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The Impact of Virtual Field Trip Programs on Elementary Students' Interest in Science Domains and STEM Fields

Jasmin Roberts Poor

THE IMPACT OF VIRTUAL FIELD TRIP PROGRAMS ON ELEMENTARY STUDENTS' INTEREST IN SCIENCE DOMAINS AND STEM FIELDS

by

Jasmin Roberts Poor

Bachelor of Arts
Michigan State University, 2004

Masters of Arts in Education
Western Carolina University, 2008

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Accepted by:

Lucas Vasconcelos, Major Professor

Ismahan Arslan-Ari, Committee Member

Fatih Ari, Committee Member

Tracey L. Weldon, Interim Vice Provost and Dean of the Graduate School

DEDICATION

This dissertation is dedicated to my family. To my husband for supporting me in every way, to my children for watching me work and giving me hugs when I needed them, and to my mom, brother, and friends for being great sounding boards.

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ABSTRACT

The number of science, technology, engineering, and mathematics (STEM) jobs available in the United States will soon outnumber those qualified to fill them, and there is a decrease in the number of students pursuing STEM careers. Promoting students' interest is an effective way to influence career choices. Field trips offer students hands-on, experiential learning opportunities that have an impact on students' interest levels. Yet, not every teacher can take field trips due to logistical, financial, and geographical constraints. Standards-based virtual field trips are a promising strategy to support student interest in science, STEM fields, and meet the educational needs of teachers and students. The purpose of this action research was to determine the impact that virtual field trip programs have on elementary students' interest in specific science domains and STEM fields. This convergent parallel mixed methods study was guided by the following questions: (1) Do virtual field trip programs affect participants' interest in specific science domains and why?, (2) Which activities are most interesting for students during a virtual field trip program offered by the science center and why?, and (3) Do virtual field trip programs affect participants' interest in STEM fields and how?

A total of 19 third and fourth grade study participants were enrolled in camp at a sports community center. Throughout the study, participants attended four standards-based virtual field trip programs related to chemistry, geology, meteorology, and astronomy. Quantitative data was collected through Likert-type pre- and post- surveys and qualitative data was collected from focus-group interviews and open-ended surveys to evaluate participants' interest. Findings from this study, though not statistically significant, suggest that participants' interest had a modest increase following virtual field trip programs in all science domains and STEM. Qualitative findings also revealed that participants with an initial interest in a science domain expressed an increased interest in the science domain following the virtual field trip. Findings regarding activities indicated that participants enjoyed working with professionals, hands-on, active lessons, and taking a role in the scenario. This research has implications for the impact that virtual field trips have on participants' interest. Recommendations are provided for virtual field trip design and future research.

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CHAPTER 1

INTRODUCTION

National Context

The number of science, technology, engineering, and mathematics (STEM) jobs available in the United States will soon outnumber those qualified to fill them (CoSTEM & National Science and Technology Council, 2013). Businesses in STEM fields have expressed concerns that students within the United States lack STEM literacy, knowledge, and understanding of scientific and mathematical processes (Trust, 2014). For the past two decades there has been increased discussion of teaching STEM in the elementary years to prepare students for future careers (Madden et al., 2016). However, American students are behind other nations when comparing test scores within STEM related fields (CoSTEM & National Science and Technology Council, 2013; Trust, 2014). CoSTEM and the National Science and Technology Council (2013) support an increase in STEM education within America; “Increasing opportunities for young Americans to gain strong STEM skills is essential if the United States is to continue its remarkable record of success in science and innovation” (p. 1). This call to action supports efforts to improve and increase opportunities within STEM fields for students around the United States. While many government initiatives place lofty goals for student outcomes, they don’t always focus on specific teaching practices and methods to achieve these goals (Kloser, 2014; Windschitl et al., 2012).

Interest is a major determiner when students select future careers (Ahmed et al., 2017). Research conducted on eighth grade students by Cwikla, Lasalle, and Wilner (2009) suggested that students interested in science were significantly more likely to pursue science related careers than students with no interest in science. If we want to tackle the issue of preparing American students for jobs within STEM fields, we need to focus on increasing their interest within science, technology, engineering and mathematics. While a main goal for science education over the past fifty years has been to increase interest in science (Richardson, 1971), the interest and enthusiasm for science within students has been shown to decline as students get older (Osborne et al., 2003; Resnick & Zurawsky, 2005; Toma & Greca, 2018). This decline begins at the elementary level (Jarvis & Pell, 2002; Krapp & Prenzel, 2011; Murphy & Beggs, 2003; Osborne et al., 2003; Tröbst et al., 2016). Declining student interest in science is very concerning (Christidou, 2006) and is manifesting in standardized testing. The most recent report from the Nation's Report Card shows a decrease in students scoring at or above grade level on science standardized tests across fourth grade (38%), eighth grade (34%), and twelfth grade (22%) (NAEP, 2015). Efforts need to be taken to combat this decline in order for the demand of STEM jobs to be met.

Science, as a subject, encompasses many different dimensions including biology, chemistry, and physics. Within schools, it can be taught as an integrated class, like in elementary school, or a specific science domain, like biology in later years. Interest has been identified as a domain specific construct. That is, students innately have interest and more confidence in some academic domains compared to others (Hidi & Renninger, 2006; Jansen et al., 2019; Krapp, 2002). Students have shown there are many factors that contribute to their science interest including specific science topics and activities (Christidou, 2006). Research has shown students can have varying interest levels even across science domains, providing value to identifying interest within each science domain individually (Jansen et al., 2016, 2019). The Nations Report Card also breaks down science within domains of physical, earth, and life sciences (NAEP, 2015).

In attempts to increase students' interests, efforts in science education are being made to place students as active constructors of conceptual understanding rather than passive memorizers of information (Tröbst et al., 2016). This shift in educational theory has shown to have a positive impact on students' academic performance when comparing 2009 to 2015 scores of both fourth and eighth grade students (NAEP, 2015). Promoting interest through instructional practices is within teacher control which provides promise for educational reform (Jack & Lin, 2014; Tröbst et al., 2016; Turner et al., 2014). Teachers are now in the role of facilitators tasked with providing opportunities for students to engage with inquiry-focused science activities (Windschitl et al., 2012) and supporting students in scientific discourse and argumentation (Kloser, 2014). Previous research has shown that providing students with opportunities to engage with science concepts positively affects their science interest (House, 2006; Swarat et al., 2012; Tröbst et al., 2016).

In this time of science educational reform, increased emphasis is being placed on the method of instruction as well as the learning environment (Groen, 2009; Nolen, 2003). Field trips have been part of the elementary school experience for many years. Teachers continue to include trips for students into their plans to extend learning, reinforce skills, and expose students to real-life experiences (Klemm & Tuthill, 2002).

These experiences have been shown to have a positive impact on student interests within science (Behrendt & Franklin, 2014). However, teachers admit that there are many obstacles that prohibit them from taking their classes on field trips including geographic, financial, logistical, and time constraints (Cassady et al., 2008; Shrock, 2014; Whitesell, 2016). All teachers may face these issues regardless of their school district and geographic location.

With the advances in technology over the years, we now have alternative options for traditional field trips (Stoddard, 2009). Many cultural institutions utilize technology to provide distance learning opportunities or virtual field trips for students (Gaylord-Opalewski & O'Leary, 2019). When used effectively, technology can open students to new experiences and places and many of the obstacles that teachers face with a traditional field trip no longer apply (Cassady et al., 2008). Teachers do not need to schedule buses, procure signed field trip permission forms, schedule chaperones, or miss valuable educational time in the classroom. Virtual field trips provide a valid option when traditional field trips are not feasible.

Research conducted by Stinson (2001) found that virtual experiences of fifth graders were just as valuable as the experiences of students who attended a museum in person. Virtual field trips can support students by having similar gains with lower costs to families and schools (Stinson, 2001). Positive impacts for students included increased interest in science when students participated in a videoconference virtual field trip with SeaTrek (Ba & Keisch, 2004). With the increase of security concerns as well as the cost of transportation, virtual field trips can provide a method of satisfying these concerns (Hehr, 2014; Stinson, 2001) as well as providing an engaging way for students to gain content knowledge (Sweet, 2014). However, there is a lack of research on virtual field trips and, specifically, student perceptions of virtual field trips and their impact on students' interest.

There is value to virtual field trips and a need for program offerings that pique participants' interest and also educate teachers and students about the value of different domains of science and STEM. They provide a wonderful opportunity for reaching all students regardless of geographic location and providing them with the same experiences as other students, creating true equality in education. Though, just attending a virtual field trip does not guarantee success. It is important to evaluate, specifically, what makes a virtual field trip successful in increasing student interest. It is important that we address the impact virtual field trip programs have on participants' interest so that we can understand if the lessons are effective.

Local Context

It is the vision of the science center, the location for this study, to be the pinnacle of innovative learning, an engine for community engagement, and a national leader in science education (Roper Mountain Science Center, 2018). During the 2017 school year, 52.3% of South Carolina students did not meet South Carolina science standards on the end-of-year SC-PASS science test (South Carolina Department of Education, 2018). Classroom teachers feel overwhelmed with classroom responsibilities, the emphasis on standardized test scores, and feel they need more support (Tye & O'Brien, 2002). The science center provides virtual field trips as resources for teachers to address science and social studies standards within certain grades. If the programs offered are going to be the pinnacle of resources, it is important that virtual field trip programs offer experiences that pique participants' interest. If the science center's programs can increase participant interest in science, it can positively impact student achievement (Grabau & Ma, 2017) and the likelihood of participants pursuing a STEM career (Roberts et al., 2018).

Since 2004, virtual field trips have been offered through the science center. The current virtual field trip programs most closely fall into Zanetis's (2010) and Newsome's (2013) definition of virtual field trips as a live interactive program taught by a content provider to a classroom with videoconferencing technology. The virtual field trip department within the science center has a unique mission to educate and inspire learners of all ages to explore and investigate the world of science and technology. The philosophy is that learning should be enjoyable as well as challenging. Offered learning experiences are interdisciplinary and incorporate science, technology, mathematics, social studies, and language arts (Roper Mountain Science Center, 2018). In order to support sustainability and growth of the virtual field trip department, it must produce high-quality science education programs that are standards-based and interesting to students. If programs are not of the highest quality, the department will not be a leader in science education, will not support higher interest and achievement for participants, nor will it be a resource for students who might not have the chance to visit the science center in person.

It is a belief of the science center that all students deserve the opportunity to participate in the programs (Roper Mountain Science Center, 2018). Without the virtual field trip department, that might not be the case for students due to geographic and other factors. Through the virtual field trip program, the science center is able to connect and promote science to students from all over North America. Every teacher in South

Carolina receives a discounted price on the virtual field trip programs offered and locals schools, within the county, can attend free of charge. In order for the science center to continue this effort, we need to provide the best quality programs for students and teachers. It is the belief of the science center that continuous improvement is fundamental to our success (Roper Mountain Science Center, 2018).

As mentioned, there are many articles and research focused on how technology can promote student interest, but none specifically concentrates on programs utilizing videoconferencing technology and the activities that are most effective. To date, the science center has not formally documented if the virtual field trip programs are interesting to the students. Teachers receive basic surveys following programs requesting feedback, though many surveys go unanswered and only focus on the teacher's feelings, not those of the participants. As an instructor, I can see when students appear interested in an activity through my view of the classroom on the TV monitor but, to date, students have never been directly asked about their perceptions and opinions in a standardized fashion. Student opinions would provide valuable information for improving our current programs as well as developing new programs.

Statement of Problem

The science center has no formal data on the impact virtual field trip programs have on students' interest in specific science domains and activities covered within our programs. This is concerning since research shows that students' increased interest in STEM fields can impact career choices (Swarat et al., 2012). The majority of the science center's lessons focus on elementary age participants, which has also been identified as an age where students' interest in science declines. Furthermore, Greenwood (1991) suggested that specific forms of instruction, like using movies or one-on-one activities, rather than just exposure to instruction, could have a big impact on students' engagement with learning.

Virtual field trips have a unique way of capturing the attention of today's cyber-literate generation while at the same time addressing standards (Rubin, 2007). Ensuring students' interest can be a challenge for a 45-minute virtual field trip session. The programs offered by the science center attempt to capture students' interest while also being enjoyable. However, are programs offered by the science center interesting to students? This question has yet to be evaluated. It is important that the programs at the science center are enjoyable for participants, offer opportunities for interaction, and capture the interest of the participants. The science center strives to provide participants with opportunities to experience science by seeing it, being curious about it, and interacting with it with a hope of increasing participant understanding of how science works while sparking their interest (Ba & Keisch, 2004). To determine the success of our program we need to identify if we are meeting our goal of capturing the interest of participants during our lessons with the material.

During 2020's main shift to online learning due to the COVID-19 pandemic, it has never been more important to evaluate the impact that virtual field trips have on student interest. During the pandemic, teachers and students have been thrust into the virtual world. The virtual field trip department and program offerings should be a resource for quality virtual instruction, utilizing the best techniques that elicit the greatest levels of student interest and engagement during programs.

Purpose Statement

The purpose of this action research was to determine the impact that the science center's virtual field trip programs have on participants' interest in specific science domains and STEM fields. Activities within the programs were also assessed to determine how the format of programs affected participant interest.

Research Questions

Three research questions guided this research:

RQ1. Do virtual field trip programs affect participants' interest in specific science domains and why?

RQ2. Which activities are most interesting for students during a virtual field trip program offered by the science center and why?

RQ3. Do virtual field trip programs affect participants' interest in STEM fields and how?

Statement of Research Subjectivities and Positionality

I am the virtual field trip teacher/coordinator at the science center, a position that I have held for over four years. In this position, I work with schools all around North America. When I began at the science center, we had three virtual field trip programs. Over the past four years, I have developed over 15 programs for elementary and middle school students in various areas of science. Prior to my position at the science center, I worked as a virtual charter school employee holding various positions ranging from teacher to family engagement coordinator during my five years with the school. I have also taught third grade in a brick-and-mortar classroom. I love learning and always dreamed of going back to school and completing a graduate degree. Being a parent of a ten-year-old and eleven-year-old gives me a new purpose with education. I want to model good habits and show them my love of learning.

Throughout my teaching career, I have embraced technology. Although new technology can cause growing pains for teachers and students alike as we learn to adapt to an evolving educational landscape, I am always excited to embrace something new that will support students. I believe that educational technology should be used to enhance education, but it must be used in a meaningful way. Empowering students to figure things out and provide support is a powerful lesson for them.

I am a problem solver and seek solutions that best fit the task. I like to work smarter, not harder. This aligns with the mixed methods approach to this research as well as my world view as a pragmatist (Creswell, 2014). Pragmatism allows researchers to use deductive or inductive research approaches. It “supports the use of a mix of different research methods as well as modes of analysis and a continuous cycle of abductive reasoning while being guided primarily by the researcher’s desire to produce socially useful knowledge” (Feilzer, 2010, p. 6). Pragmatic researchers are like architects in that they use whatever materials they need to construct their building, and whichever method is most appropriate for collecting data (Dudovskiy, 2019; Wilson, 2014).

The virtual setting of this research does provide unique challenges, especially as I identify as an insider (Herr & Anderson, 2005). I created the materials, implemented the programs, and conducted the research. This required me, as the researcher, teacher, and coordinator of the department at the science center, to be deeply involved with both the research, development, and implementation of the programs.

When I present lessons, I am removed physically which could provide barriers between the students, teachers, and myself. In many ways, I am an outsider to their environment. This transactional distance can be seen as a positive for bias. By being removed from the environment, the researcher does not have direct contact with the students and can potentially remain objective. Yet this separation between researcher and participants can also be a negative when trying to truly understand a situation. As recommended by Mertens (2009), I made every attempt to be sure that I was very clear with my expectations and worked to develop open relationships with participants throughout the research time This proved to be challenging due to the unforeseen and continually-evolving pandemic-related protocols. In order to gather meaningful data on the programs available through the science center, the research was conducted over the summer when participants could experience multiple programs and allow for dialogue about their experiences. This summertime atmosphere allowed me to develop relationships with the participants by supporting their ability to feel comfortable expressing their opinions to me over a weeklong camp atmosphere. This facilitated meaningful discussions and evaluations on more than one program over a longer period. Through this mixed method research design, a deeper understanding of the impact that virtual field trip programs have on students' interest was developed.

As a department of one, I am greatly vested in the success and effectiveness of the program. I am also fully aware of all the facets of the program and methods that we currently use to promote participant interest during programs. As recommended by Boog et al. (2019), I made every attempt to be transparent and accountable for all stages in the research process regardless of the results. Throughout this research, I acknowledged the role that my own perceptions played in the research (Wilson, 2014). The relationship and value of the participants is very important in axiology, which refers to the nature of ethical behavior and values that guide research (O'Gorman & McIntosh, 2015). It is very important that the researchers uphold ethical behavior towards humans in their study. It is also important how they design their research and conduct it in reference to their own assumptions. For example, within action research, "The values of the researcher are imposed through the overt attempt to effect a particular kind of change" (O'Gorman & McIntosh, 2015, p. 70). In acknowledging our own biases and beliefs as researchers, we may fully understand our own research and provide quality data for our audience.

