typical length of digital stories in educational settings (Robin, 2014). PowerPoint, PhotoStory 3 or Story Jumper were used as the technology tool for either of these writing tasks since any of these programs would allow students to organize their work, insert text, audio and visual components, and record student voices. PowerPoint was chosen based on a similar study by Dalton et al. (2015), and PhotoStory 3 was a resource listed on the Educational Uses of Digital Storytelling website. However, at the beginning of the school year, several of the classes received Chromebooks instead of PC laptops which were previously purchased for the school. PowerPoint and PhotoStory 3 would not run on these new Chromebooks. StoryJumper was chosen because it would provide the same options and would operate on the Chromebooks several of the classes received at the beginning of the school year.

The requirements for each of the writing tasks were based on the state English language arts (ELA) standards. The fourth grade writing curriculum standard for the explanatory task stated, "Write informative/explanatory texts to examine a topic and convey ideas and

information clearly" (Georgia Department of Education (GaDOE), n.d., p. 3). This standard

corresponded to CCSS.ELA-Literacy.W.4.2. This standard contained five components which

were addressed in the task. These components were (a) the topic will be introduced and

information arranged in sections, (b) the topic will be developed through the use of facts,

definitions, relevant information, and multimedia when useful; (c) the ideas will be linked with

words or phrases, (d) precise and domain-specific language will be used, and (e) there will be a

concluding statement. The fourth grade writing curriculum for the narrative task stated, "Write

narratives to develop real or imagined experiences or events using effective technique,

descriptive details, and clear event sequences" (GaDOE, n.d.p. 3). This standard corresponded to

CCSS.ELA-Literacy.W.4.3. This standard also contained five components which were addressed

in the task. These components were (a) the introduction of a narrator or characters into a

situation which follows a sequence of events, (b) the use of dialogue to explain characters'

response to the situation, (c) the use of transitional words and phrases to manage the sequence of

events, (d) the use of details to convey experiences and events, and (e) a conclusion. (See

Appendix A for a list of the specific ELA Georgia Standards of Excellence addressed in this

study).

The dependent variable was misconceptions of astronomy concepts. Misconceptions

were defined as a student's understanding of a scientific phenomenon which differs from the

explanation accepted by the scientific community (Gurel et al., 2015). Student misconceptions

were identified by the MOSART ASSCI. This inventory consisted of 13 multiple choice

questions that covered astronomy concepts common to science curriculum standards across the

nation, including those in the Georgia Standards of Excellence for Science (see Appendix B for a

list of the specific standards addressed in this study). The distractors for each question were

common misconceptions for each concept identified in science education research literature

(Sadler et al., 2009).

Research Question

RQ1: Is there a difference between the number of astronomy misconceptions held by

students that participate in digital narrative writing tasks and the number of astronomy

misconceptions held by students participating in digital explanatory writing tasks while

controlling for pretest scores?

Null Hypotheses

The null hypothesis for the research question is:

$H_0$1: There is no statistically significant difference between the number of astronomy

misconceptions held by students participating in digital narrative writing tasks and the number of

misconceptions held by students participating in digital explanatory writing tasks while

controlling for pretest scores as shown by the MOSART ASSCI.

Participants and Setting

This study was conducted in a public elementary school in the southeastern United States.

This school served approximately 400 students in grades three through five. The school

exhibited little ethnic diversity with 72% of the students identifying as Caucasian, 22% as

African American, and all other ethnicities accounting for 6% of the school's population. The

school had a school-wide Title I standing. Although the percentage of students qualified for the

federal Free and Reduced Lunch program rose to 64% in the latest economic downturn, it had

recently returned to its more traditional percentage within the 50-55% range.

Convenience sampling resulted in 118 fourth grade students completing both pretest and

posttest used in this study. The sample size of 118 students exceeded the minimum number of

participants of 96 according to Gall, Gall, and Borg (2007) for a medium effect size with statistical power of .7 at the .05 alpha level. Students were assigned to one of six classrooms resulting in 20-25 students in each class. Assignments were based on the students' previous report card grades, any standardized test scores that were available, and teacher recommendations. Students were placed so that classrooms had heterogeneous populations with approximately equal numbers of regular education, gifted, Early Intervention Program (EIP), and students with disabilities in each classroom. Three classrooms were randomly assigned to the control group and three classrooms to the experimental group. Scores from MOSART ASSCI pretest were used to compare variation between the classrooms and use of ANCOVA compensated for statistically significant differences found between control and experimental groups based on these pretest scores.

The sample consisted of 118 students who completed both the pretest and posttest. There were 72 male students and 46 female students. Of these students, 74 students identify as Caucasian, 39 as African-American, and 5 as another race. When divided into control and experimental groups, the control group consisted of 34 males and 22 females. Within this group, 35 identified as Caucasian, 18 as African-American, and 3 as another race. In the experimental group, there were 38 males and 24 females. Of these students, 39 identified as Caucasian, 21 as African-American, and 2 as another race.

There were six fourth grade teachers. Each teacher had over ten years of experience in elementary school education. Teachers had a common planning period with one day per week devoted to collaboratively developing lesson plans. Lesson plans were based on the state's fourth grade curriculum. The state's science curriculum was divided into three main areas: earth science, physical science, and life science. Earth science covered astronomy and weather.

Physical science covered light, sound, and force and motion. Life science covered ecosystems and animal adaptations. The school's analysis of previous student standardized test data revealed that earth science consistently remained an area of need for this school. The state's ELA writing curriculum covered three genres: explanatory, narrative, and opinion. It also included adherence to the writing process including planning, revising, editing and integrating technology.

Common planning time was also used for professional development. Professional development topics were chosen at the end of the previous year based on needs identified after analysis of standardized assessment data and staff, parent, and student surveys. The topic for the past two years had been writing because of concerns over new assessment formats requiring additional writing. The writing processes for both the explanatory and the narrative writing tasks had been addressed during this scheduled professional development. Implementation of writing strategies was accomplished through a Writing Across the Curriculum approach. Additionally, two of the six participating teachers had also received training specifically in digital storytelling. These teachers agreed to redeliver training in digital storytelling for the other teachers participating in the study.

Instrumentation

The MOSART Astronomy and Space Science Concept Inventory (ASSCI) was used to determine the number of misconceptions students had about astronomy concepts. This inventory was developed by the Science Education Department at the Harvard-Smithsonian Center for Astrophysics with grant support from the National Aeronautics and Space Administration (NASA) and the NSF. The inventory addressed four astronomy standards, three from the National Research Council's National Science Foundation (NSF) Standards and one from the American Association for the Advancement of Science's (AAAS) Benchmarks for Science

Literacy. These standards were found in the curricula and evaluation frameworks developed in all 50 states in the United States (Sadler et al., 2009).

Validity of ASSCI test items was established through a variety of experts. Initial questions and answer choices were written by a development team that included educators, content experts, and a psychometrician. After vetting initial questions, remaining questions were evaluated for accuracy by Harvard and Smithsonian scientists. Revised and accepted items were then sent to outside scientists for further review. Each reviewing scientist received a copy of standards so that questions were not only accessed for accuracy but also to ensure standards were meticulously addressed. Approved test items were forwarded to reading experts to ensure readability, guaranteeing questions were measuring content knowledge not reading ability. Finally, items with diagrams were reviewed by a technical illustrator for accuracy. The remaining 211 test items were divided into pilot tests which were then administered to approximately 7588 students across the country. The final draft of the K-4 field test was given to 1878 fifth grade students. Scores were based on a 0-100% scale with mean scores on field tests ranging from 38% to 49%. Kuder-Richardson formula, KR-20, resulted in an internal consistency measure of 0.64 (Sadler et al., 2009).