Definition of Terms

Astronomy is **"**the study of objects in our solar system and beyond" (SCDE Office of Standards and Learning, 2018, p. 27).

Chemistry is "The study of matter and the changes that it undergoes (Buthelezi et al., 2008). Student-friendly definition included three states of matter and how heat affects them.

Field Trip is defined as a visit made by students and a teacher for purposes of firsthand observation (Merriam-Webster, 2020)**.** Further described by Gillett (2011) "Field trips are guided activities for students that offer experiences interacting with materials and in situations that were not normally found in the school setting" (p. 174). Behrendt and Franklin's (2014) definition states that field trips are educational tools used to connect students to classroom concepts or standards.

Geology "deals with the history of the earth and its life especially as recorded in rocks" (Merriam-Webster, n.d.).

Interest is a “psychological state and a predisposition to reengage particular disciplinary content over time that develops through the interaction of the person and his environment” (Renninger & Hidi, 2011, p. 170).

Meteorology “the study of the Earth’s atmosphere and, in particular, its climate and weather” (Bingham, 2014, p. 153).

Science domains include areas of science for this study: astronomy, chemistry, geology, and meteorology.

STEM is the acronym for science, technology, engineering, and math, an area that has been identified by the United States government as a high priority area to support in schools (CoSTEM & National Science and Technology Council, 2013). For this research, the definition of STEM will refer to the integration of more than one STEM field (Glancy & Moore, 2013). Furthermore, STEM “education refers to solving problems that draw on concepts and procedures from mathematics and science while incorporating the team work and design methodology of engineering and using appropriate technology (Shaughnessy, 2013, p. 324).

Virtual Field Trip is a live, interactive program taught by a content provider to a classroom through the use of video conferencing technology (Newsome, 2013; Zanetis, 2010).

CHAPTER 2

LITERATURE REVIEW

The purpose of this action research was to determine the impact that the science center's virtual field trip programs have on participants' interest in specific science domains and STEM fields. Activities within the programs were assessed to determine how the format of programs affected participant interest. In an effort to evaluate if there was a change in interest levels of students after virtual field trips, the research questions developed for this research are: (1) Do virtual field trip programs affect participants' interest in specific science domains and why?, (2) Which activities are most interesting for students during a virtual field trip program offered by the science center and why?, and (3) Do virtual field trip programs affect participants' interest in STEM fields and how?

This literature review focuses on previous research and articles that have addressed questions similar to the research questions for this study. Five main topics identified from the research questions that guided this literature search were: (1) virtual field trips, (2) situational interest, (3) instructional activities, (4) science instruction, and (5) STEM. The literature for this review was collected through multiple methods. Searches through the library of South Carolina's online databases including *ERIC*, *Education Source*, and *JSTOR* provided valuable articles and book offerings. *Google Scholar* was also used to search for key terms. Keywords used included virtual field trips, electronic field trips, field trips, interest, situational interest, science education, elementary, fourth grade, activities, activity-based learning, constructivism, and technology. See Table 2.1 for a complete list of key terms used during the literature search.

Attempts were made to limit searches to more recent findings, but when searches did not provide recent research, search terms were broadened. Finally, each article was mined for additional resources, which were accessed through the online databases using University of South Carolina's library website. Multiple resources were attained through the Interlibrary Loan service offered by University of South Carolina's library system including books, articles, and chapters.

Table 2.1. *Search Terms Used Within the Literature Research*

Virtual Field Trips	Interest	Science Education	STEM
• Virtual field trips • Electronic field trips • Field trips • Synchronous • Video conferencing • Zoom • Informal learning	• Situational interest • Interest • Enjoyment • Engagement	• Elementary science education • Science teaching • Science lessons • Active science lessons • Science • Science learning	• STEM instruction • STEM programs • STEM education

Note: The searches conducted within the University of South Carolina Library System contained multiple searches with keywords from multiple categories in an attempt to find previous studies that addressed multiple keywords.

Throughout this process, two virtual meetings were held with a resource librarian, and two additional email communications were sent requesting specific support for resources identifying expected cognitive abilities of fourth-grade students (when searching University of South Carolina's library multi-search using keywords was not eliciting relevant responses). The librarian's suggestion, *PsycINFO,* provided multiple related articles, of which three proved to relate to this study. Suggested keywords included brain development and cognitive development. With additional support from a professor, specific age ranges were also applied to the search.

The review of this literature addresses the main variables within this study: (1) virtual field trips, (2) interest, (3) science activities, and (4) STEM. The literature for each of these topics will be discussed as well as how it connects to the purpose of this action research study. First, the review of literature discusses STEM fields and science domain education, then field trips. Next, learning theories applicable to virtual field trip implementation are identified and explained. Following, a definition of interest is provided and further discussed in terms of situational interest and interest towards virtual field trip activities.

Science Domains

In public schools in the United States, science is taught starting in Kindergarten and encompasses many different domains or fields. Within elementary grades many different science domains or fields, such as earth science and physical science, are taught throughout the year, as evidenced by the South Carolina Science Standards (South Carolina Department of Education, 2018). Throughout elementary school, science topics are integrated into one class (Jansen et al., 2019). The National Survey of Science and Math Education research completed by Weiss (1994) on teachers' feelings about math and science teaching showed that many elementary teachers do not feel qualified to teach all of these subjects. Only 25% felt that they were well qualified to teach science and only spent around 27 minutes per day on science. This is a cause for concern if we are expecting elementary teachers to spark the students' interest in science.

Previous studies have shown that students view domains of science differently (Wang & Berlin, 2010) and differentiate between domains of science when reflecting on interest (Hardy, 2014; Jansen et al., 2014). Jansen et al. (2016, 2019) further study also confirmed that students have varying interest levels across science domains providing value to identifying interest within each science domain individually. This also applies to academic achievement within science domains. In South Carolina, for example, students in fourth grade take the South Carolina Palmetto Assessment of State Standards (SCPASS) science test. The statewide academic proficiency results provide data for five different domains within the test including: (1) Science and Engineering practices, (2) Earth Science- encompassing weather and climate, (3) Earth Science- encompassing stars and the solar system, (4) Physical Science-including forms of energy including light and sound, and (5) Life Science- referring to characteristics and growth of organisms (SC Department of Education, 2019). The statewide results show varying levels of proficiency across the different domains with more than 60,254 students tested. Over 48% of fourth-grade students tested in 2019 received results indicating low performance in science. Just under 30% of fourth-grade students tested showed low performance in science and engineering practices and 36.2% showed low performance in Earth Science: Weather and Climate. The Nations Report Card also breaks down science into domains of physical, earth, and life sciences (NAEP, 2015).

STEM Fields

STEM is the acronym for science, technology, engineering, and math, an area that has been identified by the United States government as a high priority area to support in schools (CoSTEM & National Science and Technology Council, 2013). STEM education refers “to solving problems that draw on concepts and procedures from mathematics and science while incorporating the team work and design methodology of engineering and using appropriate technology” (Shaughnessy, 2013, p. 324). In the 1990s, the National Science Foundation introduced the concept of STEM (Bybee, 2010; Sanders, 2009). Though typically referenced as science or math, STEM should, by definition and design, include all fields including technology and engineering (Bybee, 2010). This suggests that teaching STEM lessons should be an integration of all the fields of STEM (English, 2016; Madden et al., 2016; Sanders, 2009). For this research, the definition of STEM will refer to the integration of more than one STEM field (Glancy & Moore, 2013).

The likelihood that students will pursue a STEM career depends largely on their interest in STEM fields and careers (Unfried et al., 2015). Increasing student interest in STEM careers begins with getting students interested in STEM fields from an early age (DeJarnette, 2012; Jones et al., 2019; Jones et al., 2020). If students can become interested in STEM content in elementary school, they will be prepared to undertake STEM curriculum at the middle and high school levels and to enter a STEM degree program in college (DeJarnette, 2012). Though this need for STEM education is widely accepted, there is little knowledge on the best way to accomplish it (Toma & Greca, 2018).

The learning environment where STEM lessons take place has shown to have a great impact on students’ perceptions and attitudes towards science (Toma & Greca, 2018). Research has shown that interventions focused on STEM using hands-on activities are effective in developing interest (Carino, 2019) while traditional science teaching approaches (Oh & Yager, 2004) and rote learning do not support positive attitudes towards science (Hacieminoglu, 2016). One way that educators are effectively implementing STEM education within the classroom is through attempting to solve real-world problems and packaging the curriculum in a multidisciplinary way, connecting the students to the real-world (English, 2017). English (2019) focused on the importance of integrating STEM assignments across subjects to enhance existing curriculum versus adding to it. In her four-year longitudinal study on fourth-grade students, she focused on integrating science, math, and design. Her project-based approach allowed students to explore the roles of designers and shoe manufactures, experiment with materials, and develop their own shoe materials. Results showed that elementary students, with proper scaffolding, could successfully work through the design process. This integration of STEM fields has the potential to increase interest for students in all STEM careers (Sanders, 2009).

STEM learning does not only take place in a school setting with a teacher. Opportunities for students to engage with science through experiences, like museums and science centers, have been a determiner in students' increased interest in STEM fields as well as a dividing factor for students pursuing science careers among socioeconomic status (Archer et al., 2012). In a five-year qualitative research study with over 9,000 kids and teens between nine to fourteen years old conducted by Archer et al. (2012), the impact of familial experiences was investigated. Though it was explained that children's views of science are complex, it was determined that families play an important role in shaping ideas of possible future careers for students. Those from middle class families had more opportunities offered to them to pursue their interest with science compared to working class families who did not have the same guidance from their parental figures, since it was not deemed that science was as essential to their lives (Archer et al., 2012). Jones et al. (2020) also found similar findings in their research regarding the importance of family support in access to science and STEM resources. This divide of equity in regards to access and success in STEM fields is a global issue (English, 2017). In the United States, there has been an increase in STEM focus since the Obama administration to support this discrepancy in socioeconomic status (DeJarnette, 2012). It is of utmost importance that STEM education be emphasized in school for all students, beginning early, to capture their interest.

Informal learning environments have been shown to be successful in increasing student interest in STEM and their chances of pursuing a STEM career (Roberts et al., 2018). Museums, science centers, out of school experiences, and television shows all play a part in informal learning (Krishnamurthi & Rennie, 2012). In a study conducted by Denson et al. (2015), the impact of an informal learning environment was investigated when STEM-based programs were provided for underrepresented students in California. The results showed that the program was effective in recruiting, retaining, and encouraging the students to pursue STEM careers. However, not every student has the opportunity to pursue STEM programming after school hours in an informal environment due to many factors, including time and availability of programs. This puts additional emphasis on the importance of including STEM activities and opportunities for students within the school setting.

Field Trips

Field trips have long been a staple of many school experiences (Kenna & Russell, 2015; Melber, 2008). They are educational tools used to connect students to classroom concepts and standards (Behrendt & Franklin, 2014) and can provide students with hands-on learning experiences (Cassady et al., 2008), which offer a framework for other learning to be built upon (Gillett, 2011; Noel, 2007). Field trips can provide experiential learning for students through the use of authentic tasks and experiences that offer students real-world applications for their thinking (Cassady et al., 2008; Stoddard, 2009). These authentic tasks provide relevance and meaning, which has been shown to support students in the construction of new knowledge (Gillett, 2011; Kenna & Potter, 2018).

Field trips provide opportunities for students to increase their interest in science and STEM. Authentic learning opportunities and experiential activities have been shown to develop student interest in a variety of domains (Behrendt & Franklin, 2014). Teachers utilize field trips to promote student-driven construction of knowledge through interaction with different places, experts, and artifacts (Stoddard, 2009). They are intended to connect classroom learning to the real world (Cassady et al., 2008) and can stimulate students' science interest and strengthen observations while promoting social development (Behrendt & Franklin, 2014). Through authentic real-world application of experiences, field trips have the opportunity to tie in multiple STEM fields.

During field trips, all students in attendance share experiences as a group. This allows teachers to reflect back on shared learning experiences, and it can be built on throughout the year. Shared experience and knowledge is especially important when there are varied demographics within the class (Shrock, 2014). By providing all students with the same experience, science and STEM field trips can help bridge the divide for students who may not have had prior opportunities to partake in science and STEM activities outside of school. Even with all of the value field trips provide, the number of field trips that students take each year is declining (Behrendt & Franklin, 2014; Kenna & Russell, 2015). This is due to a variety of factors including lack of funds, high-stakes testing demands, prohibitive schedules, distance and travel time, issues with accessibility for students with special needs, limited supporting resources like chaperones, and safety and liability issues (Hehr, 2014; Lei, 2015; Lukes, 2014; Noel, 2007; Wallis, 2011; Whitesell, 2016).

Virtual Field Trips

Many educators have turned to technology to overcome hurdles imposed by traditional field trips (Gillett, 2011; Hehr, 2014). Through technology, teachers are able to provide their students with new experiences, such as connecting with people and places through videoconferencing or using the internet to access websites (Zanetis, 2010). Connections with experts in an academic area or professionals in the workforce can open students up to authentic situations and possible career choices. Locations including museums, science centers, and zoos provide opportunities for students to visit places they may not get to visit in person. Virtual field trips are an example of using technology in a meaningful way. Stoddard (2009) summarized the potential allure of a virtual field trip by saying, “it is easy to imagine the flexibility and logistical powers of going on a field trip without leaving the school building” (p. 415). State initiatives require teachers to increase technology use within the classroom; however, increased technology does not guarantee success. It is how that technology enables teaching and learning that determines true successful integration (Mcknight et al., 2016). This makes quality virtual field trip offerings particularly attractive to teachers (Gillett, 2011; Kenna & Potter, 2018), and may even provide opportunities for teachers who are reluctant users of technology

(Stoddard, 2009). In addition to providing access and interaction with technology, virtual field trips can offer an alternative to traditional field trips (Cassady et al., 2008; Gaylord-Opalewski & O'Leary, 2019; Kenna & Potter, 2018; Stoddard, 2009) and provide possibilities for homebound students with medical issues (Raths, 2015) or disabled students to partake in a field trip experience (Sweet, 2014). However, it is important to realize they cannot replace traditional field trips (Cassady et al., 2008; Gaylord-Opalewski & O'Leary, 2019).

Virtual field trips allow teachers to provide opportunities for students within their controlled environment and remove many logistical factors from the experience for both teachers and students. They can offer access to locations that otherwise would be impossible to be visited on traditional field trips (Stoddard, 2009) such as the International Space Station or distant places (Zanetis, 2010a). Shrock (2014) also highlighted the benefits of virtual field trips for children in lower socioeconomic groups by providing opportunities to visit other places they might not get to see in their day-to-day life, allowing them to begin to bridge the poverty gap.

Virtual field trips can provide opportunities for students to engage in authentic, experiential learning lessons while also meeting state, national, and technology standards in a safe, affordable, and accessible manner (Kenna & Potter, 2018b; Zanetis, 2010). They can provide opportunities for educators and learners to access materials, resources, and experts that are beyond the scope of the classroom (Cassady et al., 2008; Gaylord-Opalewski & O'Leary, 2019). Melber (2008) believes that "when the focus is on active learning and connection to authentic experience, a 'field trip' can take place almost anywhere" (p. 129).

Methods of Connection

There are two main types of virtual field trips: synchronous and asynchronous (Gaylord-Opalewski & O'Leary, 2019; Kenna & Potter, 2018). Synchronous virtual field trips connect participants with an instructor in a different geographical location in real time (Gillies, 2008; Kenna & Potter, 2018). They use live video chat technology (videoconferencing), which is becoming increasingly more accessible and is regularly used in personal, educational, and professional environments (Mitchell et al., 2019). Synchronous virtual field trips are typically mediated through tools like Zoom, Google Meets, Skype, or another video communication platform (Gaylord-Opalewski & O'Leary, 2019). Videoconferencing is defined by Krutka and Carano (2016) as "synchronous audio and video communication between participants from two or more geographic sites" (p. 110) where students can ask questions and interact with the presenters (Bergin et al., 2007; Gaylord-Opalewski & O'Leary, 2019; Zanetis, 2010). In virtual field trips, students have the opportunity to learn directly from experts in the field (Kenna & Potter, 2018). Experts from many museums and cultural institutions, as well as other organizations, provide outreach through virtual field trip offerings. This provides the organization with a way of reaching different audiences from around the world compared to those that may attend personally or during a school-sponsored field trip (Gaylord-Opalewski & O'Leary, 2019).

Within synchronous virtual field trip experiences, there are two main formats utilized: point-to-point and multipoint connections. Point-to-point connections allow one group from a single location to connect with the presenter (Zanetis, 2010) while a multipoint connection allows multiple participants in multiple locations to communicate with a presenter (Gaylord-Opalewski & O'Leary, 2019). Typically, multi-point connections are less interactive than point-to-point connections due to primarily relying on a chat box for communication and questioning from participants verses video connection (Gaylord-Opalewski & O'Leary, 2019). This is due to potentially large numbers that can attend a multi-point program where it would not be feasible for all participants to provide a video feed of themselves and have audio connections with the presenter which may take away from the others participating in the program as well as potentially causing bandwidth problems. The science center, the setting for this study, utilizes a point-to-point connection with the majority of the programs presented.

Asynchronous is another format of virtual field trips where students and instructors are not connected in real time (Sweet, 2014). Essentially, asynchronous virtual filed trips involve websites that include audio, text, and video resources about specific topics (Zanetis, 2010) with one-way communication (Warden et al., 2013). This method allows students to passively observe but not interact with a presenter, for example, a virtual tour of the Smithsonian. Asynchronous virtual field trips can vary greatly in their substance, quality, and educational relevance (Zanetis, 2010).

A few previous studies have researched the benefits for students when using this asynchronous format (Ishtaiwa & Emirates, 2012; Kenna & Potter, 2018; Sweet, 2014). Cassady et al. (2008) conducted research on an asynchronous program from Ball State University called *Into the Canyon* that was created with a partnership between National Park Foundation and National Park Service. They had over 2,200 responses from children across the United States with even gender representation across 22 states. Results showed that students who completed all three parts of the educational components within the virtual field trip scored higher on a 32-item test on the Grand Canyon than those who only partook in one of the educational component offerings. Haris and Osman (2015) were able to link their asynchronous virtual field trip offering with higher learning achievement of students that participated compared with their control group who were taught through traditional methods.

More recently another virtual field trip format became available through the use of augmented or virtual reality (Brown & Green, 2016; Hehr, 2014; Kenna & Potter, 2018). Augmented reality allows a combination of real-world components captured through a camera and multimedia elements including images, text, three dimensional models, and animation (Huang et al., 2019; Martín-gutiérrez et al., 2015). Where augmented reality incorporates virtual objects into a physical space, virtual reality blocks out information from the physical environment and allows users to experience an entirely virtual world (Huang et al., 2019). Virtual reality helps immerse students in the content through the use of computer visualization techniques using virtual worlds displayed on a computer screen or through the use of a head-mounted three dimensional headset (Cheng & Tsai, 2019). Both augmented and virtual reality can require additional equipment, like headsets and programs. While it is important to highlight the different delivery formats for virtual field trips, the present study will evaluate virtual field trips using videoconferencing methods (Gaylord-Opalewski & O'Leary, 2019; Kenna & Potter, 2018; Zanetis, 2010).

Pedagogical Benefits of Virtual Field Trips

One primary benefit for virtual field trips is the ability to connect teachers and students with materials, expertise, and resources they normally would not have access to

(Cassady & Mullen, 2006). Teachers and students are now able to be connected with international collaborators from anywhere in the world and have the opportunity to learn about new careers and practice skills they may use in the future (Raths, 2015). This exciting break from the day-to-day classroom learning can be used to spark memorable real-world experiences that can solidify the curriculum in their minds (Zanetis, 2010). It is important to realize, though, that neither traditional nor virtual field trips can guarantee authenticity, interactive experiences, or success of the students due to variances of programs and offerings (Stoddard, 2009). To provide the most valuable experience for students, teachers need to incorporate the field trip experience into the curriculum goals of the classroom (Cassady et al., 2008; Noel, 2007).

While virtual field trips are very promising for providing opportunities for students to engage in experiential learning (Klemm & Tuthill, 2003), it is important that we examine how they are created and the activities utilized. Many program offerings provided on the internet are not regulated and do not always use the most up to date pedagogical practices (Zanetis, 2010). Content experts, not traditionally trained educators, create many virtual field trips offered by museums. When attempting to provide the highest quality virtual field trip offering, it is important to examine learning theories as they apply to virtual field trips.

Theoretical Background

Videoconferencing is typically seen as a mode of lecture style teaching, which is not ideal in today's teaching pedagogy (Gillies, 2008). However, with appropriate pedagogy, activities, and content ties to the classroom curriculum, virtual field trips can have significant impacts on student learning (Hehr, 2014). In order for virtual field trips to be successful, they must be properly designed utilizing effective learning theories (Lei, 2015). This section covers learning theories and how they apply to virtual field trip programs. First, constructivism is discussed as it applies to virtual field trips. Next, experiential learning is examined with a lens towards virtual field trips. In order to support a constructivist approach while providing experiential learning opportunities for students, the science center's programs are goal-based. This method will be described as it applies to providing authentic opportunities for students to engage with the curriculum.

Constructivism

As we begin looking at virtual field trip program offerings as well as the activities included for students to interact during them, it is important to identify appropriate learning theories that can be applied. There are many implications for learning and instruction that stem from a constructivist approach to learning (Mestre, 2005). Constructivism originated from John Dewey, Jean Piaget, Lev Vygotsky, and Howard Gardner who believe learning is an active process where students construct their own knowledge based on their experiences (Cetin-Dindar, 2016). The goal of any program should be to engage learners by creating opportunities for them to construct and make sense of their knowledge. Virtual field trips can offer a constructivist learning environment during the program wherein students build upon their previous knowledge (Cochran et al, 2017). Through quality virtual field trips, students can be provided with activities to discover scientific concepts by applying logical thought to results of interactions with objects and phenomena (Murphy, 2012). Proudfoot and Kebritchi's (2017) study using a mobile STEM lab utilizing a constructivist approach produced findings to support the use of authentic situations having a positive impact on fifth-grade students' STEM interest and achievement.

Active participation of students is very important when developing a constructivist approach to learning (Rubin, 2007). The best environment for constructivist learning is one where the students are actively thinking about and applying the knowledge during instruction, not passively listening to material presented to them (Mestre, 2005). Virtual field trips can embed learning in real-world, relevant contexts, engaging students in rich, multimedia environments (Cassady & Mullen, 2006; Rubin, 2007) and allow for active participation. Direct experience in learning gives students opportunities to engage with information in real-life scenarios, allowing deeper learning to take place (Cassady et al., 2008). Constructivism emphasizes the need for students to actively think about and apply their knowledge during lessons (Mestre, 2005). Kolb (1984) states, "learning is the process whereby knowledge is created through the transformation of experience" (p. 38). Previous studies suggest that learning activities that provide concrete experiences combined with active experimentation lead to the greatest degree of individual learning (Cassady et al., 2008). In order for this learning to occur there must be some level of activity on the part of the learner.

Experiential Learning

The emphasis on active learning supports the use of experiential learning (Behrendt & Franklin, 2014; Kolb, 1984) which encourages authentic, first-hand, sensory-based learning. Experiential learning has been shown to increase student interest, knowledge, and motivation (Behrendt & Franklin, 2014). Kolb's (1984) experiential learning theory has four stages that must be completed before true learning can occur.

The first stage is concrete experience, which focuses on creating a new experience or situation to be encountered or a reinterpretation of an existing experience. This includes students participating in hands-on, active, and engaged experiences. The second stage is reflective observation, which suggests learners reflect back on experience and draw a conclusion. It is also implied they will reflect on any inconsistencies between experience and their understanding or previous knowledge. The third stage is abstract conceptualization, which occurs when the learner attempts to place experience and new knowledge in their own schema or modify an existing schema from their learned experience. Finally, the fourth stage is active experimentation and encourages learners to test their conceptualization through further experimentation and investigation with the world around them. This can be achieved through post-activities provided to the teacher following the virtual field trip program. This includes opportunities to continue the learning beyond the connection (Cassady et al., 2008; Kenna & Potter, 2018; Stoddard, 2009). Cassady et al. (2008) state that field trip experiences are the most meaningful when teachers make references to the experience as an anchor for future content. They also state that when multiple learning resources are associated with the curriculum optimal learning can occur.

Goal-Based Scenarios

The science center virtual field trip programs are story- or scenario-based in order to provide meaningful opportunities for authentic tasks that allow the students to engage with the content (Gonda et al., 2015). This utilizes the characteristics of Goal-Based Scenarios, developed by Robert C. Shank, which focus on learning by doing (Campbell & Monson, 1994). Components of Goal-Based Scenarios, as defined by Campbell and

Monson (1994) that are addressed in virtual field trips at the science center include: (a) students are presented with a motivating and challenging end goal created to support them in building upon prior knowledge and skills, (b) the environment is authentic, and skills are not taught in isolation, but incorporated in the context of the goal and experience with a focus on learning and reflecting on acquired knowledge by using authentic tasks utilizing teamwork.

Authentic tasks have been shown to make learning meaningful for students by providing opportunities for the transfer of learning (Kenna & Potter, 2018). Students were more motivated to learn science when they had more opportunities to relate science with real world issues. Therefore, science educators should emphasize more on the connectedness of science at school to real life for motivating students to learn science (Cetin-Dindar, 2016). Goal-Based Scenarios teaching provides a real-world context for instruction where students are immersed in the scenario to support their understanding of the content (Gonda et al., 2015). Melber (2008) suggested “current research, national standards documents, and even national tests indicate a need for authentic, inquiry-based experience for elementary students” (p. 9). There needs to be a focus on inquiry that not only allows students to develop their critical thinking and problem-solving skills but also better understand the work of real scientists (Melber, 2008).

It is difficult to determine academic growth of participants after a virtual field trip program due to discrepancies in prior knowledge. There are a number of factors that could affect results when investigating a relationship between a virtual field trip program and academic achievement. Puhek et al. (2012) attempted to compare the knowledge attained during a traditional field trip and a virtual field trip. The findings produced from their study suggested that the knowledge gained by students is greatly dependent on the situation and teacher more so than the method of instruction, virtual or traditional. They also suggested future research should focus on student motivational levels gained during field trips verses academic gains. Since it has been shown that science interest is linked to student achievement (Grabau & Ma, 2017), Hehr (2014) suggested the focus of research shift to increasing and assessing interest in the subjects to determine success of a program.

Interest

In order to promote students to choose careers related to science and STEM areas, we need to develop their interest in these areas (Kang & Keinonen, 2018). Interest has been identified as a key factor for student motivation and learning outcomes (Ainley et al., 2002; Jansen et al., 2016; Kang & Keinonen, 2018; Krapp, 2002). Renninger and Hidi's (2011) review of recent research on interest concluded that interest is recognized to be a "critical cognitive and affective motivational variable that guides attention, facilitates learning in different content areas for learners of all ages, and develops through experience" (p. 169). There does not appear to be one definition for the term and idea of interest among educational psychologists (Boekaerts & Boscolo, 2002; Feilzer, 2010; Jones, 2009; Renninger & Hidi, 2011; Swarat et al., 2012). One commonality among most definitions is that interest is a "psychological state and a predisposition to reengage particular disciplinary content over time that develops through the interaction of the person and his environment" (Renninger & Hidi, 2011, p. 170) and most agree it is directed towards an object, activity, field of knowledge, or goal (Krapp & Prenzel, 2011).

Interest is considered a domain specific construct (Hidi & Renninger, 2006; Jansen et al., 2019; Kang & Keinonen, 2018; Krapp, 2002) meaning that it is specific to subject areas. Students may have more individual interest in a particular domain, therefore more specific topics of that domain, covered within the classroom, may draw on that interest (Ainley et al., 2002). Interest within science can be for a specific subject like chemistry or physics or even an activity like analyzing data (Kang & Keinonen, 2018).

Student interest is closely tied to achievement (*AECT Code of Professional Ethics*, 2007; Capie & Tobin, 1981; Kang & Keinonen, 2018; Kobayashi, 2017). In order for true learning to occur, teachers must foster students' interest (Hentges, 2016) because it can influence students' levels of learning, their academic performance, and the quality of their learning experience (Holstermann et al., 2010). It is imperative that we understand how interest develops in order to support student learning because "the level of a person's interest has repeatedly been found to be a powerful influence on learning" (Hidi & Renninger, 2006, p. 111). In a meta-analysis conducted by Schiefele et al. (1992) on the positive correlation between students' interest in specific topics and their achievement in that topic, it was found that interest is associated with a readiness to attain new domain-specific knowledge. However, not all students are innately interested in every domain and subject covered in the classroom which is of concern because previous research suggests a link between academic achievement, for example scores on standardized tests, and interest in that area (Kang & Keinonen, 2018). Interest has also been found to be the most dominant factor influencing career choices (Afaq Ahmed, Sharif, & Ahmad, 2017; Jones et al., 2020). In order to have a larger number of students pursuing STEM careers, students' interest in those areas must be fostered.

Individual interest

Most researchers of interest agree that there are two main types of interest: individual and situational. Individual interest is defined by Boekaerts and Bosocolo (2002) as "interest built on stored knowledge about and value for a class of objects or ideas which leads to a desire to be involved in activities related to that topic" (p. 378). Renninger and Hidi (2016) describe individual interest as a person's enduring predisposition to re-engage and persevere to work with a particular content over time. They further link individual interest to intrinsic motivation, enjoyment, and engagement.

Situational Interest

Situational interest, as opposed to individual interest, is a temporary state sparked by a situation, task, or object that represents an immediate affective reaction (Hidi, 2001; Krapp, 2002). Situational interest can be triggered for someone even with little previous interest of the subject or prior knowledge of the topic (Renninger & Hidi, 2016). Learning environments that support meaningful and authentic activities like using project-based learning or group work have been shown to support situational interest in students (Hidi & Renninger, 2006). Additional research shows that teachers have a large impact on students' situational interest through their use of activities in the classroom (Mitchell, 2019). The learning material can provide a catalyst for student interest lasting for shorter or longer periods of time, which can be maintained and developed into individual interest within the context (Boekaerts & Boscolo, 2002; Harackiewicz et al., 2000; Krapp, 2002).

Development of Interest

Due to the important role interest plays in learning, it is necessary to determine how it can be developed (Hofer, 2010). Hidi and Renninger (2006) have developed a four-phase model of interest development. The four phases are triggered situational, maintained situational, emerging individual, and well-developed individual interest (Hidi & Renninger, 2006; Renninger et al., 2019; Renninger & Hidi, 2011). Hidi and Renninger's (2006) definition of interest includes the psychological state of an individual during engagement with content as well as their motivation to engage with that content (Renninger et al., 2019). A new interest can be initiated by something catching the attention of the learner, which is termed *triggering* and can establish situational engagement in the learner (Renninger et al., 2019; Renninger & Hidi, 2011). This may be short lived or lead to a maintained interest allowing it to turn into a more developed phase of interest. Triggering can occur in later phases of interest as well and may be self-generated developing on the previous knowledge of students, typically exhibited through children questioning concepts or ideas (Renninger et al., 2019).

During these earlier phases, typically the interest trigger is provided by a teacher, parent, peer, a novel experience, and/or activity or instructional practice (Renninger et al., 2019). Renninger et al. (2019) found that "triggered situational interest can support learners to seriously engage with disciplinary content and improve performance" (p. 2). The review of literature supports that, in order to trigger situationally-based interest, the instructor must provide a meaningful, problem-based environment that can sustain the learners' attention (Renninger et al., 2019). Due to the limited time that synchronous virtual field trips have to influence students' interest in the subject, the focus for this literature review is on earlier phases of situational interest.

At the beginning of life, kids are interested in everything (Krapp, 2002; Krapp & Prenzel, 2011). As children begin to grow up, they observe societal and gender norms, which can affect interest in certain areas (Krapp, 2002; Krapp & Prenzel, 2011). Science is an interest domain that sees a decline among students specifically from elementary to middle school (Bae & Lai, 2019; Krapp & Prenzel, 2011). Findings from Krapp and Prenzel (2011) reported that when science is taught with a direct connection to practical life situations, students' interest remains the same throughout time versus a typical decline. Drops in science engagement happen during the middle school years (Lee et al., 2016). Researchers have speculated that this is due to a lack of classroom activities and educational experiences that meaningfully engage students in science (Bae & Lai, 2019; Krapp, 2002). Gender roles have been identified to play a part in the decline of interest in science beginning at four years old (Jansen et al., 2019; Krapp, 2002; Krapp & Prenzel, 2011).

Boekaerts and Bosocolo (2002) discovered that "teachers seem to argue that students develop favorable and unfavorable beliefs about school subjects, and that they enjoy doing task and activities related to topics they value" (p. 377). Timostsuk and Jaanila (2015) believe that what happens in an elementary science class has an influence on students' motivation to learn science and can impact future career choices. This suggests that lesson attractiveness and manner in which it is presented and taught is of utmost importance when attempting to gain and retain student interest. There is a mismatch in classrooms between the authentic use of science and science assignments, the latter causing a decline in interest among students since science is so contextualized with strong social dimensions (Christidou, 2006). One idea for solving this decrease in interest is to develop it through lessons that spark student interest by using authentic activities.