The MOSART ASSCI consisted of 13 multiple choice questions covering the four astronomy and space standards from the NSF and the AAAS documents. The answer choices consisted of one correct answer plus four distractors based on common misconceptions identified in science education literature. This format encouraged students to "choose among conceptions that may closely, but not exactly, match their own" (Sadler, 1998, p. 268). This use of identified misconceptions for the answer choices made this a distractor-driven multiple choice test which research verified as effective in evaluating conceptual understanding (Sadler et al., 2009).

The MOSART ASSCI was available to science educators to use free of charge after completing four online tutorials. The inventory was given through a paper and pencil format which took approximately 30 minutes to administer. For this study, the researcher examined the number of misconceptions each student chose, resulting in scores from 0-13. Lower scores corresponded to fewer misconceptions. Although scores could be converted to a traditional 1-100 range, with higher scores demonstrating fewer misunderstandings, scores from the ASSCI were not designed to be used as a test score for student grades. The scores were only designed to evaluate the effectiveness of an intervention or to help teachers determine instructional activities to address misconceptions.

The researcher completed the requirements for the use of this assessment instrument. See Appendix E.

Procedures

The researcher obtained all permissions needed to conduct this study. These included IRB approval through the university and administrative permission at the study location. The IRB review determined that parental consent was not required since all study activities were based on normal classroom practices. Parents were notified that the study was being conducted through letters sent home before the study began. The researcher only received work coded with a student identifier assigned by and known only to the teacher, and no names or any other identifying student information was given to the researcher.

Once the needed permissions were obtained, the researcher met with administration and participating teachers to review the study and address any additional concerns. Participating teachers were randomly assigned to either the control or experimental group. The control group teachers were assigned to the space unit which incorporated an explanatory WTL task. The

experimental teachers were assigned to the space unit which utilized a narrative WTL task.

Since writing had been a focus at this school for the past two years, all teachers had participated

in professional development involving WTL activities. Additionally, two of the teachers have

participated in digital storytelling professional development and had agreed to redeliver the

training needed after teachers had been randomly assigned to the experimental group. When all

questions and concerns had been addressed, participating teachers administered the ASSIC

pretest. Following pretest administration, all teachers followed previously developed astronomy

unit lesson plans (see Appendix C experimental group lesson plans and Appendix D for control

group lesson plans). These units addressed the Georgia Performance Standards, S4E1 and S4E2,

which were the state's fourth grade science curriculum standards regarding space (see Appendix

B for the science standards addressed). The science unit covered six weeks based on 50 minute

class periods each day. After the third week of the space unit, all participating teachers began

the WTL assignment. However, the control group produced explanatory writing while the

experimental group produced narrative writing.

All six teachers followed the developed astronomy unit lesson plans so that all students

received the same science content presented through the same instructional methods and

completed the same instructional activities. This helped reduce the threat to internal validity that

could result from existing differences in the teachers and their instructional practices. After the

third week of the astronomy unit was completed, teachers started the assigned WTL activity.

Lesson plans for both the explanatory task and the narrative task followed the writing process

described by Waters (2014). The steps included planning, drafting, reviewing, and editing, with

the type of writing being the difference in this study. When a writing task was implemented as a

pedagogical strategy, teachers acted as facilitators. Their role followed the description by Tomas

and Ritchie (2015). Teachers introduced the writing task and clarified instructions so that students were aware of what they were to do. They assisted with research. Periodically during the writing process, they conferenced with students to review and provide feedback. They allowed for peer review and ensured time for revising and editing. With the addition of technology, teachers also helped with technical issues as they arose.

At the conclusion of the astronomy unit, teachers administered the ASSCI posttest.

Data Analysis

Data were collected over a six-week period. Classroom teachers administered the MOSART ASSCI via paper and pencil before beginning the astronomy unit. Tests did not include any identifying student information; instead there was a student identifier known only to the teacher. After administration of the pretest, all teachers delivered instruction as outlined in interdisciplinary unit lesson plans. Experimental treatment diffusion was controlled in several ways. First was the application of language arts standards for explanatory writing in the control group projects and language arts standards for narrative writing in the narrative group projects. These two sets of standards had different requirements which helped prevent diffusion of digital storytelling into explanatory projects. Secondly, both writing tasks integrated technology. This was a change from previous years when there were a variety of projects such as paper and pencil research papers, posters, tri-fold board projects, models, and computer-based presentations. Since both the control and experimental groups were completing technology-enhanced projects, there was less chance of experimental treatment diffusion than if one group was using technology while another group was not. At the conclusion of the astronomy unit, classroom teachers again administered the MOSART ASSCI via paper and pencil, using the same student identifiers as the pretest to ensure student privacy. Teachers provided the researcher with pretest

and posttest assessments. These assessments were coded by the teachers so that no identifying information was given to the researcher and student scores remained completely anonymous. The researcher was responsible for scoring and evaluation of pretests and posttests.

The researcher analyzed all resulting data using Analysis of Covariance (ANCOVA). ANCOVA was used because this procedure adjusted for preexisting differences between the control and treatment groups (Gall, Gall, & Borg, 2007). This was necessary because participants were not randomly assigned to a group; preexisting groups were used in this study. Therefore, the researcher could not ensure that the groups were equal in respect to prior knowledge of astronomy concepts. If one group already had a deeper understanding of astronomy concepts than the other group, differences in the scores from the MOSART ASSCI could be due to prior knowledge instead of the WTL assignment. ANCOVA allowed the researcher to account for a preexisting condition so that differences in results could be attributed to the testing variable. Since all ten assumptions for the use of ANCOVA were met, ANCOVA was used to analyze the data. Scores from the MOSART ASSCI pretest were used as the covariate, enabling the researcher to account for differences in the control and experimental groups caused by student prior knowledge. An alpha level of .05 was used for all statistical analyses. Since a statistically significant difference was found, the effect size was calculated using partial eta squared.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this study was to evaluate the effectiveness of a digital narrative Write To Learn (WTL) activity in reducing the number of misconceptions fourth grade students held about astronomy concepts when compared to the number of misconceptions held by students that completed an explanatory Write To Learn (WTL) activity. Chapter Four presents the analysis of the data collected for this study. Data was analyzed using IBM SPSS Statistics Version 25 to perform ANCOVA.

Research Question

RQ1: Is there a difference between the number of astronomy misconceptions held by students that participate in digital narrative writing tasks and the number of astronomy misconceptions held by students participating in digital explanatory writing tasks while controlling for pretest scores?

Null Hypothesis

The null hypothesis for the research question was:

H$_0$1: There is no statistically significant difference between the number of astronomy misconceptions held by students participating in digital narrative writing tasks and the number of misconceptions held by students participating in digital explanatory writing tasks while controlling for pretest scores as shown by the MOSART ASSCI.

Descriptive Statistics

The sample for this study consisted of fourth grade students who attended an elementary school located in the southeastern United States. There were 118 students who completed both the pre and posttest required for this study. The study population consisted of 72 male students

and 46 female students. Of these 118 students, 74 students identify as Caucasian, 39 as African-American, and 5 as another race. When divided into control and experimental groups, the control group consisted of 34 males and 22 females. Within this group, 35 identified as Caucasian, 18 as African-American, and 3 as another race. In the experimental group, there were 38 males and 24 females. Of these students, 39 identified as Caucasian, 21 as African-American, and 2 as another race.

The unadjusted descriptive statistics for the pretest and posttest scores of the control and experimental groups are listed in Table 4.1. Based on the unadjusted means, the control group had a mean of 8.09 misconceptions on the pretest while the experimental group had a mean of 8.00 misconceptions. For the posttest, the control group had a mean score of 7.25 misconceptions while the experimental group had a mean of 5.27 misconceptions.

Table 4.1

Unadjusted Descriptive Statistics for Control and Experimental Groups

Variable	Control: Explanatory WTL			Experimental: Narrative WTL		
	N	M	SD	N	M	SD
Pretest	56	8.09	1.61	62	8.00	2.07
Posttest	56	7.25	2.21	62	5.27	2.52

Results

Assumption Tests

Approval for the study was obtained in September 2018 from the IRB committee at Liberty University, the school district, and the school in which the study took place (see Appendices F). Participating classroom teachers were informed of the approvals in early

October. The MOSART ASSCI was chosen to act as both the pretest and the posttest. This assessment was chosen because it measured student understanding of astronomy concepts instead of student recall of astronomy facts. The pretest was administered in mid-October. The six-week Astronomy unit began after the administration of the pretest. At the conclusion of the Astronomy unit, the posttest was administered. Pre- and posttests were delivered to the researcher in early December.

IBM SPSS Statistics Version 25 was used to run ANCOVA statistical tests on the obtained data. However, for ANCOVA analysis to be valid, 10 assumptions had to be met. The first four assumptions were related to the study design. The first assumption was that the dependent variable produced data that was either interval or ratio. This assumption was met because the dependent variable was measured using the MOSART ASSCI, resulting in scores ranging from 0-13. The second assumption was that that there was one independent variable with independent categories. This assumption was met because the independent variable, type of writing assignment, had two categories. Students were either assigned to the control group, explanatory writing, or the experimental group, narrative writing, but no students were assigned to both groups. The assignment of students to an independent variable category also addressed the third assumption of independent observations. Data obtained from one group was independent of data obtained from the second group since no student produced both an explanatory and a narrative writing. A final assumption before data was analyzed was that the covariate produced data that was either interval or ratio. This assumption was also met since pretest scores from the MOSART ASSCI was used as the covariate. These scores ranged from 0-13.

Since these first four assumptions related to the study design and were met, data analysis

was performed to ensure the remaining six assumptions required for ANCOVA were also met. The first of these remaining assumptions was that the covariate was linearly related to the dependent variable at each level of the independent variable. There was a linear relationship between pre- and posttest scores for each level of the independent variable as assessed by visual inspection of a scatterplot. The next assumption was that there was no interaction between the covariate and the independent variable. This was visually confirmed since the lines obtained in the scatterplot were parallel but was also verified statistically. There was homogeneity of regression slopes as the interaction term was not statistically significant, $F (1, 114) = .344$ $p = .558$. The assumption of normality was met. Posttest scores were normally distributed for both the control group and the experimental group, as assessed by Shapiro-Wilk's test $(p > .05)$. The assumption of homoscedasticity of error variances was met. There was homoscedasticity, as assessed by visual inspection of the standardized residuals plotted against the predicted values. The homogeneity of variances was examined using Levene's test. There was homogeneity of variances, as assessed by Levene's test of homogeneity of variance $(p = .208)$. The final assumption was there were no significant outliers. There were no outliers in the data, as assessed by no cases with standardized residuals greater than ± 3 standard deviations. Since all 10 assumptions were met, ANCOVA could be used to analyze the collected data.

Hypothesis

Once all assumption tests were performed and requirements were met, ANCOVA was used to analyze the collected data. Once scores were adjusted to account for prior misconceptions as measured by the pretest, the control group $(M = 7.25, SE = 2.209)$ retained more misconceptions compared to the experimental group $(M = 5.27, SE = 2.52)$. Comparison of unadjusted and adjusted statistics are listed in Table 4.2.

Table 4.2

Unadjusted and Adjusted Means of Posttest Scores for Control and Experimental Groups

Group	N	Unadjusted		Adjusted	
		M	SD	M	SE
Control: Explanatory	56	7.25	2.209	7.24	.316
Experimental: Narrative	62	5.27	2.517	5.28	.300

Based on these adjusted scores, the experimental group had fewer misconceptions as identified

by the posttest than the control group. Further, there was a significant difference in the posttest

scores between the two groups, $F(1,115) = 20.25$, $p < .001$, partial eta squared = .150.

Table 4.3

Summary ANCOVA

Dependent Variable: posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
pretest	15.295	1	15.295	2.727	.101
group * pretest	1.932	1	1.932	.344	.558
Error	639.462	114	5.609		
Total	769.703	117			

a. R Squared = .169 (Adjusted R Squared = .147)

The null hypothesis for this study stated there would be no difference between the

number of misconceptions held by the control group, participating in the digital explanatory

WTL activity, and the experimental group, participating in the digital narrative WTL activity, as

determined by the MOSART ASSCI. However, analysis of the data using ANCOVA resulted in

a significant difference between the two groups when using an alpha level of .05, leading to a

rejection of the null hypothesis. After adjustment for pre-existing misconceptions, there was a statistically significant difference in the number of astronomy misconceptions held between the control, digital explanatory task, and the intervention, digital narrative task, $F(1, 115) = 20.25$, $p < .001$, partial eta squared $= .150$. The experimental group had statistically significant fewer astronomy misconceptions than the control group, however, the partial eta squared effect size value suggested low practical significance.

CHAPTER 5: DISCUSSION

Overview

Chapter 5 provides a discussion of the finding resulting from this study. The discussion begins with a summary of the statistical analysis. Next there is a discussion relating these results to the existing literature. The implications section of this chapter discusses how the results of this study could impact classroom instruction. Following this section, is a discussion of the limitations of this study. The chapter concludes with recommendations for future research.

Discussion

The purpose of this quantitative, quasi-experimental study was to address a gap in the literature by providing empirical data regarding the effectiveness of student-produced digital narratives on elementary students' understanding of science content when compared to the understanding of content by students producing digital explanatory writings. Analysis of the data collected during this study found a statistically significant difference in the number of astronomy misconceptions held by students participating in a digital narrative Write To Learn (WTL) task and the number held by students participating in digital explanatory WTL writing task, leading to the rejection of the null hypothesis. Although the partial eta squared value indicated that the effect size was small, these findings still support the use of digital storytelling as an instructional strategy to help change student misconceptions. Since misconceptions are difficult to change (Stamp & O'Brien, 2005; Wendt & Rockinson-Szapkiw, 2014), even a small reduction in the number of misconceptions held, as experienced by the students in this study who produced digital narratives, can be beneficial to the student.

As determined by the Partnership for 21st Century Learning (P21, 2015), to become successful citizens in the 21st century, students must develop skills in four areas. The first is mastery of academic content. Students must develop a deep understanding of concepts instead of a superficial recall of unrelated facts. The second area involves learning and innovation. Students need to be able to think critically, communicate their understanding and ideas, and collaborate with others in order to creatively solve problems. To succeed at this, students must be able to find and evaluate information and be able to use media and technology tools safely and responsibly. Finally, students must possess the ability to adapt to constantly changing conditions and be life-long learners who are self-directed, accountable, productive, and responsible.

Educators and policy makers are concerned with identifying and implementing instructional practices that will promote the skills needed by 21st century learners. Digital storytelling has been proposed as an instructional practice that would address a majority of these skills. Although a review of the literature uncovered numerous articles that support the use of digital storytelling to address 21st century skills, the number of articles based on empirical studies was limited and numerous gaps appeared in the literature. Before digital storytelling will be widely accepted or rejected, there must be a comprehensive body of empirical studies that provide evidence to its effectiveness, especially when used in traditional classroom settings.

One gap this study addressed was the use of digital storytelling in a regular classroom setting. Several earlier studies were found that supported the positive effects of digital storytelling but these were conducted in settings other than a normal classroom. For example, the case study by Anu et al. (2014) found that digital storytelling had a positive effect on student learning by allowing students to become self-directed learners who used technology for

information gathering, communication and collaboration. Additionally, these students practiced critical thinking skills as they creatively addressed the assigned task. However, the study by Anu et al. was conducted with mixed age groups as opposed to a traditional classroom setting. The current study was conducted in a traditional fourth grade classroom as the students participated in the science curriculum prescribed by the state board of education and resulted in the students producing digital stories having fewer misconceptions about astronomy concepts at the conclusion of the science unit than the students who produced digital explanatory writings.