Interest in Science

Interest is an important factor that motivates a learner to develop their science literacy and therefore is a critical goal for science education to work towards increasing among students (Swarat et al., 2012). Hidi and Renninger (2006) believe "the potential for interest is in the person but the content and the environment define the direction of interest and contribute to its development" (p. 112). It has been found that interest is created out of interactions a person has with a particular content (Hidi & Baird, 1986; Hidi & Renninger, 2006). This means that some students may feel more comfortable learning about one subject more than another. Within educational subjects, students can have an interest in science in general or be more domain specific and enjoy biology versus chemistry (Krapp & Prenzel, 2011).

Interest in STEM

The decline in STEM interest among adolescents has been a phenomenon of concern for decades (Falk et al., 2016). In order for the United States to increase the number of students entering the STEM workforce, there needs to be an emphasis on getting students interested in STEM from an early age (Jones et al., 2020). Influences on STEM interest have been found to come from both in-school and out-of-school experiences (Falk et al., 2016). In an effort to find out if specific programming could maintain interest in STEM as students transition to middle school, Solberg (2018) conducted mixed methods research on fourth through sixth grade girls using inquiry-based activities, engaging first-hand experiences, online resources, and design challenges within aerospace science. Results showed that embedding these types of activities increased the girls' confidence and interest and fostered their interest in STEM as they transitioned to middle school. With an emphasis on igniting interest in younger students to reduce the decline seen in middle school, it can be said that "elementary teachers are the gatekeepers of fostering the gifts and talents of future STEM innovators" (Cotabish et al., 2013, p. 216).

Activities

One role of the teacher is to capture the attention and interest of their students, which can be achieved by incorporating a variety of teaching methodologies and techniques aimed to gain the interest of students (Anwer, 2019). Research shows that student-centered activities can have a positive effect on student interests (Kang & Keinonen, 2018). When trying to trigger interest, teachers need to go beyond just an interesting topic for lessons and think about different activities and instructional methods (Swarat et al., 2012). Then they need to select activities that enhance levels of interest in children regarding the topic (Kane, 2004). This suggests that there should be a large emphasis on the role of activity when developing lessons intended to trigger interest levels of participants (Swarat et al., 2012). One major contributing factor to raising situational interest of students is by providing them with novel activities, like virtual field trips (Hehr, 2014), which have shown to increase student interest in specific subjects such as art and science (Bergin et al., 2007). The science center virtual field trips utilize best pedagogical practices from previous research in supporting students' interest in science and STEM.

Student views and perceptions are important to consider when designing activities (Gentry et al., 2002). Students' opinions of a successful lesson are tied to the educational activity they are engaged in (Kane, 2004; Sweet, 2014) over the topic and learning goal (Swarat et al., 2012). Responses from students suggest that hands-on lessons that allow for engagement with the content is an important factor in generating interest (Swarat et al., 2012) as well as the opportunity for students to make their own decisions and have autonomy within the classroom (Gentry et al., 2002; Timostsuk & Jaanila, 2015a). Providing activities where students collaborate has also been shown to have significant impacts on their learning (Fall et al., 2000). According to Piaget, as summarized by Fall, Webb, and Chudowsky (2000), exchanges with peers are more likely to promote conceptual change, allowing students to activate each other's prior knowledge, and challenge each other's ideas. The science center's virtual field trips use activity-based learning in programs to promote students' interest by including student-centered opportunities in multiple formats utilizing Goal-Based Scenarios including whole-group work, small-group work, and hands-on activities.

Activity-based learning is defined as a situation where students actively participate in the learning experience rather than sit as passive listeners (Anwer, 2019). The main difference between an activity-based learning environment and a traditional learning environment is the active role and involvement of the students and the presence of collaboration among the students in the environment (Anwer, 2019). Students with higher interest levels have been linked to higher participation levels in the classroom

(Jansen et al., 2016)). Ing et al. (2015) produced findings that showed participation, specifically students explaining their own thinking and collaborating with others, positively predicted student achievement. Positive results were also attained in an experimental study done by Anwer (2019) that provided findings that students retain and find activity-based learning more interesting than lecture. When students were asked their favorite teaching strategies, students responded by describing teachers who were enthusiastic, provided hands-on activities, group work, and activities that relate to the real world (Anwer, 2019).

Haris and Osman (2015) noted that 21st-century students require a wide variety of teaching methods and techniques to keep them interested. Many students have access to multiple forms of media, and simple conventional ways are not enough to keep today's students interested. Increased student interest has been shown in research when teachers include multiple activity types in their lessons: whole group, small group, data gathering, and discussion. If activities or methodologies are not cognitively appropriate, the students will lose interest in the activity. When designing and developing programs, it is important to remember the cognitive abilities of the participants and consider the length as well as the type of activity.

Data show that upper elementary school is an ideal time for a virtual field trip program because as students get older their attention span increases implying they can handle longer and more cognitively demanding tasks (Hallez & Droit-Volet, 2017). Upper elementary students are also independent enough to take on power within the classroom (Cochran et al., 2017; Hallez & Droit-Volet, 2017). Performance in working memory continues to improve during childhood (Camos & Barrouillet, 2011) and developmental research across the last 20 years has provided evidence that scientific reasoning abilities already exist in elementary-school-aged children (Schiefer et al., 2019).

Within a virtual field trip experience, it is important that authentic tasks are offered through the experience (Kenna & Potter, 2018). These high quality and varied representations of concepts support students in constructing their own knowledge. Ensuring quality, accuracy and variety of activities is very important (Kenna & Potter, 2018). Authentic activities are many times constructed in a social context (Kenna & Potter, 2018) which supports evidence for group work and discussions during programs. Suggestions provided for increasing interest within the classroom environment include providing resources that promote problem solving (Hidi & Renninger, 2006).

Whole group

During virtual field trips, it is necessary, due to the transitional distance of the instructor and students, to have whole-group discussions to introduce the scenario, provide knowledge to the whole group, and reflect on knowledge acquired. This whole-class discussion, when used to prime students' knowledge for an activity, has proven an effective method of supporting students' active learning (Mestre, 2005). Capie and Tobin (1981) determined that discussions are one effective way to engage students within lessons, but others have suggested that whole-group instruction is not the most effective (Godwin et al., 2016). Adapting teaching formats to benefit children with Attention-Deficit/Hyperactivity Disorder (ADHD) should also be considered. Children with ADHD displayed lower engagement and higher inattention during teacher-led instruction compared with other teaching formats, and lower engagement in fourth grade than in second grade (Steiner et al., 2014). Keulers & Jonkman (2019) further added to the research that when fourth-graders' minds wander their task performance goes down. The more demanding the task, the more important that full attention is given. Findings showed that minds wandered more during whole-group time than during complex tasks.

Small Group

Virtual field trips can provide students opportunities to collaborate in small-group settings. Smaller groups provide time for more scientific talk to take place (Cochran et al., 2017). Intentionally structured large and small-group settings allow students to explain their scientific thinking (Cochran et al., 2017; Gillies, 2008). Research over the past 30 years has shown academic, social, and emotional growth benefits for students participating in group work (Gillies, 2008). Research has shown group work that allows students to collaborate with hands-on activities is an effective instructional strategy to increase interest (Hampden-Thompson & Bennett, 2013). Bossert (1988) emphasized that cooperation is an important part of life and must be practiced within the classroom. He stated it is necessary skill for accomplishing learning activities and a general norm that should be learned. Group work that includes collaboration has been tied to student achievement and been shown to promote positive interpersonal relations, a motivation to learn, and increased self-esteem among students (Bossert, 1988).

Hands-on

Hands-on activities have been recognized to foster engagement in the classroom (Newton & Newton, 2011; Timostsuk & Jaanila, 2015a). Hands-on activities refer to students learning by experience (Holstermann et al., 2010) including touching, manipulating and observing (Türk & Kalkan, 2018), and they have been shown to have a direct effect on science achievement and students' interest (Grabau & Ma, 2017). Hands-on learning takes place within virtual field trips in a variety of ways. By using materials collected by the teacher or sent through the virtual field trip program, students are able to use manipulatives to support their learning.

Hands-on models proved to be a successful way to provide students with hands-on activities that increased knowledge over a longer period of time within an astronomy lesson on seasons when compared with students who were taught using traditional methods without the use of models (Türk & Kalkan, 2018). However, a study by Holstermann, Grube, and Bögeholz (2010) showed that just providing hands-on activities does not guarantee increased interest. They found that the quality of the activity and the students' perception of the activity played a role in increasing student interest. This suggests that activities need to be enjoyable for the students as well.

Timostsuk and Jaanila (2015) found that "teachers' activities and support are the most influential in classroom context besides personal and relational aspects of learning" (p. 1598). Students who acquire hands-on, authentic experiences, develop curiosity and interest, leading to a desire to learn more (Behrendt & Franklin, 2014). Determining the most impactful activities is very important when creating a virtual field trip because it is difficult to develop relationships with students through a 30-45-minute program.

Chapter Summary

As presented through this literature review, it is important that we address the issues of increasing student interests in science and STEM through innovative lessons that utilize authentic experiences if we hope to increase the number of students pursuing science and STEM careers in the future (Archer et al., 2012). Field trips can provide opportunities for student to interact with science concepts to increase their interest and have been shown to provide great value within education (Kenna & Russell, 2015). They have been shown to support interest and academic achievement. However, due to many hurdles teachers face, there has been a decline in the number of field trips students take (Behrendt & Franklin, 2014).

Virtual field trips can provide an opportunity for teachers to include meaningful experiences for students within their classrooms through technology (Cheng & Tsai, 2019; Haris & Osman, 2015; Zanetis, 2010). They do not replace traditional field trip options but can be a valuable resource for students to connect with an expert offering experiences they may not get to encounter in their lives (Gaylord-Opalewski & O'Leary, 2019). It is important to understand the perception of students about their interest during virtual field trips so that the science center can provide the highest quality offerings.

Constructivism holds great promise when attempting to create meaningful, student-centered virtual field trip programs by providing students an authentic experience in which to engage with the content (Cetin-Dindar, 2016; Rubin, 2007). It should be the goal of virtual field trip programs to create an environment where students are actively thinking about and applying knowledge during the instruction (Mestre, 2005). Programs should give students opportunities to think and talk about subjects and actively participate (Tanner, 2013). Using Goal-Based Scenarios for lessons focusing on learner-centered activities that require students to reflect on previous knowledge and construct new knowledge (Campbell & Monson, 1994) may be successful in influencing participant interest within a virtual field trip.

Interest can influence students' levels of learning, their academic performance, and the quality of their learning experience (Holstermann et al., 2010). Interest in science has been determined to have an impact on students' development of science literacy (Swarat et al., 2012) and be a determining factor in career decisions with regards to science and STEM careers (Ahmed et al., 2017). There are two main types of interest: individual and situational (Hidi, 2001; Krapp, 2002). Individual interest describes the individuals predisposition to re-engage with content over time (Renninger, & Hidi, 2016) while situational interest refers to a temporary state sparked by a situation, task, or object (Hidi, 2001; Krapp, 2002). Research shows that teachers can have an impact on student interests (Renninger et al., 2019) which provides promise for the opportunity that virtual field trips have to impact participants' situational interest by creating quality programs. Due to the limited time and exposure to students, virtual field trips programs should focus on triggering the interest of students. However, without direct student input it is difficult to know students' perceptions of the programs or if the programs affected their interest levels.

When identifying appropriate activities to interest students, virtual field trip teachers should take cognitive abilities into account. Expecting students to engage with material that is too easy or difficult will not produce desired outcomes. Hidi and Renninger (2006) believe that interest can be nurtured and supported through interactions with others and by design of the learning environment. "Fostering and generalizing students' interest can be achieved by either addressing one's interest in a specific context or in a specific activity type" (Blankenburg et al., 2016, p. 382). Understanding what interests students in lessons and activities will help support a more thorough understanding of what the science center can do to create the most interesting virtual field trip offerings.

CHAPTER 3

METHOD

The science center does not have data on the impact that virtual field trip programs have on participants' interest. This research is necessary to determine the value of the virtual field trip department and programs. The purpose of this action research was to determine the impact that the science center's virtual field trip programs have on participants' interest in specific science domains and STEM fields. Activities within the programs were also assessed to determine how the format of programs affected participant interest.

RQ1. Do virtual field trip programs affect participants' interest in specific science domains and why?

RQ2. Which activities are most interesting for students during a virtual field trip program offered by the science center and why?

RQ3. Do virtual field trip programs affect participants' interest in STEM and how?

Research Design

Action research is most applicable to this study. Greenwood and Levin (2007) describe action research as "collaborative problem analysis and problem solving while in context" (p. 3). The focus of action research is to improve educational practice within the researcher's own sphere of influence with an emphasis on problem solving while allowing time for reflection (Bassey, 1998; Costello, 2003). The goal is to "improve the practice, either one's own practice or the effectiveness of an institution" (Koshy, 2005, p. 9). Through steps of identifying an area of focus, data collection, analyzing and reflecting on data, and then finally developing a plan of action, researchers are able to make generalizations and changes for their own population (Mertler, 2017). Action research is not designed to generalize data collected to large populations as traditional research is because the design of data collection is taken from a specific population, which in many studies is limited to a single classroom or case study (Collatto et al., 2018; Koshy, 2005; Mertler, 2017).

Action research differs from traditional formats of research due to the researcher's personal involvement with the study. It is a systematic process of research conducted by vested individuals concerned with learning about their particular school within their sphere of influence (Koshy, 2005; Mertler, 2017). There is a great benefit for teachers within their classroom when trying to improve their teaching practice. It provides practical and realistic ways for teachers to reflect on the data so that they can respond and transform their actions in the classroom (Carr & Kemmis, 2005). Action research is appropriate for this study due to the nature of the environment and researcher position. I am attempting to improve my practice and conducting research within my own sphere of influence with a small group of participants (Bassey, 1998; Carr & Kemmis, 2004; Koshy, 2005; Mertler, 2017).

The research design for this study utilized mixed methods. Through a pragmatic philosophy, mixed methods integrates quantitative and qualitative data (Chisaka et al., 2013; Feilzer, 2010). Pragmatism supports that researchers may be both objective and subjective while attempting to answer research questions (Subedi, 2016). Mixed methods is an approach and technique for collecting and analyzing data, as well as a methodology involving the integration of qualitative and quantitative methods in the research process "from philosophical assumptions to data collection and analysis" (Li et al., 2015, p. 2). Sweet's (2014) research on virtual field trips was exclusively conducted utilizing quantitative methods, and she admitted that further knowledge could have been gained if she had used a mixed methods approach. I chose to support my research through the collection of both quantitative and qualitative data because individually they would not provide a thorough picture to answer the research questions (Creswell, 2015).

Each research method, quantitative and qualitative, has strengths it brings to the study including the ability to quickly assess and compare pre- and post- interest levels as well as recording feelings and perceptions from the participants in their own words. Utilizing a mixed methods approach also allowed me to gain a deeper understanding of the situation and the thoughts of those involved through the convergence of quantitative and qualitative methods and supported answering my research questions more thoroughly (Mertler, 2017; Morgan, 2014).

Within my research design, quantitative and qualitative data were collected before formal analysis was conducted which is referred to as a convergent parallel or parallel convergent design (Alavi et al., 2018; Creswell, 2014). Quantitative data collected from this research included quantifiable perceptions from participants. Qualitative data, collected through focus groups and open-ended surveys, allowed me to further explore my research questions by allowing participants to express their perceptions in their own words (Koshy, 2005) to develop a greater understanding of the impact on participant interest levels in the subject. This triangulation of data provided greater credibility to my findings (Mertler, 2017).

By conducting action research, I was able to remain an integral part of the study and conduct the research within the specific context (Koshy, 2005). This allowed me to bring the story about how virtual field trips influence participants' interest to life. By using a mixed methods design, I sought out answers to my research questions through both quantitative and qualitative methods, which supported a more thorough understanding of the impact that virtual field trips have on participants' interest.

Setting

This study took place at a small science center, the location for the creation and presentation of the virtual field trip programs. The science center is owned by the local school district. Currently, there are 25 full-time staff members including 11 full-time educators. The science center, during a typical year, sees over 47,000 students for in-person field trips. The virtual field trip department reaches over 10,000 students from all over North America with the majority connecting from the local school district. The science center also offers public programs including Friday Starry Night planetarium shows, Summer Adventure public programming, and summer camp offerings.

Throughout this study, participants attended virtually from a local sports community center. Throughout the program connections, participants were located in the local community center's gym and connected via a large screen television while they sat on the floor and bleachers. All communication and interaction with participants took place virtually. This format was in place to ensure the safety of both participants and staff during COVID-19 regulations set by the school district, state, and local health officials.