Another gap this study addressed was the incorporation of technology into WTL tasks. Sinaga and Feranie (2017) found that when used in college classes, all the WTL tasks assigned in the study promoted learning but that the non-traditional tasks, such as narratives, supported deeper understanding while the traditional tasks, such as note taking, supported application. These findings were repeated in studies by Chen (2013) and Sampson et al. (2013). However, these studies did not incorporate technology into the WTL task and a survey by Ray et al. (2016) found that the majority of teachers did not incorporate technology into WTL tasks. The current study builds on the findings of these previous studies by incorporating technology into the WTL tasks to determine if the addition of technology still allows the WTL task to support increased learning. Even with the addition of the technology component into the writing task, the narrative writing produced greater understanding of the science concepts. Students who produced digital narratives held fewer misconceptions at the end of the science unit than did the students who produced digital explanatory writings.

This study also addressed a gap in the literature by providing quantitative measurement of science content acquisition. Studies, such as that by Yang and Wu (2012), showed positive results in content acquisition after participation in digital storytelling but these studies were in

content areas other than science. Another example of the use of digital storytelling to improve content acquisition was the study by Clarke and Adam (2010). That study found positive support of science content acquisition but the results were based on perceptions, not a quantitative measure of acquisition. The current study provided a quantitative measurement of science content acquisition by determining the number of misconceptions students corrected based on the MOSART ASSCI after participating in digital storytelling compared to the number corrected after participation in a digital explanatory task. The current study built on the study by Yang and Wu by showing growth in science content acquisition and on the study by Clarke and Adam by providing quantitative measures of that growth.

In addition to the gaps mentioned above, a literature review also revealed conflicting results when digital storytelling was used in support of science content acquisition. Hung et al. (2012) reported students participating in digital storytelling had improved science achievement over students participating in traditional projects. However, the study by Tan et al. (2014) contradicted those results. Tan et al. found no significant difference in science achievement between students participating in digital storytelling and the students in the control group. Additional studies were needed to either support improvement or confirm the lack of improvement. The current study supports the results of the study by Hung et al. and provides another contradiction to the study by Tan et al. In the current study, students who participated in digital storytelling showed statistically significant improvement in the number of astronomy misconceptions held over students who participated in digital explanatory writing.

In addition to the gaps in the literature that this study addressed, there were several insights gained from this study that may prove beneficial to educators and administrators considering implementing digital storytelling in their classrooms. One of the reasons the

teachers in this study were willing to participate was that students in their school had scored

lower in the area of science that than students at schools with similar demographics for several

years. To address this issue, these teachers participated in professional development based on

the reform efforts in science education. This professional development stressed hands-on

activities. Teachers integrated a number of hands-on activities that allowed students to work

together as they investigated scientific concepts into their lessons throughout the year. To help

evaluate the effectiveness of incorporating hands-on activities, the teachers had students

complete the MOSART ASSCI as a pretest before the unit started and again as a posttest at the

end of the unit. The teachers used a paired t-test to analyze the resulting scores and found that

there was no significant difference between the pretest and posttest scores. Since this

instructional strategy had not produced the desired results, teachers were searching for other

instructional strategies that would help improve student achievement. They agreed to participate

in the current study integrating WTL activities into the science curriculum. When the teachers

finished the astronomy unit in the current study, they were curious to see if the WTL activity in

which they participated made a difference in the pretest-posttest scores of the MOSART ASSCI.

A paired t-test of the pretest-posttest scores of the explanatory writing group found no

statistically significant difference between the scores. On the other hand, the narrative writing

group found there was a statistically significant difference between their students' pretest and

posttest scores. When the researcher used ANCOVA to compare the scores between the

explanatory writing and the narrative writing groups she found that there was a statistically

significant difference in the scores of the two groups but that the effect size was small. However,

since there was a change, even though it was small, it was deemed important considering there

had not been any change when either hands-on activities or explanatory writing activity had been used as an instructional strategy.

One possible explanation for the lack of improvement after the integration of hands-on activities was that the integration placed emphasis on the activity without recognizing the contribution writing made to the learning process. In a literature review, Bradbury (2014) found that when students participated in programs which integrated language arts standards and science activities, academic achievement scores were higher than programs that focused on a hands-on, inquiry based approach alone. Bradbury's findings reflect the experiences of the teachers who participated in this study. When they had used a hands-on activities approach, they did not see positive changes in science achievement scores but integrating the non-traditional WTL activity had produced positive results on the MOSART ASSCI. Then Sinaga and Feranie (2017) offer a possible explanation for why digital narratives provided greater change in the number of misconceptions held by students than digital explanatory writing. Sinaga and Feranie stated non-traditional writing, such as digital storytelling, tended to promote more active learning and resulted in deeper conceptual understanding. Traditional writing, such as the digital explanatory activity, tended to be a more passive learning activity and led to application but not necessarily understanding.

A second insight gained from this study involved teacher perceptions and professional development. Following the professional development designed to improve science achievement, the teachers began preparing for upcoming changes in curricula and standardized assessments that would place a greater emphasis on writing. Teachers participated in professional development designed to help teachers effectively implement Writers Workshop into their language arts curriculum. In addition, this professional development stressed the

importance of incorporating the WTL strategies from Writers Workshop across the curriculum. Furthermore, several interested teachers participated in a professional development strand involving digital storytelling. The digital storytelling professional development built on the previous professional development by adding the technology component to the Writers Workshop and WTL strategies teachers were implementing across the curriculum. When asked to participate in the current study, the teachers were willing because they had already started implementing WTL strategies into the language arts and social studies curricula and were planning to include these strategies in the science curriculum in the upcoming year. Teachers who had participated in the digital storytelling professional development were willing to redeliver that training to the other fourth grade teachers so that the study could have that technology component. They felt experience with technology was important since upcoming standardized tests would be administered on computers instead of paper and pencil versions. The teachers involved in the current study were willing to participate but in discussions with the teachers at the completion of the study, the researcher noticed a difference in the attitude of the teachers in the classrooms chosen for the explanatory writing compared to that of the teachers in classrooms chosen for narrative writing. Explanatory writing was the traditional type of writing used in science classrooms so for those teachers, the writing activity not only integrated smoothly into the curriculum, it specifically addressed standards related to how scientists work. However, narrative writing was not traditionally used in science classrooms. The teachers in the narrative writing classrooms had a harder time seeing narrative writing as a legitimate strategy for teaching scientific facts. They felt more as if the storytelling was an added activity instead of a learning activity. This difference in attitude may possibly have had an unforeseen impact on

the resulting data. Future studies may want to include professional development that would better prepare teachers to implement non-traditional writing activities into science curricula.

A third insight gained from this study involved the computer to student ratio. As mentioned above, interested teachers had participated in professional development on digital storytelling. These teachers were given enough computers to meet a one computer to four students ratio in their classroom with the understanding that they would implement a minimum of one digital storytelling project by the end of the school year. The required project was integrated into the social studies curriculum. Although the students were excited about these projects, teachers had difficulty getting the projects completed because of the limited computer access. Even though the students worked in groups and the first writing drafts did not require technology, other phases of the project required more computer access than was available when students had to share the computers. A one to four computer student ratio did not provide the computer access needed when students were trying to research their topic or when they were creating or searching for images for their story. However, before the current study was proposed, the school system adopted a one-to-one computer student ratio in grades three through twelve. Although the WTL activities in this study were scheduled to cover several weeks, the added computer access allowed the digital WTL activities to be completed within that allotted time. This was an improvement over the teachers' previous experience with digital storytelling where additional instructional time had to be scheduled in order for each student to have the access needed during certain phases of the project. Based on these two experiences, educators wanting to implement digital storytelling should be cognizant of the fact that classrooms without one-to-one computer access may require additional time for students to complete digital projects.

Implications

Results of the current study found a statistically significant difference between the number of misconceptions held by students in the digital narrative group when compared to the students in the digital explanatory group. However, the effect size was considered small. At first glance, it seemed that since the study showed a reduction in the number of misconceptions held by the digital storytelling group, the results supported the study by Hung et al. (2012) which also had growth in science achievement. Yet the small effect size meant that the difference held little practical importance. That fact could be used in support the study by Tan et al. (2014) that found no difference in science achievement after the use of digital storytelling. Despite these seemingly inconclusive results, there were other issues to consider when evaluating the results of the current study. The first was that students' science misconceptions are difficult to change (Stamp & O'Brien, 2005; Wendt & Rockinson-Szapkiw, 2014). Teachers at this study's site had experienced the difficulty of changing student misconceptions. Instructional activities used in previous years did not produce significant changes in students' misconceptions as measured by the MOSART ASSCI or on standardized assessments. Therefore, the fact that digital storytelling reduced the number of misconceptions held by students at the study site, even though the change was small, was considered to be meaningful. Consequently, these results did provide support for other studies which found digital storytelling to be an effective instructional method.

Another issue to consider was that when digital storytelling is implemented, numerous skills are supported simultaneously. Coe (2002) argued that effect sizes must be interpreted based on the benefits provided. Even a very small effect size could be significant, especially if the benefits were cumulative. Studies by Gyabak and Godina (2011) and Niemi et al. (2014) showed acquisition of technology skills. A study by Duveskog et al. (2012) showed digital

storytelling supported creativity while a study by Morris (2013) showed digital storytelling supported critical thinking. This study, along with that of Hung et al. (2012), showed increased content knowledge. Therefore, even though the effect size on content acquisition in this study was small, the use of digital storytelling as an instructional practice is worthwhile because of the numerous 21st century skills it promotes while improving content acquisition.

The results of this study will help other educators who are searching for effective instructional strategies for addressing science misconceptions. Since science misconceptions are so difficult to change, even small changes can prove to be beneficial to students. This study promotes digital storytelling as an effective instructional strategy when attempting to reduce those misconceptions. However, for this strategy to be effective, teachers must receive professional development in several different areas. The first area is the writing process and how to implement this into content area curricula. Teachers need to be able to instruct their students not only in the writing process but how to use that writing to further learning in that content area. The second area of professional development that will be needed is on digital storytelling. Teachers need to be familiar with the writing process and how to effectively integrate it into their content but also with the technical devices and programs needed to produce the digital story. The devices and programs that can be used are not only numerous but constantly changing so ongoing support should be provided. Finally, educators wanting to implement digital storytelling need to consider the available technology and how that availability will impact the instructional time needed to implement digital storytelling. Digital storytelling can be done as a group project, reducing the number of devices needed at the final compilation stage, but other stages of the process, such as the research and image search stages, require more student access. If students are sharing devices during these stages, the process takes longer to complete.

Limitations

There are twelve factors that can affect the internal validity of a study, however, different study designs can control or eliminate the effects of certain factors. The quasi-experimental pretest-posttest design chosen for this study controls for the majority of these factors. One factor that this study design does not control is selection. Since the participants in this study design are not randomly assigned to either the control or experimental group, this design is susceptible to pre-existing differences between the control and experimental groups (Gall et al., 2007). In the current study, this factor was addressed through the use of ANCOVA to statistically compensate the posttest scores for any differences that existed between the two groups at the beginning of the study.

Another factor that could have influenced this study was treatment diffusion since both the control and experimental groups were in the same building. The researcher felt this could be an issue if the control group completed a hand-written assignment while the experimental group used technology. To reduce the threat of treatment diffusion, both the control and experimental groups integrated technology into the WTL activity. This helped conditions in the two groups remain as close as possible and reduced this threat to internal validity.

A third factor which could have influenced the current study was compensatory rivalry. Since both the control and experimental groups were in the same building, the control and experimental groups could have seen this as a competition. However, since both groups were participating in writing activities that were designed to meet their grade level language arts standards, a competitive atmosphere between the two groups never developed.

In addition to the factors affecting internal validity, there are factors which can affect the external validity of the study. These factors can limit the ability of the research findings being generalized to other populations. One factor limiting the generalization of the current study was the small sample size. The researcher chose to conduct the study at only one school so that certain conditions could be controlled. These conditions included a strong focus on writing as a means of promoting learning and a commitment to integrating technology into the curriculum. The school where this study took place had chosen writing as a focus for the school over the past several years and continued this focus during the school year when the study took place. Staff participated in professional development in writing instruction, the use of writing as an instructional strategy, and writing across all curriculum areas during the previous years and continued that professional development focus during the current school year. Further, several interested teachers had participated in professional development which culminated with the production of digital stories and promoted its use in the classroom. In addition, the school district had committed to one-to-one student to technology ratio. The school system accomplished this one-to-one ratio for the fourth grade classrooms earlier in the fall before the study began. Since the researcher would have no control over the professional development focus or in the student-to-technology ratio, she chose to limit the study to one school to ensure conditions in the classrooms were as consistent as possible. However, this decision to limit the study to the one school also limited the generalization of the study results.

Another factor limiting the generalization of the current study was the limited diversity in the school body. The school population was 63% Caucasian, 33% African-American, and 4% are other ethnicities. Ethnicities represented in this other category were students of mixed race, students from Spanish-speaking countries, students from southern Asia and the Pacific Islands,

however, because of the small study population, there was only one student from each of these cultures. Storytelling occurs across all cultures but some value it more than others. A student's cultural background could have an influence on how effective digital storytelling was in promoting understanding for that student but it was not possible to evaluate that in this study because of the very limited number of students from different ethnicities that participated in this study.

Recommendations for Future Research

One recommendation for future study would be to evaluate the effectiveness of digital storytelling when teachers receive professional development on how to integrate the practice into the curriculum. Technological Pedagogical Content Knowledge (TPCK) was used as part of the theoretical framework for this study. In this study, the teachers had participated in professional development on the writing process and in technology. This professional development covered two of the branches of this theory. However, when talking with the teachers at the conclusion of the study, comments were made that led the researcher to believe that they still considered writing a digital story as an added activity instead of a learning experience. They did not understand how to integrate digital storytelling into the curriculum to achieve an effective overlap of pedagogy and technology as they addressed the content.

Another recommendation would be to examine the use of digital storytelling to enhance the learning of specific subgroups of the population. This study did not disaggregate data into specific subgroups to determine if digital storytelling was more effective when used with a specific subgroup. Additionally, the sample used in this study was unusual because over 60 percent of the participating students were male as opposed to the more common fifty-fifty ratio of males to females found in the general population. The sample was also limited in cultural

representation. The sample consisted mostly of Caucasian and African-American students with only five students identifying with any other culture. Future studies could examine the effectiveness of digital storytelling within a specific culture or gender to see if it would be an instructional practice to use with that subgroup.

A third area of future research could be the use of digital storytelling in other content areas. A review of the literature found several studies where digital storytelling was used for both primary and second language acquisition, however, the number of empirical studies addressing the use of digital storytelling to promote learning in other content areas was limited.

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APPENDICES

Appendix A

4th Grade English Language Arts Georgia Standards of Excellence (ELAGSE)

The following are the specific fourth grade English language arts standards which are addressed in this study.

Writing	4W

ELAGSE4W2:   Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

a. Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
b. Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
c. Link ideas within categories of information using words and phrases. (e.g., another, for example, also, because).
d. Use precise language and domain-specific vocabulary to inform about or explain the topic.
e. Provide a concluding statement or section related to the information or explanation presented.

ELAGSE4W3:   Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.
a. Orient the reader by establishing a situation and introducing a narrator and/or characters; organize an event sequence that unfolds naturally.
b. Use dialogue and description to develop experiences and events or show the responses of characters to situations.
c. Use a variety of transitional words and phrases to manage the sequence of events.
d. Use concrete words and phrases and sensory details to convey experiences and events precisely.
e. Provide a conclusion that follows from the narrated experiences or events. □

Speaking and Listening	4SL

ELAGSE4SL4:   Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

ELAGSE4SL5:   Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes

Language   4L

ELAGSE4L6: Acquire and use accurately grade-appropriate general academic and domain-specific vocabulary, including words and phrases that signal precise actions, emotions, or states of being (e.g., quizzed, whined, stammered) and words and phrases basic to a particular topic (e.g., wildlife, conservation, and endangered when discussing animal preservation).