This was a change from the original proposal due to the science center being closed to visitors over the summer of 2020.

Participants

This study had 19 participants that had completed third (*n* = 9) or fourth grade (*n* = 10). Students were nine (*n* = 10) and ten (*n* = 9) years old. All students were enrolled in the sports community center's summer camp program. Of the participants, 42% (*n* = 8) White/Caucasian (non-Hispanic), 36% (*n* = 7) self-identified as African American/Black, 5% (*n* = 1) Asian/Asian American, 10% (*n* = 2) were not present for the participant survey, and 5% (*n* = 1) preferred not to answer. Male participants represented 52% (*n* = 10) while 47% (*n* = 9) were female participants. Of the participants, 12 selected they had participated in previous STEM activities. Finally, six participants had previously attended a virtual field trip and three stated that they had attended a virtual field trip with the local science center. Not every participant was present for each day of the camp and two students participated in virtual field trips but had to leave before taking the survey, so their data are not included in the analysis.

Participant selection relied on purposeful sampling by limiting the participants of the study to only those who were enrolled in the summer camp program at the sports community center and met the criteria of grade completion (third or fourth). The programs utilized for this study covered third and fourth grade science standards, which determined the criteria for selection. Consent for participation in this research study was obtained by all participants' parents as well as the International Review Board (see Appendix A).

Two smaller groups of participants were selected for focus groups on the last day of research. These participants were chosen by the director for their behavior and focus during the programs, as well as their participation in all of the programs for the week. Focus group one consisted of four students. The group was made up of 50% (*n* = 2) girls and 50% (*n* = 2) boys. Two of the students were 10 (*n* = 2) years old and two were nine (*n* = 2) years old. Finally, there was an even split of completed third grade (*n* = 2) and completed fourth grade (*n* = 2). Focus group two consisted of three students. The group was made up of 66% (*n* = 2) girls and 33% (*n* = 1) boys. All of the students were nine (*n* = 3) years old and had completed third grade (*n* = 3).

Intervention

This study utilized science virtual field trips as an intervention that spanned over a weeklong summer camp. Virtual field trip programs are live, interactive programs taught by a content provider to a classroom through the use of video conferencing technology (Newsome, 2013; Zanetis, 2010). The researcher facilitated four virtual field trips to the participants for this study from the local science center. Each program focused on a different domain of science including chemistry, geology, meteorology, and astronomy. There is no known previous research on the effectiveness of virtual field trips and specifically their impact on participants' interest in the topic covered during the programs. This section describes an overview of the virtual field trip programs and gives specific information about each of the programs utilized in this study. Specific information about each individual program is presented later in this chapter under the timeline and procedures section.

Overview of Virtual Field Trip Programs

Virtual field trip programs are presented from the science center's studio (Figure 3.1), located on the science center campus. The studio is equipped with videoconferencing and green screen technology designed to support live synchronous lessons. During programs, students utilize materials created for the program in the form of worksheets.

Figure 3.1. Virtual Field Trip Studio

Each of virtual field trip programs were designed for a single class meeting with a maximum of 35 participants using research-based learning theories including experiential learning (Kolb, 1984), scenario-based learning (Gonda et al., 2015), and goal-based scenarios (Campbell & Monson, 1994; Shank et al., 1993), all within the constructivist framework (Mestre, 2005). Each program provides a scenario requiring participants to take on roles, complete tasks, and accomplish a learning goal. Throughout the programs, a green screen was used to support participant instruction. Video clips were used to simulate connecting with professionals. For the videos when I was directly communicating with professionals, I remained on camera and a smaller video was displayed, similar to a newscast program. Many of the prerecorded videos create the illusion of live connecting with characters, which gives the participants a sense of interactivity. All efforts were made to provide as typical of a classroom connection as possible for this research. Next, the individual virtual field trip programs will be discussed.

Magic of Matter

The Magic of Matter virtual field trip program covers how heat affects the states of matter. The scenario presents two science professors who have been tasked with designing a magic show. The professors have planned a few demonstrations but wanted a test audience to see if the demonstrations worked. As part of the test audience, study participants were asked about their perceptions of the demonstrations (e.g., Do you think that was magical?) and supported the professors in creating a new experiment.

Fossil Finders

The Fossil Finders virtual field trip program engages participants with a scenario where the join a dig team. During this program, participants accept the role of an excavator, paleontologist (fossil expert), ecologist, or reporter. In four groups, assigned to four different dig site locations in South Carolina, the participants undergo a fossil dig. Using the knowledge and fossils that each of the groups uncover, a greater understanding of what South Carolina was like years ago is discovered.

Weather Watchers

During the Weather Watchers virtual field trip program, participants make predictions as members of a weather-consulting firm using previous data from South Carolina. During the program, participants receive an request to support with an emergency case. Hurricane Roper is headed to the coast of South Carolina and a small town has contacted Weather Watchers to consult on how to prepare for it. Participants are broken up into three groups and asked to review past data of hurricanes that have hit the coast of South Carolina to make a prediction about the fate of the small town.

Seasons Reality Check

Seasons Reality Check virtual field trip invites participants to join the fact-checking team at the science center for a reality TV show similar to MythBusters. Participants use graphs and tables with data about daylight and temperature to compare locations in the Northern and Southern hemispheres and answer the question, *What causes the seasons*?

Data Collection

Multiple data collection methods were used to determine the impact virtual field trips have on participants' interest. Participants responded to pre- and post-surveys and some participated in semi-structured interviews during focus groups. Multiple data sources were collected through Zoom video conferencing and Google Forms and triangulated to address each research question as outlined in Table 3.1.

Surveys

Multiple surveys were used throughout this study to collect quantitative data on the impact virtual field trips have on students' interests. Surveys as data collection instruments allow participants to reflect on their thoughts, feelings, and perceptions by responding to questions or statements (Johnson & Christensen, 2017). The use of surveys allowed the collection of a lot of information in a short amount of time (Mertler, 2017). Two data collection surveys were used to assess the change in participants' interest before and after program participation. In addition, survey questions were used to assess participants' interest in specific activities within each virtual field trip program.

Table 3.1. *Research Question and Data Sources Alignment*

Research Question	Data Sources
RQ1: Do virtual field trip programs affect participants' interest in specific science domains and why?	• Pre/post interest survey • Semi-structured interview in focus groups • Whole group, open-ended survey questions
RQ2: Which activities are most interesting for students during a virtual field trip program offered by the science center and why?	• Activity survey • Semi-structured interview in focus groups • Whole group, open-ended survey questions
RQ3: Do virtual field trip programs affect participants' interest in STEM and how?	• Pre/post STEM interest survey • Semi-structured interview focus group • Whole group, open-ended survey questions

Survey Description and Reliability

Surveys were distributed electronically to all participants using iPads or tablets with the help of the sports community center director and staff. Students answered surveys on the first day of the study and following each of the programs on days two through five.

Science Domain Survey. The Mathematics Interest Inventory (Stevens et al., 2006) was slightly modified and adapted to assess participants' interest in specific science domains (RQ1). The first subscale of *Emotion* (items = 10) was most suitable to address RQ1 on participants' interest in science domains. Written for fourth-grade students, the survey uses a four-point Likert type scale ranging from (1) not at all like me to (4) very much like me. Studies with three samples produced alpha coefficients of .91, .96, and .93 respectively for the subscale of emotion (Stevens et al., 2006). Slight modifications to the survey items were made to replace math with the specific science domains of chemistry, geology, meteorology, and astronomy (See Table 3.2). Five items were removed from the subscale because they were not applicable to this study. For example, the item *I feel good when it comes to working on math,* was removed because it does not assess interest.

Table 3.2. *Math Interest Inventory Questions Alterations*

Initial Question	Adjusted Question
• I like math	• I like (science domain)
• I am interested in math	• I am interested in (science domain)
• I feel excited when a new math topic is announced	• I feel excited when we start a new (science domain) lesson in school
• I want to learn more about math	• I want to learn more about (science domain)
• I want to know all about math	• I want to know all about (science domain)

The survey was piloted with one fourth-grade student, reviewed by a licensed clinical child psychologist, and a third-grade teacher to determine appropriateness of questions. Slight modifications were made to one survey question following the suggestions of the childhood psychologist to support greater understanding for participants. The question *I feel excited about when a new (science domain) topic is announced* was changed to *I feel excited when we start a new (science domain) lesson in school*. The survey was piloted with a fourth grader and notes were taken to improve the survey. While reading the science domain survey the student struggled with understanding what chemistry and geology were. After explaining chemistry to him and having him read the definition in the survey, he had a better understanding. He also struggled with geology, stating that he had never studied geology before. As soon as I mentioned studying rocks, he immediately remembered his science lessons on rocks. His answers varied throughout the survey, which showed that he was thinking and processing the questions. I had assumed those answers would be identical. A reliability test was completed following data collection.

The science domain survey focused on the four main science domains that were taught within the programs: chemistry, geology, meteorology, and astronomy as shown in Table 3.3 (see Appendix C). The survey, in its entirety covering all four science domains, was administered on the first day of research to assess participants' baseline interest levels. Directly following each day's virtual field trip program, participants answered questions pertaining to the specific science domain covered during that virtual field trip. Operational definitions for each domain were provided prior to the survey administration to help participants' understanding of the survey. For example, chemistry is "The study of matter and the changes that it undergoes" (Buthelezi et al., 2008, p. 4). Additional examples were provided to support participants understanding of chemistry, including the three states of matter and how heat affects them. Geology was described to participants as it "deals with the history of the earth and its life especially as recorded in rocks" (Merriam-Webster, n.d.). Lastly, meteorology was explained to include "the study of the Earth's atmosphere and, in particular, its climate and weather" (Bingham, 2014, p. 153), and (d) "astronomy is the study of objects in our solar system and beyond" (South Carolina Department of Education (SCDE) Office of Standards and Learning, 2018 p. 27). During survey administration, I was available to answer questions through Zoom when students needed support.

Activity survey. To identify which activities within the virtual field trip program most affected students' interest (RQ2), an activity survey was developed. This 4-point Likert type survey was completed after each of the virtual programs, allowing participants to reflect on their experiences and interactions (Mertler, 2017) during different parts of the programs. Participants were asked to rate each of the main activities from (1) did not enjoy very much to (4) enjoyed very much. Six subscales were created to evaluate similar types of activities within each of the programs: (a) whole group, (b) small group, (c) role-playing, (d) active learning, (e) working with professionals, and (f) analyzing data. Table 3.4 provides an overview of the activities, which correspond to survey items, within each subscale. The activity was piloted with one fourth-grade student, reviewed by a licensed clinical child psychologist, and a third-grade teacher to determine appropriateness of questions. No changes were noted for this survey after the piloting phase.

Table 3.3. *Science Domain Interest Survey*

Subscale	Questions
Chemistry	I like chemistry.
	I am interested in chemistry.
	I feel excited when we start a new chemistry lesson in school.
	I want to learn more about chemistry.
	I want to know all about chemistry.
Geology	I like geology.
	I am interested in geology.
	I feel excited when we start a new geology lesson in school.
	I want to learn more about geology.
	I want to know all about geology.
Meteorology	I like meteorology.
	I am interested in meteorology.
	I feel excited when we start a new meteorology (weather) lesson in school.
	I want to learn more about meteorology.
	I want to know all about meteorology.
Astronomy	I like astronomy.
	I am interested in astronomy.
	I feel excited when we start a new astronomy lesson in school.
	I want to learn more about astronomy.
	I want to know all about astronomy.

STEM Survey. To assess participants' interest, the instrument used was the STEM-related attitudes subscale within the Common Instrument Suite 3.1 created by The PEAR Institute: Partnerships in Education and Resilience at Harvard Medical School and McLean Hospital. The PEAR survey is a self-report survey that measures STEM-related attitudes, including engagement, career knowledge, identity, and activity participation. It was designed to be utilized for students enrolled in out-of-school STEM programs in fourth grade and beyond.

For the purposes of this research, only the STEM engagement survey portion was administered as it assesses how STEM programs affect students' perceptions/attitudes toward STEM. Though engagement and interest are not the same constructs, they are closely related. After discussing with the PEAR Institute and reviewing the test questions, it was determined that it evaluated participants' interest and would be appropriate to collect data to address the research questions for this study. It was administered as a pre- and post-test on the first and last day of the study. The survey reliability analysis involved 2,100 participants and the STEM engagement subscale yielded a Cronbach's alpha of .91 (PEAR, 2018). The STEM engagement subscale has 11 questions utilizing a 4-point Likert scale that ranges from (1) strongly disagree to (4) strongly agree. See Table 3.5 for survey items. Additional questions were provided by the PEAR program, including participants rating their curiosity in science, technology, engineering, and math ranked on 4-point Likert type questions (1= not curious at all and 4= very curious). See Appendix D for full survey.

Table 3.4. *Activity Type Subscales per Program*

Program	Subscales					
	Whole Group	Small Group	Role-Playing	Active Learning	Working with Professionals	Analyzing/ Managing Evidence
Magic of Matter	• Discussion that all matter has mass including shouting out answers to the large group	• Defining matter while working in small groups	• Taking on the role of a test audience	• Dancing as particles of matter as a large group	• Connecting with the professors	• Providing suggestions for new experiments
Fossil Finders	• Talking as a large group about petrified wood in Arizona	• Working with small group on assigned dig site	• Taking on the role of an expert within group	• Enacting tree petrification process	• Working with the scientists at the science center	• Compiling evidence to make conclusion using charts
Weather Watchers	• Whole group Hurricane Gaston • Graph analysis	• Working in small group on (Hugo, Bob, or Bonnie)	• Taking on the role of Weather Watchers Member and making	• Hurricane high winds/low pressure	• Christy Henderson studio tour	• Graph analysis • Radar and satellite discussion • Prediction

			suggestions to the mayor • Emergency Scenario			using map
Seasons Reality Check	• Season discussion • Analysis of Vostok in large group	• Construct response to student using evidence	• Taking on the role of fact-checking team member	• Enact Earth's rotation with partner	• Connecting to science center Reality Check team	• Analysis of sunlight and temperature using graphs and charts

Table 3.5. *Common Instrument Suite 3.1 STEM Engagement Survey (PEAR, 2018)*

Example items
• I get excited about STEM. • I like to participate in STEM projects. • I want to understand STEM. • I like to see how things are made. • I get excited to learn about new discoveries. • I pay attention when people talk about the environment. • I am curious to learn more about cars that run on electricity. • I am interested in STEM inventions. • I would like to have a STEM job in the future. • I enjoy playing games that teach me about STEM. • I like to make things.

Interviews

Interviews are commonly used in action research because they allow the researcher to probe participants' thoughts and encourage them to provide deeper responses (McNiff, 2016). Group interviews can prove advantageous over individual interviews by revealing more diverse opinions, generating deeper responses by allowing participants to build off of each other, and can support previous data measured by other methods (Lewis, 1992). During interviews, students speak freely about their ideas and beliefs beyond the limits of a survey, thus providing valuable data (Smith & Osborn, 2015). Semi-structured interviews allow the researcher to ask follow-up or probing questions while encouraging participants to offer new ideas and thoughts on the topic (Galletta, 2013; Mertler, 2017; Schwandt, 1997). Through the use of semi-structured interviews, qualitative data were collected on each of the research questions (Table 3.6).

Focus-Group Interviews

Focus groups were created in order to provide a smaller setting for participants to express their views on particular topics and concepts (Aubusson et al., 2009). A focus group is an interview with a small number of participants (Johnson, 2008; Mertler, 2017) allowing the researcher to gain information to assess the research questions and bring improved depth of understanding to the research (Vaughn et al., 1996). They support participants by allowing them to respond to questions in a conversational manner, a method of communication they are very familiar with, which often leads to data discoveries that may not be revealed through other methods of collection (Doody et al., 2013).

Table 3.6. *Interview Questions*

Research Question	Interview Questions
RQ1: Do virtual field trip programs affect participants' interest in specific science domains and why? (Focus Group and open-ended Google Form)	• After viewing all of the programs, which area (chemistry, geology, meteorology, or astronomy) are you most interested in learning more about and why? • Were there any topics (matter, geology) that you weren't excited about until participating in the virtual field trip? Which ones? • What was your favorite virtual field trip? Why? • What was your least favorite virtual field trip? Why?
RQ2: Which activities are most interesting for students during a virtual field trip program offered by the science center and why? (Focus Group and open-ended Google Form)	• Think back to your favorite activity during a virtual field trip program. What was it? What did you like about it? • Think back to your least favorite activity during a virtual field trip program. What was it? What did you not like about it? • Did you like when we did activities with the whole class or smaller groups? Like shouting it out? Why? • Think back to one of the virtual field trip programs. What was your personal role? Did that role help you connect with the program more? Why? • In many parts of the programs, you were asked to move around. Did you enjoy acting like a particle or like a tree? Do you think it helped you stay interested in the program? Why? • Throughout each of the programs, we worked with professionals, for example Professors Roper and Mountain and Christy Henderson. Did you enjoy that? Why? • Did you enjoy analyzing evidence with your groups? Why? • Each of the virtual field trip programs were live, meaning that you were able to talk directly to me. How did that impact your interest in the programs and activities?

	• How would you describe virtual field trips to someone?
RQ3: Do virtual field trip programs affect participants' interest in STEM fields and how? (Focus Group and open-ended Google Form)	• Did these virtual field trips make you want to take another science class or STEM class? Why? • Did showing science professionals in the virtual field trip help you understand possible STEM job opportunities in the future? How? • Would you want to take another STEM class or camp? Why? • Do virtual field trip programs affect your interest levels in STEM in any way? If more, why do you think that is?

This study used two focus groups consisting of four participants for the first focus group and three participants for the second focus group. The focus groups took place following the last program on the last day of research. Students were selected to participate by the director of the sports community center after volunteering to be part of it. The interviews were conducted within a Zoom room and were recorded. Participants were posed with a question, raised their hand and waited to be called on. I made every attempt to state their name and allow them to freely answer the question. Not all participants answered every question but all participants expressed their opinions at some point during the interview and interacted with each other about their opinions. When combined with the quantitative data collected through surveys, a more complete picture of the impacts virtual field trips have on participants' interest and activity preferences was understood. Multiple sources of data, related to my research question, were collected and analyzed supporting triangulation (Hubbard & Power, 1999; Schwandt, 1997).

Due to the fact that the semi-structured interviews took place potentially days after the participants experienced a specific program, visuals were available to be utilized. Stimulated recall interviews involve the use of materials or visuals to support the participant in remembering the events (Henderson et al., 2010; Tůma et al., 2014). Hard copies of materials from each of the programs were available to be referenced throughout the interview. This helped the participants remember each of the programs and reflect on their feelings and experiences about them (Burden, 2015).

Whole-Group, Open-ended Response

Through the use of open-ended response questions within the surveys, participant opinions were able to be gathered beyond the structured survey. Due to restrictions, a formal whole-group interview was not able to be conducted, but by allowing participants to respond to open-ended survey questions, it allowed all participants to respond in their own words. Questions following the Likert-type scale prompts included, “What was your favorite part of the (title of virtual field trip) program?” as well as asking them to respond to their least favorite part, and if they’d like to add anything else about the program. Participants responded to these questions after each program. Finally, on the last day, participants were asked to identify their favorite and least favorite program throughout the week.

Data Analysis

Multiple forms of data were analyzed during this convergent parallel mixed methods study (Creswell, 2014; Subedi, 2016). Mixed methods is both a method, involving the collection of quantitative and qualitative data (Leech & Onwuegbuzie, 2009; Mertler, 2017), as well as a methodology involving the integration of both quantitative and qualitative methods to address the research questions. This integration of methods can provide a more thorough understanding of the impact (Li et al., 2015) virtual field trips have on participants' interest. See Table 3.7 for a description of the data sources and analyses for each research question.

Table 3.7. *Research Question, Data Sources, and Data Analysis Methods*

Research question	Data sources	Data Analysis
RQ1: Do virtual field trip programs affect participants' interest in specific science domains and why?	• Pre/Post interest survey • Semi-structured interview	• Wilcoxon signed rank test • Inductive analysis
RQ2: Which activities are most interesting for students during a virtual field trip program offered by the science center and why?	• Activity survey • Semi-structured interview	• Descriptive statistics • Inductive analysis
RQ3: Do virtual field trip programs affect participants' interest in STEM and how?	• Pre/Post STEM interest survey • Semi-structured interview	• Wilcoxon signed rank test • Inductive analysis

Quantitative

The pre- and post-survey data addressing interest in science domains, STEM, and specific program activities were analyzed using JASP, a free statistical analysis program. Student responses were downloaded from Google Forms into an Excel document. Data were cleaned up, when necessary, and uploaded into JASP for analysis. Preliminary analysis throughout the week of data collection was completed within Google Forms and Excel.

RQ1: Interest in science domains

To assess how virtual field trip programs affect participants' interest in specific science domains, participant pre- and post-survey item responses were analyzed in the domains of chemistry, geology, meteorology, and astronomy. The statements referencing specific domains were grouped to create a Likert-type scale, which is a series of four or more Likert-type items (Norman, 2010). These individual items were combined during the analysis phase to produce a composite score (Boone & Boone, 2012), which provided a quantitative measure of the impact virtual field trips have on participants' interest in the specific science domains. The pre- and post- data, at the subscale level, were analyzed using a Wilcoxon signed-ranks test due to small sample sizes (Harris & Hardin, 2013).

RQ2: Interest in program activities

Descriptive statistics were used to analyze student activity survey data for each subscale: (a) whole group, (b) small group, (c) role-playing, (d) active learning, (e) working with professionals, and (f) analyzing/managing evidence. Descriptive statistics help to organize, display and summarize a group of data effectively (Shafer & Zhang, 2012). Subscale data were analyzed using descriptive statistics to identify the mean and standard deviation to show central tendency and variability respectively (Boone & Boone, 2012). This provided a score for each of the six different subscale activities utilized in the virtual field trip programs, which provides data for the research question on which type of activities were most interesting to participants during a virtual field trip program.

RQ3: Interest in STEM

To determine the impact virtual field trip programs have on participants' interest in STEM the pre- and post-test item responses were analyzed using a Wilcoxon signed-rank test to compare the pre- and post-participant responses (Harris & Hardin, 2013). The results were analyzed for their statistical significance with the alpha level for all analyses set at .05 (Mertler, 2017; Shafer & Zhang, 2012).

Qualitative

Using an inductive approach, attempts were made to understand the impact that virtual field trip programs have on participants' interest in specific science domains and STEM and their opinions on activities within the programs. Creswell (2017) describes qualitative analysis as an inductive process where data move from narrow, raw responses to codes and finally widespread, encompassing themes. Themes are revealed through the researcher's consideration and interpretation of the data when using an inductive approach (Bernard et al., 2017; Fereday & Muir-Cochrane, 2006).

Qualitative data for this study consisted of responses from semi-structured interviews within focus groups and open-ended survey questions after the science domain and activity questions were administered following each of the virtual field trip programs. While analyzing and coding interview transcripts, I used a thematic process. The primary goal in thematic analysis is to reduce the volume of information collected by identifying and organizing the data into important patterns or themes (Mertler, 2017; Thomas, 2006).

I used Creswell's (2017) data analysis spiral to support my analysis. First, I transcribed both focus-group interviews and transferred the open-ended participant responses to Microsoft Word. Then I read the transcripts line-by-line. I used a computer-aided analysis method to support my coding analysis (Creswell, 2017). Delve, a web-based qualitative analysis tool, allowed me to make notes about responses and important ideas expressed. First, I grouped common response topics and ideas using codes. Codes are used to categorize data that are similar in meaning, allowing the researcher to organize data that relate to one another (Fereday & Muir-Cochrane, 2006; Stuckey, 2015). Codes were not created before the initial readings of the transcripts. During the initial reading, notes or memos were taken as the codes were identified (Creswell, 2017). Through the coding process and using common participants' responses and ideas expressed, themes were revealed (Fereday & Muir-Cochrane, 2006). Delve was used throughout making initial observations, coding transcripts, and the creation of themes allowing the ability to filter by code or theme to see specific responses. Delve creates tables and/or graphs from the data to support the analysis process (Miles & Huberman, 1994). Open-ended responses collected through Google forms allowed participants to express their thoughts directly following the programs. These responses were then downloaded into an Excel spreadsheet, transferred into Word and uploaded into Delve for analysis.

Triangulation

Triangulation is the method of utilizing both quantitative and qualitative data to validate emerging themes to answer research questions (Creswell, 2014; Hubbard & Power, 1999; Schwandt, 1997). The integration of both methods minimizes their limitations (Creswell, 2014). Interview data, while it can provide a broad range of information and allows the researcher to provide clarification to questions, can be time-consuming and difficult to determine consensus of information (Queirós et al., 2017). Survey data, quantitative in nature, is not impacted by the subjectivity of the researcher, yet it is very dependent on the quality of the survey's structure to provide reliable findings (Queirós et al., 2017). Data collected from qualitative methods can be used to corroborate quantitative findings or vice versa (Mertler, 2017; Morgan, 2014). Survey data and interview data were individually analyzed to generate findings on the impact virtual field trips have on participants' interest and then findings were compared

(Morgan, 2014) for each research question. Triangulation supports the rigor and trustworthiness of the interpretation of findings because the data were derived from multiple sources (Leech & Onwuegbuzie, 2009).

Procedures and Timeline

The data for this study were collected over the course of a one-week summer camp. The timeline for the procedures was as follows: phase one: participant recruitment, phase two: pre-survey data collection, phase three: intervention implementation, and phase 4: post-survey data collection. Each phase will be described in detail below. See Table 3.8.

Table 3.8. *Overview of Study Procedures and Timeline*

	Phase One	Phase Two	Phase Three	Phase Four
Activities	• Email consent forms to parents	• Pre-surveys: interest and STEM PEAR	• Intervention	• Post-survey on science domain subscale and activity interest • STEM PEAR interest survey • Focus-group interviews

COVID Procedures

Additional procedures due to COVID-19 were required for this research collection. All materials and devices provided to the sports community center were dropped off the Friday prior to research. All data collection, including focus groups, was taken remotely. Protocols were followed by the sports community center aligning with their organization's COVID-19 procedures to ensure staff and participant safety. The safety measures taken by the sports community center followed the CDC's guidelines as well as local and state health centers' recommendations at the time of research collection.

Devices provided for students were disinfected after student use and kept in a box within the director's office when not in use. Paper materials were not shared among participants throughout the programs. Materials provided for the program and devices were picked up following the research. Teacher program guides for Magic of Matter (see Appendix E), Fossil Finders (see Appendix F), Weather Watchers (see Appendix G), and Seasons Reality Check (see Appendix H) were provided for the sports community center.

Phase One

The week before the camp, electronic consent forms (see Appendix A) were emailed to all parents or guardians of children enrolled in summer camp at the local sports community center through the support of the Director of Youth and Family Services. Information about the research project and my contact information was provided to parents and guardians in case they had questions. The director followed up numerous times with reminder emails for parents to encourage them to complete the consent forms. Hard copies were made available for parents and guardians on the first day of camp. The director at the local sports community center received packets with materials for each program as well as a computer to connect to the Zoom videoconferencing room and ten devices for students to complete surveys. See Table 3.9 for the list of program packet materials.

Phase Two

During phase two, data were collected in the form of pre-surveys. Day one was used to develop a sense of community and rapport among participants and myself. Participants joined a Zoom videoconference call where the participants were led through a short getting-to-know-you activity. During this connection, participants were asked to rate, using their hands, how much they liked chocolate to familiarize them with Likert-type item response options. Following the getting-to-know-you activity, the participants were asked to complete a welcome survey through Google Forms (see Appendix B). Then they were asked to complete initial surveys including the science domain interest pre-survey (see Appendix C) and STEM PEAR interest survey (see Appendix D). In order to support the director and participants, a Google site was created with links to each of the surveys. The students used their personal devices or devices provided to them to log into the website with links to each of the surveys. Throughout the entire survey administration, I remained available in the Zoom videoconference for questions and to oversee survey administration.

Table 3.9. *Packet Materials*

Program	Materials
Magic of Matter	• Link to the promo for program
Fossil Finders	• Dig packet by group • Habitat sheet • Fossil expert sheet
Weather Watchers	• Storm data by group • Prepare sheet • Weather nametag
Seasons Reality Check	• Link for promo video • Map sheet • Hours of sunlight sheet • Average high temperature sheet

Phase Three

During phase three, participants experienced the intervention. The virtual field trip programs were delivered from the studio at the science center while the participants were located in the sports community center’s gym. The director and staff supported participants on site. The beginning of each connection consisted of making sure that participants had their materials needed for the programs and were arranged correctly for the activities. See Table 3.10 for an overview of program activities.

Day 2: Magic of Matter

Participants first experienced the 30-minute Magic of Matter program on how heat affects the states of matter. The scenario presents two science professors who have been tasked with designing a magic show. The professors have planned out a few demonstrations but wanted a test audience to see if the demonstrations worked. As part of the test audience, study participants were asked about their perceptions of the demonstrations (e.g., Do you think that was magical?) and supported the professors in creating a new experiment.

Participants watched a short video clip with an introduction to the scenario at the sports community center before connecting virtually through Zoom to the local science center studio. Each participant was visible throughout the program and the group remained unmuted. To begin I (a) introduced myself as a staff member of the science center, (b) briefly explained the purpose for their participation in the virtual field trip program scenario, and (c) introduced the learning target: *I know the different states of matter and how heat can affect them*. In small groups, participants defined matter and shared their definitions with the class. Through guidance and leading questions, (e.g., What does all matter have?), participants refined the definition of matter to include having mass and taking up space.

Table 3.10. *Program Activities*

Day/ Program	Duration	Science Domain/ Learning Target	Activities
Day 1			• Pre-surveys • Develop rapport
Day 2: Magic of Matter	30 minutes	Chemistry I know the different states of matter, and how heat can affect them.	• Introduction of program and learning goal • Define matter in small groups • Enact behavior of particles of matter • Observe and discuss demonstration that matter has mass • Reflect and discuss states of matter as whole group • Enact behaviors of particles as matter changes states • Experiment: liquid nitrogen with balloon filled with air • Enact what happened to particles inside balloon • Make suggestions to professors for other experiments • Enact prediction of water particles inside balloon when put in liquid nitrogen • Experiment: Liquid nitrogen with water balloon • Wrap-up and review learning goal
Day 3: Fossil Finders	45 minutes	Geology I can use evidence from plants and animals to understand what environments were like long ago.	• Introduction of the program and learning goal • Enact definition of a fossil. • Discuss implications of presence of petrified wood in Arizona and what it tells us about that area • Enact tree petrification process • Work with group on assigned dig sites across regions of South Carolina • Jobs defined: excavators in groups reveal fossil, expert paleontologist identifies animal, ecologist matches animal to habitat it needs to survive • Reporters relay the fossil their group found, characteristics of the habitat that animal needs to survive, and what evidence that provides for their dig location long ago

			• Compile evidence and review learning goal
Day 4: Weather Watchers	1 hour	Meteorology I can use weather data to make predictions about the weather.	• Introduction of the program and learning goal • Discuss examples of weather and climate • Analysis and prediction using average temperature graph • Video: Satellite image highlighting atmosphere and storm locations • Video: Local meteorologist - tour of station • Analysis of radar maps and satellite image • Assignment to support with upcoming hurricane • Identification of hurricanes categories, dangers, enact characteristics • Analysis of past storms and assigning categories using data and safety plan in small groups • Analysis of current Hurricane Roper data • Recommendation to the mayor and program wrap-up
Day 5: Seasons Reality Check	2 hours	Astronomy I can explain what causes Earth's seasons.	• Introduction of the program, learning goal, and student question • Observe diagram of Earth's distance to the sun in orbit • Request help from Reality Check Team • Discuss season characteristics and globe • Enact rotation of Earth with map of North America • Analysis of locations in Northern and Southern hemisphere to determine if tilt of Earth has an affect • Analysis of hours of sunlight and average temperatures for each location • Analysis of Vostok, South Pole temperature and sunlight data • Demonstration from Reality Check Team on direct sunlight • Observe direct and indirect sunlight in the planetarium • Analysis of direct and indirect light • Analysis of Earth's tilt using the North Star • Demonstration of seasons in groups • Construct response to student question and wrap-up analysis of evidence and learning goal

Next, as a whole group, participants shouted out states of matter (solids, liquids, and gasses), and we identified the properties and particle behaviors of each state. Participants enacted the movement and distance of particles. For example, they learned that liquid particles are farther apart and move faster than solids. Following, we connected to the science professors through a short video clip that simulates live streaming where the professors demonstrated that gas has mass using two identical balloons and a balance. In small groups, participants discussed the experiment, results, and provided feedback on the demonstration with questions such as, “Do you feel that was magical?” Next, participants used their fists to enact the behavior of particles in different states of matter when heated and cooled. For example, their fists began close together as a solid, and then moved further apart as they gain heat, simulating the process of melting. The same was done to represent other transitions between the states of matter. Participants were asked to share real-life examples, like ice cream melting or condensation on a cold glass of water. Then we connected back with the science professors where they demonstrated how a balloon filled with air is affected when submerged and then removed from liquid nitrogen (Figure 3.2).