Appendix B

4th Grade Science Georgia Standards of Excellence

Science Grade 4 Earth and Space Science Standards   **S4E**

S4E1:   Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets.

a. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky.
b. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others.
   (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.)
c. Construct an explanation of the differences between stars and planets.
d. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun.
   (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)

S4E2:   Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth.

a. Develop a model to support an explanation of why the length of day and night change throughout the year.
b. Develop a model based on observations to describe the repeating pattern of the phases of the moon (new, crescent, quarter, gibbous, and full).
c. Construct an explanation of how the Earth's orbit, with its consistent tilt, affects seasonal changes.

Appendix C

| The Stars and Our Solar System / WTL: Narrative |
| Unit Lesson Plans |

Focus Standards:
S4E1: Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets.

a. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky.
b. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others. (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.)
c. Construct an explanation of the differences between stars and planets.
d. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun.   (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)

S4E2: Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth.

a. Develop a model to support an explanation of why the length of day and night change throughout the year.
b. Develop a model based on observations to describe the repeating pattern of the phases of the moon (new, crescent, quarter, gibbous, and full).
c. Construct an explanation of how the Earth's orbit, with its consistent tilt, affects seasonal changes.

Enduring Understandings:

The patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons (Project 2061, p. 63).

Telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye (Project 2061, p. 63).

Planets change their positions against the background of stars (Project 2061, p. 63).

The earth is one of several planets that orbit the sun, and the moon orbits the earth (Project 2061, p. 63).

Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light (Project 2061, p. 63).

The Stars and Our Solar System / WTL: Narrative Conceptions	
Common Misconceptions:	Proper Conceptions:
1. Our solar system is an Earth-centered solar system in which the sun and planets revolve around Earth.	1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun.
2. The sun moves around the Earth, i.e. it rises in the East and sets in the West, to form day and night.	2. Day and night occur because the Earth rotates on its axis. Half of Earth, which faces the sun, has day; at the same time, the other half of the Earth has night. As the Earth rotates, the locations of Earth having day and night change.
3. The change of seasons occurs because the Earth revolves around the sun in an elliptical (oval-shaped) orbit. When Earth nears the sun, summer occurs; and when the Earth is farthest from the sun, winter occurs.	3. The change of seasons is caused by the tilt of the Earth and its position in relation to the sun as the Earth orbits the sun in almost perfect circles. For example, when the northern half of the Earth tilts toward the sun, summer occurs in the northern hemisphere and winter occurs in the southern hemisphere.
4. Planets and stars are alike.	4. Planets and stars are different in their appearance and motion.
5. All stars are alike.	5. Stars vary according to size and color.
6. The sun is the largest star in the sky.	6. The sun is a medium-sized star, but it appears larger than other stars because it is so close to Earth.
7. Constellations move across the sky at night.	7. Changes in the locations of constellations during the night are due to the rotation of Earth on its axis.
8. Earth's moon produces its own light.	8. Earth's moon reflects the light of the sun.
9. Lunar phases are caused by Earth's shadow being cast on the moon.	9. Different phases of the moon are observed because of the relative positions of the moon to the Earth.
10. The same stars can be seen during the entire year.	10. Different stars can be seen during different seasons.
11. There are thousands of stars in our solar system.	11. There is just one star in our solar system, i.e. the sun.

The Stars and Our Solar System / WTL: Narrative
Week 1

Standards:	Concepts:
S4E2: Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth. a. Develop a model to support an explanation of why the length of day and night change throughout the year. b. Develop a model based on observations to describe the repeating pattern of the phases of the moon (new, crescent, quarter, gibbous, and full). c. Construct an explanation of how the Earth's orbit, with its consistent tilt, affects seasonal changes.	2. Day and night occur because the Earth rotates on its axis. Half of Earth, which faces the sun, has day; at the same time, the other half of the Earth has night. As the Earth rotates, the locations of Earth having day and night change. 8. Earth's moon reflects the light of the sun.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science			KWL Intro to Space (PPT)	Earth's Motion PPT	Lesson 1 in Interactive Text: Day and Night Demonstration with Styrofoam balls and Earth

The Stars and Our Solar System / WTL: Narrative
Week 2

Standards:	Concepts:
S4E2: Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth. a. Develop a model to support an explanation of why the length of day and night change throughout the year. b. Develop a model based on observations to describe the repeating pattern of the phases of the moon (new, crescent, quarter, gibbous, and full). c. Construct an explanation of how the Earth's orbit, with its consistent tilt, affects seasonal changes.	1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun. 2. Day and night occur because the Earth rotates on its axis. Half of Earth, which faces the sun, has day; at the same time, the other half of the Earth has night. As the Earth rotates, the locations of Earth having day and night change. 3. The change of seasons is caused by the tilt of the Earth and its position in relation to the sun as the Earth orbits the sun in almost perfect circles. For example, when the northern half of the Earth tilts toward the sun, summer occurs in the northern hemisphere and winter occurs in the southern hemisphere. 8. Earth's moon reflects the light of the sun. 9. Different phases of the moon are observed because of the relative positions of the moon to the Earth. Resources: http://astro.unl.edu/naap/motion1/animations/seasons_ecliptic.html http://spaceplace.nasa.gov/oreo-moon/en/

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science: Section I	Lesson 1: Tilt and Seasons Fill in Interactive Text Use Models Online Applet	Lesson 1: Moon Phases Cut and Paste Moon Activity	Lesson 1: Chapter Review in Textbook	Oreo Lab	Lesson 1 Vocabulary Quiz Magic School Bus: Space

	The Stars and Our Solar System / WTL: Narrative Week 3				

Standard:
 	
S4E1:   Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets.
 	
   a. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky.
   b. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others. (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.)
   c. Construct an explanation of the differences between stars and planets.
   d. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun.   (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)
			Concepts:
			
			1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun.
			
			4. Planets and stars are different in their appearance and motion.
			
			11. There is just one star in our solar system, i.e. the sun.		

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science	Inner Planets Slideshow with Graphic Organizer	Outer Planets Slideshow with Graphic Organizer	Solar System Sort (using organizer)	Scale Model of Solar System Activity	*Crater Lab*

The Stars and Our Solar System / WTL: Narrative		
:---:		
Week 4		

Standard:	Concepts:

S4E1:   Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets.
 	
   a. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky.
   b. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others. (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.)
   c. Construct an explanation of the differences between stars and planets.
   d. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun.   (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)
	1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun.
	
	4. Planets and stars are different in their appearance and motion.
	
	11. There is just one star in our solar system, i.e. the sun.

Supporting Standards:

ELAGSE4W3:   Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

ELAGSE4W4:   Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

ELAGSE4W5:   With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.

ELAGSE4W6:   With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.

ELAGSE4W8:   Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science / WTL: Narrative	Crater Lab Demonstration Explanation of Digital Story on Space Identify student groups	Scale Model of Solar System Activity Group Work on Project Begin plans for story by deciding on characters and situation/problem	Review: Solar System Media Center: Research for additional facts to include	Interactive Text Lesson 2 Group work on story Focus: decide on information to include in story	Stars Presentation Group work on story Focus: event sequence

	The Stars and Our Solar System / WTL: Narrative
	Week 5

Standard:	Concepts:

S4E1:   Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets.
   a. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky.
   b. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others. (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.)
   c. Construct an explanation of the differences between stars and planets.
   d. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun.   (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)
	5. Stars vary according to size and color.
	