Figure 3.2. Professors’ Demonstration

After observing it, participants enacted what happens to the particles in the balloon as I described the demonstration process. Professors asked participants to help design an experiment that uses the leftover liquid nitrogen. Participants discussed with those around them and then made suggestions. Through guidance, a water balloon was chosen as the group's suggestion. Participants acted out their prediction of what they thought would happen to a water balloon if submerged in liquid nitrogen. Professors then demonstrated the experiment while participants observed the liquid changing into a solid. We discussed participants' thoughts and feelings on the experiments and reviewed the learning goal.

Day 3: Fossil Finders

On day three, participants attended the 35-minute Fossil Finders program where I assumed the role of a researcher at the science center. During this program, participants accepted the role of an excavator, paleontologist (fossil expert), ecologist, or reporter. Participants were broken up into four groups and assigned to four different dig site locations in South Carolina by the director of the sports community center. Using a paper flip chart (Figure 3.3), the excavator uncovered a fossil, worked with their dig team to gather clues about the fossil, and made inferences about the dig location long ago. Each participant had individual materials to support their role.

To begin this program, I first introduced my role as a researcher at the science center, and provided an overview of the learning target: *I can use evidence from plants and animals to understand what environments were like long ago*. Next, participants defined the term *fossil*. Following, participants were shown a piece of petrified wood found in Arizona. As a whole group, participants role-played the petrification process of a tree starting when it was alive and healthy until it turned to a stone. Participants made conjectures about the implications of finding a piece of petrified wood in a desert location and what that could tell us about that location long ago. Through guidance, they inferred that all trees need water, which must have been available in Arizona at some point in history.

Figure 3.3. Fossil Finders Dig Flipchart

Subsequently, participants performed their own digs at their assigned sites around South Carolina. They assumed their assigned role (e.g., excavator, paleontologist/fossil expert, ecologist, or reporter), and began their dig. All students had their own materials due to COVID restrictions which allowed all members to contribute to their group's discovery. The excavators slowly flipped back the pages of the flipbook (Figure 3.3) revealing different layers of time. Once the fossil was found, the paleontologist identified the animal that the fossil came from (Figure 3.4) and the ecologist matched that animal with the habitat it would need to survive using the provided charts. Finally, group reporters shared their findings with the whole group.

As groups presented, I overlaid habitat images on their dig site locations. Participants discovered that all fossils found were from marine animals located below the Sandhills region of South Carolina. We concluded that these discoveries provide evidence that the coast of South Carolina used to be located in the Sandhills region.

Figure 3.4. Handouts for Fossil Finders

Day 4: Weather Watchers

On the fourth day, participants took part in the 45-minute Weather Watchers program, which focused on participants using data to make predictions as members of a weather-consulting firm. During the program, participants were called in to support with an emergency case. Hurricane Roper is headed to the coast of South Carolina and a small town has contacted Weather Watchers to consult on how to prepare for it. Participants were broken up into three groups and asked to review past data of hurricanes that have hit the coast of South Carolina to make a prediction about the fate of the small town.

Weather Watchers begins with participants being introduced to the scenario. They were welcomed to the orientation, and I introduced myself as the head of the Weather

Watchers team conducting their orientation. Next, participants identified the learning goal: *I can use weather data to make predictions about the weather*. Participants took part in an individual icebreaker asking them to write down examples of weather and then shout out the answers. Next, we discussed climate and showed a graph displaying average high temperatures for Greenville, SC for over a year (Figure 3.5). Participants identified the warmest and coldest months and analyzed if it was accurate to our climate in South Carolina. Finally, they made a prediction about the average temperature for March in comparison to February utilizing the previous year's data from the graph.

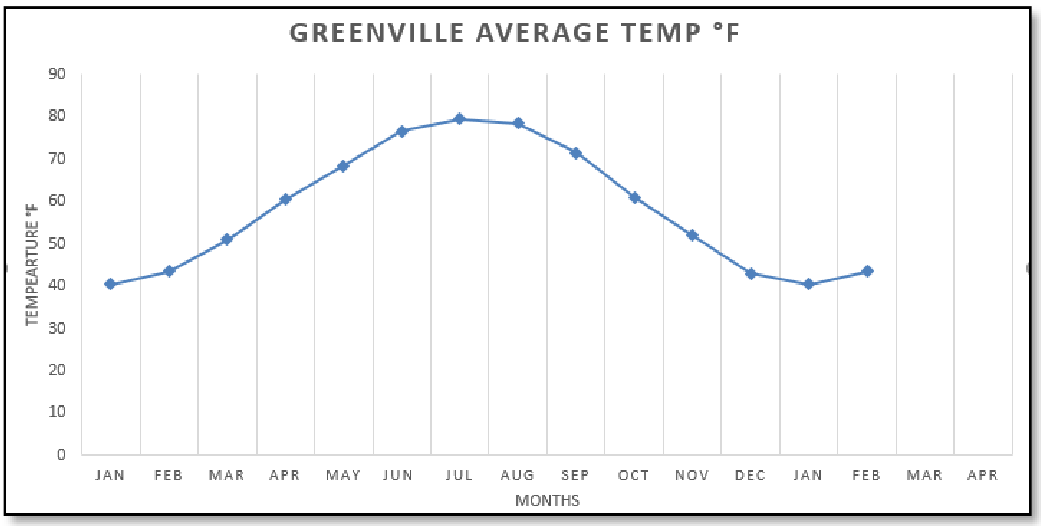


Figure 3.5. Graphic for Weather Watchers

Participants then watched two videos: (1) a satellite video highlighting the troposphere layer of the atmosphere, wherein weather phenomena take place, and (2) a video of a meteorologist giving a tour of her studio and explaining how weather predictions are made. The video of the meteorologist alludes to a live connection. Next, participants observed a radar and satellite image taken during a hurricane, which led into a discussion about the characteristics and dangers of hurricanes (Figure 3.6).

A loud crack of thunder was heard, and I excused myself to pick up my phone. Pretending it was my boss telling me to check my email, I hung up the phone and brought up my email, which shows a message that the orientation group has been called to consult on a developing hurricane. Next, participants were briefed on the location, Shell Island, and watched a video showing the destruction caused by a category four hurricane on the small town off the coast of South Carolina 10 years before. Next, they learned how tropical storms are categorized based on pressure and wind speeds and watched a video, produced by the Weather Channel that compares the damage that each hurricane category can cause to a house. Participants were asked to enact high winds and low pressure using their hands, similar to the stadium wave.

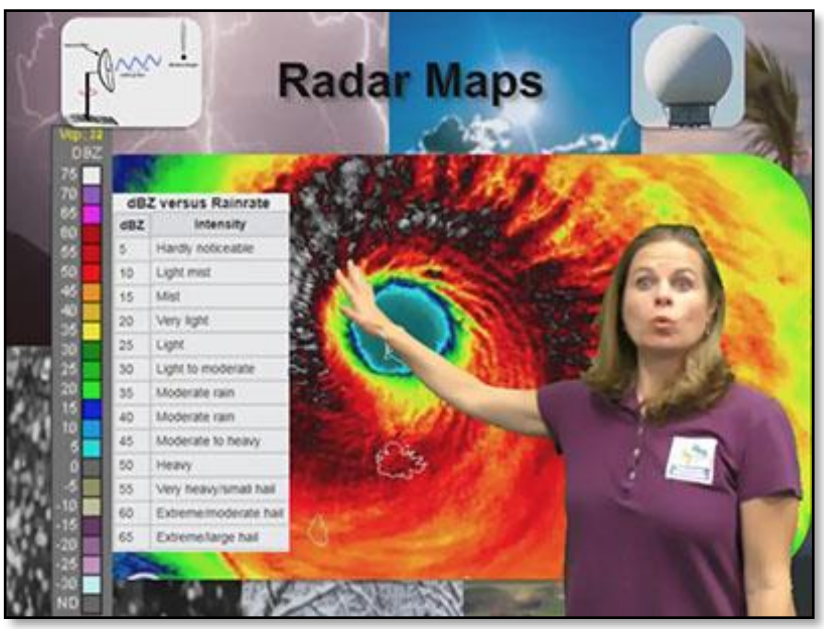


Figure 3.6. Hurricane Radar Map

As a large group, participants analyzed wind speed and atmospheric pressure data to determine the category of a previous tropical storm that hit South Carolina’s coast in August 2004. Participants communicated by raising their hands to be called on to contribute. Next, they were broken up into three groups and assigned a storm to analyze. They completed the same process of identifying a storm's category and determined safety precautions that should be taken. Focus was placed on the time of year the hurricanes took place. The groups presented their findings to the rest of the class and received a dataset for Hurricane Roper. Participants analyzed the data from Hurricane Roper, and by taking the time of year and estimated water temperature into account, collectively composed a response including safety recommendations. Finally, participants supported with crafting a response to the mayor. I modeled calling the mayor with their recommendations over my phone.

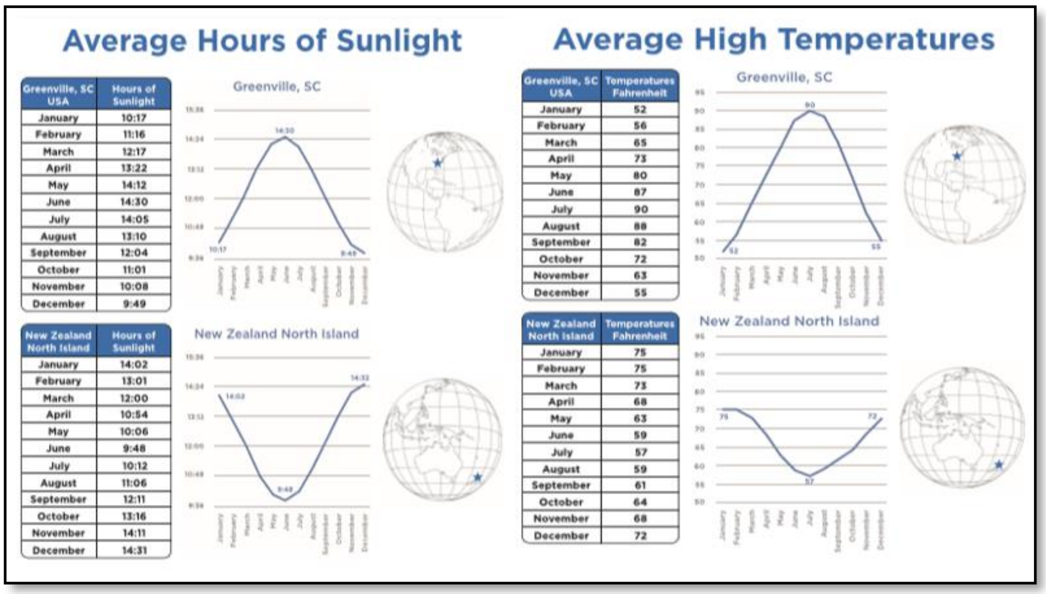
Day 5: Seasons Reality Check

On the last day, participants experienced the 45-minute Seasons Reality Check program where they joined the fact-checking team at the science center for a reality TV show similar to MythBusters. Participants used graphs and tables with data about daylight and temperature to compare locations in the Northern and Southern hemispheres and answer the question, *What causes the seasons*?

First, the participants watched a video promotion for Reality Check before connecting with me for the virtual field trip. When they connected to the virtual room, I welcomed and introduced myself as the host of Reality Check. The participants were then introduced to the question for the show by watching a video from a fan of the show asking the question about whether seasons are caused by the tilt of the Earth or the distance from the Earth to the sun. Then the learning goal was introduced: *I can explain what causes the Earth's seasons*.

Next, as a whole group, we examined a diagram of the Earth's orbit and determined that Earth is closer to the Sun during our (North America's) winter, disproving that the distance from the Sun has an impact on seasons. Participants actively participated in the discussion about the distance from the Earth to the Sun. Next, participants watched me enlist the Reality Check Team for help. Participants discussed characteristics of seasons as well as the hemispheres and axis of the Earth using a globe. In pairs, they determined the direction of Earth's rotation and sunrise using a map. Moving into groups, participants analyzed temperature and amount of sunlight graphs and charts for a location equidistant from the equator in the Northern and Southern hemispheres to test the theory that it is the Earth's tilt that affects seasons (Figure 3.7). In a whole-group discussion, they observed that there is an inverse relationship between the Northern and Southern hemisphere graphs for both temperature and sunlight. Next, as a large group we discussed the need to observe another location on the Earth and chose the South Pole. Graphs were displayed for amounts of temperature and sunlight for Vostok and noted that there are months of extreme cold temperatures with no hours of sunlight.

The group then checked in with the Reality Check Team where they demonstrated impacts of direct and indirect sunlight on a globe, using a heat lamp and infrared thermometer. All connections with the Reality Check Team were filmed to allude to a live connection. Participants were able to observe that the poles are cooler than areas near the equator. The Reality Check Team then took the group to the planetarium for further explanation on the impacts of direct and indirect sunlight. Participants discovered that Earth's tilt is constantly pointing to the North Star by using a dipper finder, providing evidence that the Earth's tilt is constant. Next, participants surrounded a ball that represented the sun in the center of the viewing area, and faced the North Star located on the TV. Participants were instructed to lean slightly, 23.5%, towards the TV. Then, participants worked in groups to determine what season they were in depending on their relative location to the Sun and North Star and reported back to the class. Wrapping up the virtual field trip, participants determined that the tilt of the Earth causes the seasons using evidence they gathered during the program.



Greenville, SC USA	Hours of Sunlight
January	10:17
February	11:16
March	12:17
April	13:22
May	14:12
June	14:30
July	14:05
August	13:10
September	12:04
October	11:01
November	10:08
December	9:49

New Zealand North Island	Hours of Sunlight
January	14:02
February	13:01
March	12:00
April	10:54
May	10:06
June	9:48
July	10:12
August	11:06
September	12:11
October	13:16
November	14:11
December	14:31

Greenville, SC USA	Temperatures Fahrenheit
January	52
February	56
March	65
April	73
May	80
June	87
July	90
August	88
September	82
October	72
November	63
December	55

New Zealand North Island	Temperatures Fahrenheit
January	75
February	75
March	73
April	68
May	63
June	59
July	57
August	59
September	61
October	64
November	68
December	72

Figure 3.7. Handouts for Seasons Reality Check

Phase Three

In phase three, directly following each of the programs, I shared the link to the science domain (chemistry, geology, meteorology, and astronomy) interest post-survey, which is identical to the pre-survey, along with the post-program activity interest survey using Google Forms. See Appendix I for Magic of Matter survey, Appendix J for the Fossil Finders survey, Appendix K for the Weather Watchers survey, and Appendix L for the Seasons Reality Check survey. On the final day of camp, all participants took the STEM post-survey (Appendix D) following the Seasons Reality Check survey.

Focus-group interviews were conducted on the last day. Two focus groups, containing a total of seven participants broken up among the two groups, took place to gain qualitative data through a semi-structured interview format. Participants volunteered to be part of these focus groups with the support of the director of the sports community center. The focus groups were conducted within the same Zoom videoconference room that the Seasons Reality Check program took place. Each focus group took less than 15 minutes, which was partially restricted due to student focus and activities taking place for their camp programs. Additional qualitative data were collected from all students who attended the virtual field trip programs through open-ended response options following the activity and post science domain Google Surveys taken following each of the virtual field trip programs.

Rigor and Trustworthiness

Throughout this study, I utilized many methods to improve rigor, validity, and trustworthiness. Rigor, as described by Tracy, "refers to the care and effort taken to ensure that the research is carried out in an appropriate manner" (2013, p. 231). This helps support the study's credibility so that future readers have confidence in the use of data and interpretations of findings (Tracy, 2013). In order to enhance rigor, validity, and trustworthiness, I utilized methodological triangulation; invited expert reviews; maintained an audit trail; utilized thick, rich descriptions; participated in peer debriefing; as well as underwent an external audit upon completion of my study.

Methodological Triangulation

First, I used methodological triangulation or the collection and analysis of multiple sources of data that related to my research questions (Hubbard & Power, 1999;

Schwandt, 1997). Triangulation allows for the ability to assess content validity and enables the researcher to obtain a more holistic and complete understanding of the phenomena being studied (Jick, 1979). It provides a greater depth and dimension to the study therefore enhancing the credibility of findings (Johnson, 2008). Data collected included multiple surveys and interviews with participants regarding each of the research questions. Through quantitative and qualitative data, I was able to develop a more complete understanding of the impact that virtual field trips have on participants' interest.

Expert Reviews

Experts reviewed the instruments and methods of data collection and analysis to check for accuracy and screen for any biases within data collection methods or analysis (Schwandt, 1997). Questions used for the quantitative surveys and qualitative interview protocols needed to be as free of bias as possible. The semi-structured interview protocol was reviewed by my dissertation chair, committee, and a clinical child psychologist in an attempt to identify potential biases and assess if the interview protocol had potential to yield meaningful data for the study (Creswell, 2014). This helped to support the validity by confirming that the tools used measure what they are reported to measure (Johnson, 2008).