	6. The sun is a medium-sized star, but it appears larger than other stars because it is so close to Earth.
	
	7. Changes in the locations of constellations during the night are due to the rotation of Earth on its axis.
	
	10. Different stars can be seen during different seasons.
	
	11. There is just one star in our solar system, i.e. the sun.

Supporting Standards:

ELAGSE4W3:   Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

ELAGSE4W4:   Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

ELAGSE4W5:   With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.

ELAGSE4W6:   With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.

ELAGSE4W8:   Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science / WTL: Narrative	Stars/ Constellations Lesson 3 in Interactive Text	Groups begin editing space stories – focus on narrative elements of character, situation/problem, and sequence of events Peer review of stories and edit as needed	Meet with each group - focus on accuracy of included information Groups complete final edits and begin storyboarding	Begin converting to digital format	Finalize digital stories Begin working on study guides

The Stars and Our Solar System / WTL: Narrative
Week 6

Focus Standards: S4E1: Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets. S4E2: Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth.	Concepts: Review of concepts 1-11

Supporting Standards:
ELAGSE4W3:   Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

  a. Orient the reader by establishing a situation and introducing a narrator and/or characters; organize an event sequence that unfolds naturally.
  b. Use dialogue and description to develop experiences and events or show the responses of characters to situations.
  c. Use a variety of transitional words and phrases to manage the sequence of events.
  d. Use concrete words and phrases and sensory details to convey experiences and events precisely.
  e. Provide a conclusion that follows from the narrated experiences or events.

ELAGSE4W4:   Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

ELAGSE4W5:   With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.

ELAGSE4W6:   With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.

ELAGSE4W8:   Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science / WTL: Narrative	Complete digital stories Complete study guide	Project Presentations Peer feedback / discussion	Project Presentations Peer feedback / discussion	Review Game: Space Jeopardy	Space Unit Test

Appendix D

<div style="text-align: center">

The Stars and Our Solar System / WTL: Explanatory
Unit Lesson Plans

</div>

Focus Standards:
S4E1:   Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets.

  e. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky.
  f. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others. (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.)
  g. Construct an explanation of the differences between stars and planets.
  h. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun.   (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)

S4E2:   Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth.

  d. Develop a model to support an explanation of why the length of day and night change throughout the year.
  e. Develop a model based on observations to describe the repeating pattern of the phases of the moon (new, crescent, quarter, gibbous, and full).
  f. Construct an explanation of how the Earth's orbit, with its consistent tilt, affects seasonal changes.

Enduring Understandings:

The patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons (Project 2061, p. 63).

Telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye (Project 2061, p. 63).

Planets change their positions against the background of stars (Project 2061, p. 63).

The earth is one of several planets that orbit the sun, and the moon orbits the earth (Project 2061, p. 63).

Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light (Project 2061, p. 63).

The Stars and Our Solar System / WRL: Explanatory Conceptions	
Common Misconceptions:	Proper Conceptions:
1. Our solar system is an Earth-centered solar system in which the sun and planets revolve around Earth.	1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun.
2. The sun moves around the Earth, i.e. it rises in the East and sets in the West, to form day and night.	2. Day and night occur because the Earth rotates on its axis. Half of Earth, which faces the sun, has day; at the same time, the other half of the Earth has night. As the Earth rotates, the locations of Earth having day and night change.
3. The change of seasons occurs because the Earth revolves around the sun in an elliptical (oval-shaped) orbit. When Earth nears the sun, summer occurs; and when the Earth is farthest from the sun, winter occurs.	3. The change of seasons is caused by the tilt of the Earth and its position in relation to the sun as the Earth orbits the sun in almost perfect circles. For example, when the northern half of the Earth tilts toward the sun, summer occurs in the northern hemisphere and winter occurs in the southern hemisphere.
4. Planets and stars are alike.	4. Planets and stars are different in their appearance and motion.
5. All stars are alike.	5. Stars vary according to size and color.
6. The sun is the largest star in the sky.	6. The sun is a medium-sized star, but it appears larger than other stars because it is so close to Earth.
7. Constellations move across the sky at night.	7. Changes in the locations of constellations during the night are due to the rotation of Earth on its axis.
8. Earth's moon produces its own light.	8. Earth's moon reflects the light of the sun.
9. Lunar phases are caused by Earth's shadow being cast on the moon.	9. Different phases of the moon are observed because of the relative positions of the moon to the Earth.
10. The same stars can be seen during the entire year.	10. Different stars can be seen during different seasons.
11. There are thousands of stars in our solar system.	11. There is just one star in our solar system, i.e. the sun.

The Stars and Our Solar System / WTL: Explanatory Week 1				

Standards:

S4E2:   Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth.

d. Develop a model to support an explanation of why the length of day and night change throughout the year.
e. Develop a model based on observations to describe the repeating pattern of the phases of the moon (new, crescent, quarter, gibbous, and full).
f. Construct an explanation of how the Earth's orbit, with its consistent tilt, affects seasonal changes.

Concepts:

2. Day and night occur because the Earth rotates on its axis. Half of Earth, which faces the sun, has day; at the same time, the other half of the Earth has night. As the Earth rotates, the locations of Earth having day and night change.

8. Earth's moon reflects the light of the sun.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science			KWL Intro to Space (PPT)	Earth's Motion PPT	Lesson 1 in Interactive Text: Day and Night Demonstration with Styrofoam balls and Earth

		The Stars and Our Solar System / WTL: Explanatory Week 2		

Standards:

S4E2:   Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth.

 d. Develop a model to support an explanation of why the length of day and night change throughout the year.
 e. Develop a model based on observations to describe the repeating pattern of the phases of the moon (new, crescent, quarter, gibbous, and full).
 f. Construct an explanation of how the Earth's orbit, with its consistent tilt, affects seasonal changes.

Concepts:

1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun.

2. Day and night occur because the Earth rotates on its axis. Half of Earth, which faces the sun, has day; at the same time, the other half of the Earth has night. As the Earth rotates, the locations of Earth having day and night change.

3. The change of seasons is caused by the tilt of the Earth and its position in relation to the sun as the Earth orbits the sun in almost perfect circles. For example, when the northern half of the Earth tilts toward the sun, summer occurs in the northern hemisphere and winter occurs in the southern hemisphere.

8. Earth's moon reflects the light of the sun.

9. Different phases of the moon are observed because of the relative positions of the moon to the Earth.

Resources:
http://astro.unl.edu/naap/motion1/animations/seasons_ecliptic.html
http://spaceplace.nasa.gov/oreo-moon/en/

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science	Lesson 1: Tilt and Seasons Fill in Interactive Text Use Models Online Applet	Lesson 1: Moon Phases Cut and Paste Moon Activity	Lesson 1: Chapter Review in Textbook	Oreo Lab	Lesson 1 Vocabulary Quiz Magic School Bus: Space

The Stars and Our Solar System / WTL: Explanatory
Week 3

Standard:	Concepts:

S4E1: Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets.
 	
  e. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky.
  f. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others. (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.)
  g. Construct an explanation of the differences between stars and planets.
  h. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun.   (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)
	1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun.
	
	4. Planets and stars are different in their appearance and motion.
	
	11. There is just one star in our solar system, i.e. the sun.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science	Inner Planets Slideshow with Graphic Organizer	Outer Planets Slideshow with Graphic Organizer	Solar System Sort (using organizer)	Scale Model of Solar System Activity	*Crater Lab*

The Stars and Our Solar System / WTL: Explanatory Week 4	

Standard:
S4E1: Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets.
  e. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky.
  f. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others. (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.)
  g. Construct an explanation of the differences between stars and planets.
  h. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun.   (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)
	Concepts:
	1. Our solar system is a sun-centered system in which the planets, including Earth, revolve around the sun.
	
	4. Planets and stars are different in their appearance and motion.
	
	11. There is just one star in our solar system, i.e. the sun.

Supporting Standards:

ELAGSE4W2:   Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
  a.   Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
  b.   Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
  c.   Link ideas within categories of information using words and phrases. (e.g., another, for example, also, because).
  d.   Use precise language and domain-specific vocabulary to inform about or explain the topic.
  e.   Provide a concluding statement or section related to the information or explanation presented.
ELAGSE4W4:   Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
ELAGSE4W5:   With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.
ELAGSE4W6:   With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.
ELAGSE4W8:   Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science / WTL: Explanatory	Crater Lab Demonstration Explanation of Explanatory writing on Space Identify student groups	Scale Model of Solar System Activity Group Work on Project Begin plans for writing by organizing information	Review: Solar System Media Center: Research for additional facts to include	Interactive Text Lesson 2 Group work on explanatory writing Focus: decide on information to include and how to organize it	Stars Presentation Group work on explanatory writing Focus: expanding details

The Stars and Our Solar System / Explanatory Writing Week 5	
Standard: S4E1: Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets. e. Ask questions to compare and contrast technological advances that have changed the amount and type of information on distant objects in the sky. f. Construct an argument on why some stars (including the Earth's sun) appear to be larger or brighter than others. (Clarification statement: Differences are limited to distance and size, not age or stage of evolution.) g. Construct an explanation of the differences between stars and planets. h. Evaluate strengths and limitations of models of our solar system in describing relative size, order, appearance and composition of planets and the sun. (Clarification statement: Composition of planets is limited to rocky vs. gaseous.)	Concepts: 5. Stars vary according to size and color. 6. The sun is a medium-sized star, but it appears larger than other stars because it is so close to Earth. 7. Changes in the locations of constellations during the night are due to the rotation of Earth on its axis. 10. Different stars can be seen during different seasons. 11. There is just one star in our solar system, i.e. the sun.

Supporting Standards:
ELAGSE4W2:   Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
  a. Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
  b. Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
  c. Link ideas within categories of information using words and phrases. (e.g., another, for example, also, because).
  d. Use precise language and domain-specific vocabulary to inform about or explain the topic.
  e. Provide a concluding statement or section related to the information or explanation presented.
ELAGSE4W4:   Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
ELAGSE4W5:   With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.
ELAGSE4W6:   With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.
ELAGSE4W8:   Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 10:30 Science / WTL: Explanatory	Stars/ Constellations Lesson 3 in Interactive Text	Groups begin editing writing – focus on organization, transitions, and accuracy of facts Peer review of writing and edit as needed	Meet with each group - focus on organization and accuracy of included information Groups complete final edits and begin outlining digital presentation	Begin developing digital presentations	Finalize digital presentations Begin working on study guides

The Stars and Our Solar System / WTL: Explanatory
Week 6

Focus Standards:	Concepts:
S4E1: Obtain, evaluate, and communicate information to compare and contrast the physical attributes of stars and planets. S4E2: Obtain, evaluate, and communicate information to model the effects of the position and motion of the Earth and the moon in relation to the sun as observed from the Earth.	Review of concepts 1-11

Supporting Standards:
ELAGSE4W2:   Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
   a.   Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings, illustrations, and multimedia when useful to aiding comprehension.
   b.   Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
   c.   Link ideas within categories of information using words and phrases. (e.g., another, for example, also, because).
   d.   Use precise language and domain-specific vocabulary to inform about or explain the topic.
   e.   Provide a concluding statement or section related to the information or explanation presented.
ELAGSE4W4:   Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
ELAGSE4W5:   With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.
ELAGSE4W6:   With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.
ELAGSE4W8:   Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:40 – 11:00 Science / WTL: Explanatory	Complete digital presentations Complete study guide	Project Presentations Peer feedback / discussion	Project Presentations Peer feedback / discussion	Review Game: Space Jeopardy	Space Unit Test

Appendix E

MISCONCEPTIONS-ORIENTED STANDARDS-BASED ASSESSMENT RESOURCES FOR TEACHERS

ABOUT MOSART | **TUTORIALS** | TEST INVENTORY | MOSART FAQ | RESOURCES

TUTORIALS

☑ What is a misconception?

☑ How are these tests different?

☑ How do I use the tests?

☑ How do I interpret the results?

TEST ACCESS

Request Tests

☐ Not yet completed ☑ Completed
Note: The grades 9-12 life science test file is now in the Test Inventory.

Congratulations, Pam Wimpey!

You've completed all four MOSART tutorials. We hope that it is helpful as you go on to use the tests in your classes.

You may now download the MOSART tests that are currently available, and if you return in the future you will have access to any and all additional tests as they are released.
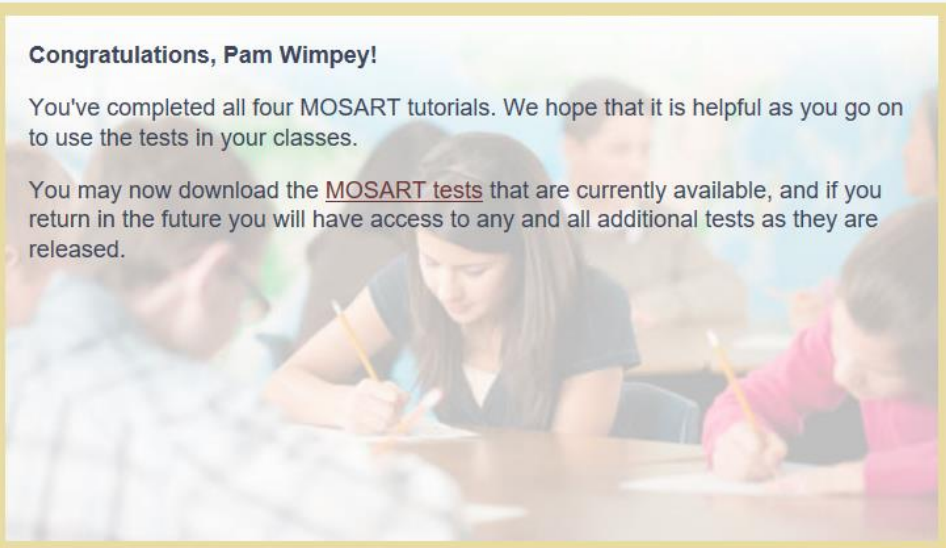
Home   Video Archive   Contact Us   Privacy   Site Map   Credits

Appendix F

IRB, IRB
Wed 8/8/2018, 8:39 AM

Dear Pamela Wimpey,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under exemption category 46.101(b)(1), which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:101(b):

> (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Please retain this letter for your records. Also, if you are conducting research as part of the requirements for a master's thesis or doctoral dissertation, this approval letter should be included as an appendix to your completed thesis or dissertation.

Your IRB-approved, stamped research statement is also attached. This form should be copied and used to inform parents and students of your research.

Please note that this exemption only applies to your current research application, and any changes to your protocol must be reported to the Liberty IRB for verification of continued exemption status. You may report these changes by submitting a change in protocol form or a new application to the IRB and referencing the above IRB Exemption number.

If you have any questions about this exemption or need assistance in determining whether possible changes to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
The Graduate School

Liberty University | Training Champions for Christ since 1971

From: ██████████████ @doe.k12.ga.us>
Sent: Monday, March 26, 2018 9:30 AM
To: Wimpey, Pamela
Subject: RE: asking for copyright permission

Ms. Wimpey,

See below from our legal Department.

> This correspondence serves as notification that the Georgia Department of Education (GaDOE) grants limited permission to you to use the following in your dissertation and appendices: (1) the chart of misconceptions and proper conceptions found on page 3 of the Grade 4 Georgia Performance Standards Framework for Science entitled "The Stars and Our Solar System"; (2) the earth and space science standards S4E1, S4E2, and S4E3 found at https://www.georgiastandards.org/Georgia-Standards/Documents/Science-Fourth-Grade-Georgia-Standards.pdf; and (3) the fourth grade writing standards ELAGSE4W2, ELAGSE4W3, ELAGSE4SL4, ELAGSE4SL5, and ELAGSE4SL6 found at https://www.georgiastandards.org/Georgia-Standards/Frameworks/ELA-Grade-4-Standards.pdf.

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██████████████

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