Audit Trail

Throughout the entire study, I maintained an audit trail that included a collection of materials including coding schemes and themes generated from the study, personal notes taken, and copies of instruments used in the study (Schwandt, 1997). The audit trail included information describing how data were collected and analyzed which supports the transparency of the study. I reflected in my study journal following each connection with participants, and took notes during interviews and throughout the data coding process to provide an audit trail reflective of my thoughts and interpretation of findings (Creswell, 2014).

Thick, Rich Description

Many readers may not have knowledge or experience with virtual field trips. When writing descriptions of programs and settings, I used vivid descriptions to provide enough information for other researchers to understand the setting and techniques used in the study (Hubbard & Power, 1999). This allowed the reader to share the experience and have a more in-depth understanding of the study (Creswell, 2014). Thick, rich descriptions support the credibility of the study by allowing the readers insight into the study and supports their comprehension of the research and findings (Shenton, 2004).

Peer Debriefing

Within action research, reliability of studies can be a challenge since a researcher's focus is not to generalize findings beyond the local context of research. Reliability is described as the degree that a study can be repeated with similar results (Johnson, 2008). One method of ensuring reliability is through the process of peer debriefing (Mertler, 2017). In this study, peer debriefing included a clinical child psychologist reviewing the instruments used and my dissertation chair reviewing the research process, data analysis findings, and interpretation of findings. Peer debriefing throughout the study improves rigor, trustworthiness, credibility, and reliability (Mertler, 2017; Onwuegbuzie et al., 2010).

Plan for Sharing and Communicating Findings

The results of this research have been compiled in a short report including infographics about the impact virtual field trip programs at the science center have on students' interest in specific science domains, their interest during activities within programs, and their interest in STEM. This report will be presented to multiple stakeholders, and findings will be shared locally, regionally, and internationally.

Findings were first presented at the local level to the director of the science center. During this meeting, specific suggestions and possible implementation plans for future programs and revisions of current programs were discussed. Results were also shared with the educational team at the science center, including the assistant director and other full-time educational staff in the form of a short discussion as well as action plans following the research (Creswell, 2014). The action plans, informed by research findings, include how the virtual field trip department can improve current programs and create additional high-quality programs reflecting the results from the research findings.

Results will also be shared at the regional, national, and international levels. At the regional level, results will be conveyed to the dissertation committee at the University of South Carolina as well as state conferences including the South Carolina Education Technology (SC Ed Tech) conference. At the national and international levels, the study design and findings will be submitted to be (a) published in a journal article, (b) presented to the Center for Interactive Learning and Collaboration (CILC), and (c) presented at conferences such as the International Society for Technology in Education (ISTE) annual convention.

CHAPTER 4

ANALYSIS AND FINDINGS

The purpose of this action research was to determine the impact that the virtual field trip programs have on participants' interest in specific science domains and STEM fields. Activities within the programs were also assessed to determine how the format of programs affected participant interest. The study focused on the following research questions: (1) Do virtual field trip programs affect participants' interest in specific science domains and why?, (2) Which activities are most interesting for students during a virtual field trip program offered by the science center and why?, and (3) Do virtual field trip programs affect participants' interest in STEM fields and how?

An overview and analysis of the data collected during this mixed methods action research study is presented in this chapter. Participant survey data and focus-group data were combined to develop an understanding of the impact virtual field trips have on participants' interest and address the study's research questions. The results from the surveys produced quantitative data to analyze. Qualitative data were collected from open-ended questions following surveys and from select participants who attended focus-group interviews. The focus-group interviews were transcribed and both transcript and open-ended survey responses were coded for qualitative analysis. Part one of this chapter addresses the quantitative analysis while part two reports and reflects on the qualitative data collected during the study. Lastly, triangulation of both quantitative and qualitative data is addressed.

Quantitative Data Analysis and Findings

The following section reports the quantitative data findings from the science domain, activity, and STEM surveys. The survey responses were collected using a Google Form and then downloaded into an Excel file. Code numbers and pseudonyms were assigned to each participant and names were removed from student data to provide anonymity (Kaiser, 2009). Multiple students were absent from the sports community center each day of the research which meant that not all participants had data for each day of the study. The survey data collected was analyzed using descriptive statistics and Wilcoxon signed-rank tests to determine the impact virtual field trips had on participant interest.

Throughout the study, attendance at the sports community varied by day and therefore, so did the amount of data collected. For the first day of research, 17 participants were present for the initial introduction as well as initial surveys, but one student did not complete the science domain pre-survey. For the second day of research, 16 students were present. The third day had a total of 17 and the fourth day had 15. The final day only had 13 participants in attendance. See Table 4.1 for participant attendance by day.

Table 4.1. *Participant Attendance by Day*

	Monday	Tuesday	Wednesday	Thursday	Friday
Participants	17*	16	17	15	13

Note: One participant did not participate in all surveys.

The absence of participants during the research period caused a dilemma with missing data. It was not possible to offer make-up programs for participants not in attendance, so it was important to determine how the absence of data would be managed to ensure the integrity of the study. There are not clear guidelines for handling missing research data (Cheema, 2014; Mcknight et al., 2007). Mcknight et al. (2007) suggest it is important to identify how the missing data will impact the study. It was the researcher's decision to handle missing data uniquely per research question in order to preserve the most data possible. Participants absent on days there was survey administration about science domain interest (RQ1) were removed from corresponding analysis. Consequently, their scores were simply not calculated with the rest of the participants using a listwise deletion for that particular science domain (Mcknight et al., 2007). This method consists of removing participants with missing data (Cheema, 2014; Mcknight et al., 2007). All data collected from activity surveys (RQ2) were utilized. To handle missing data from participants absent in either pre- and post-surveys about STEM interest and curiosity (RQ3), a listwise deletion method (Cheema, 2014) was used.

All surveys were reviewed for abnormalities or outliers, for example, a participant who selected the same response for every selection in their pre- and post-responses. These data could largely affect the integrity of the study since it may have been arbitrarily selected by the participant and not be a true representation of their feelings. Once outliers were identified at the participant level, an attempt was made to understand if the selected response was the true intention of the participant, or they may have rushed through the survey. Due to the small sample sizes for this study, it was the intention of the researcher to include as much data collected as possible. More information about individual cases will be discussed below. Survey findings are presented in the following sections by topic: (a) science domain interest, (b) activity interest, and (c) STEM interest.

Science Domain Interest (RQ1)

The science domain survey was used to collect data from participants to address RQ1: Do virtual field trip programs affect participants' interest in specific science domains and why? The science domain survey was divided into four subscales, each containing five questions pertaining to chemistry, geology, meteorology, and astronomy. Questions prompted participants to reflect on their feelings about each domain. Participants responded using a four-point Likert-type scale ranging from (1) strongly disagree to (4) strongly agree.

Next, reliability coefficients for the science domain surveys, by subscale, were calculated using Microsoft Excel for each of the subscales of interest in chemistry, geology, meteorology, and astronomy for both the pre- and post-surveys (see Table 4.2). Coefficient alpha, commonly named Cronbach's alpha, is one of the most common and widely used methods of calculating internal consistency in behavioral sciences (Drost, 2011). Due to the sum of the item variances being used in the numerator of the equation, it is suggested that coefficient alpha is appropriate to use with Likert-type scale data (Henson, 2001). Alpha score outputs closer to one provide the highest level of reliability. Gliem and Gliem (2003) suggest following the rule that alpha values above .90 are excellent, .80 are good, .70 are acceptable, .60 are questionable, and below .50 are unacceptable. All calculations about subscales in the science domain interest survey produced scores above .90, which demonstrates high reliability (Drost, 2011; Henson, 2001; Shafer & Zhang, 2012; Traub, 1994).

Table 4.2. *Cronbach's Alpha Reliability Scores*

	Pre	Post
	α	α
Chemistry (*n*=13)	.93	.91
Geology (*n*= 12)	.95	.96
Meteorology (*n*=14)	.97	.94
Astronomy (*n*= 12)	.94	.90

Descriptive Statistics

First, descriptive statistics were used to analyze the data. Participant pre- and post-survey score means were calculated for each subscale. Then they were combined into one Excel document and entered into JASP. Descriptive statistics analysis showed means and standard deviations for interest in chemistry pre-survey (M = 2.68, SD = 1.17) and post-survey (M = 2.83, SD = 1.04), interest in geology pre-survey (M = 2.63, SD = 1.16) and post-survey (M = 2.82, SD = 1.25), interest in meteorology pre-survey (M = 2.73, SD = 1.21) and post-survey (M = 2.77, SD = 1.21), and interest in astronomy pre-survey (M = 3.03, SD = 1.19) and post-survey (M = 3.25, SD = 1.04). Table 4.3 includes means and standard deviations of both the pre- and post-survey responses as well as the number of participant responses used to calculate the scores. Calculating measures of central tendency helped assess the impact virtual field trips had on participant interest by comparing pre-and post-response scores. Identifying the spread or deviation of the scores showed the variation in participant responses. Participant responses suggested a slight increase in interest for all of the science domains (see Figure 4.1).

Table 4.3. *Descriptive Statistics for Science Domain Surveys*

	Pre		Post	
	M	*SD*	*M*	*SD*
Chemistry (*n*=13)	2.68	1.17	2.83	1.04
Geology (*n*= 12)	2.63	1.16	2.82	1.25
Meteorology (*n*=14)	2.73	1.21	2.77	1.21
Astronomy (*n*= 12)	3.03	1.19	3.25	1.04

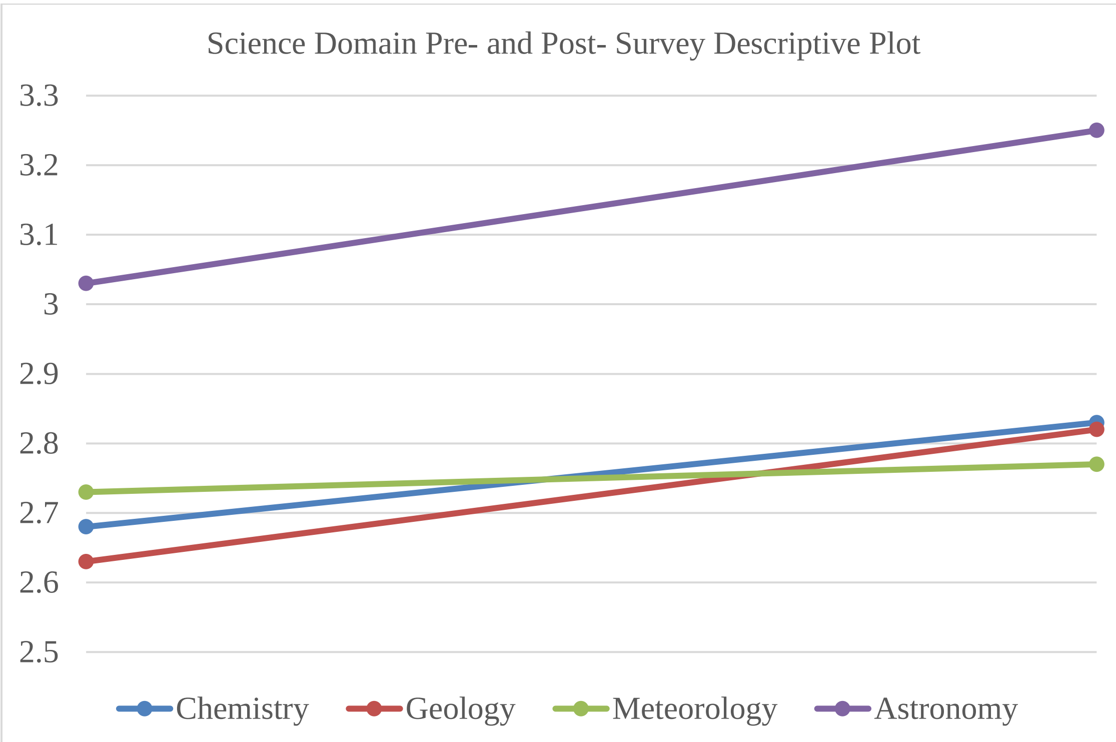


Figure 4.1. Descriptive Plot for Science Domain

Shapiro-Wilk Normality Tests

The Shapiro-Wilk test was used to examine if the participant interest response scores, by subscales, were normally distributed or not. Though there were subscales that were deemed to be normally distributed, it was determined to use the Wilcoxon signed-ranks test for all subscales due to the small sample sizes (Harris & Hardin, 2013). Using the statistical software JASP, the Shapiro-Wilk test were performed on the pre- and post-survey scores from the science domain survey data using the null hypothesis that the data was normally distributed. The test output provides a value, *W*, from a scale of zero to one. "Small values of *W* lead to the rejection of normality whereas the value of one indicates normality of the data" (Razali & Wah, 2011, p. 25). The test output also produces a *p* value score or probability for the data sets. A *p* value of more than .05 is representative of normally distributed data whereas a *p* value of less than .05 provides evidence to support the data, with a 95% confidence, is not normally distributed (Razali & Wah, 2011).

Results from the Shapiro-Wilk test produced results suggesting that the data from both interest in chemistry ($W = .95$, $p = .62$) and interest in geology ($W = .87$, $p = .06$) were normally distributed. Results from the interest in meteorology ($W = .79$, $p = .004$) and interest in astronomy ($W = .84$, $p = .03$) domains suggest that the data were not normally distributed. Due to small sample sizes, it was determined that the Wilcoxon signed-rank test was appropriate to access all subscales (Harris & Hardin, 2013).

Wilcoxon Signed-Ranks Test

The Wilcoxon signed-ranks test was performed on the subscale's pre- and post-survey responses to determine statistical significance after the data were determined to be not normally distributed following the Shapiro-Wilk test results. The Wilcoxon signed-ranks test indicated there was no statistically significant change in participants' interest in Chemistry ($W = 45$, $p = .67$), Geology ($W = 18$, $p = 86$), meteorology ($W = .41$, $p = .72$) or in astronomy ($W = .95$, $p = .40$). See Table 4.4 for Wilcoxon signed-ranks results for participants' interest in science domains.

Table 4.4. *Wilcoxon Signed-Ranks Tests for Interest in Science Domains*

	Pre-survey		Post-survey				
Domains	*Mdn.*	*SD*	*Mdn.*	*SD*	*W*	*df*	*p*
Chemistry	2.80	1.17	3.20	1.04	45	12	.67
Geology	2.80	1.17	2.60	1.30	18	12	.86
Meteorology	2.90	1.21	2.80	1.21	32	13	.72
Astronomy	3.70	1.19	3.90	1.04	15	11	.40

Activity Survey (RQ2)

To identify which activities within the virtual field trip programs most affected participants' interest during a virtual field trip (RQ2), an activity survey was developed. Following each of the virtual field trip programs, participants rated the main activities on a Likert-type scale that ranged from (1) did not enjoy very much to (4) enjoyed very much. Six subscales were created utilizing similar activities within each of the programs: (a) whole group, (b) small group, (c) role-playing, (d) active learning, (e) working with professionals, and (f) analyzing data. Each program had at least one question pertaining to each of the subscales.

Due to participants being absent for some programs and in an effort to utilize all data collected, the researcher had to decide how to handle missing data. Since participants were absent and could not answer the questions, the data are considered missing completely at random so a standard missing data technique is appropriate (Parent, 2012). All participant scores were collected for each program they attended and then averaged by subscales: (a) whole group, (b) small group, (c) role-playing, (d) active learning, (e) working with professionals, and (f) analyzing data. Test reliability was determined by using internal consistency estimates calculated by Cronbach alpha (Henson, 2001).“Internal consistency estimates relate to item homogeneity, or the degree to which the items on a test jointly measure the same construct" (Henson, 2001, p. 177). Cronbach alpha scores were calculated for each of the subscales in JASP (See Table 4. 5). All subscales produced alpha values above .93 showing high reliability for the test questions. Cohen et al. (2007) suggest that alpha values between .80 and .90 show high reliability that the test items are correlated.

Table 4.5. *Cronbach's alpha Reliability Scores Activity Survey*

	a
Whole group	.94
Small group	.94
Role-playing	.94
Active learning	.93
Working with professionals	.96
Analyzing/managing evidence	.94

Descriptive Statistics

Different numbers of participants were present each day of the study, but all scores collected were calculated to determine mean and median scores for each of the subscales. All participant data collected were analyzed using a pairwise deletion method in order to preserve the most data collected possible for analysis (Parent, 2012). Sixteen responses were calculated following the Magic of Matter program. Seventeen responses were recorded responding to the activities following the Fossil Finders program. Weather Watchers had 15 participant rankings for activities within the program. Finally, 13 participants were present for the Seasons Reality Check program.

All participant responses for the activity survey were grouped by subscales: (a) whole group, (b) small group, (c) role-playing, (d) active learning, (e) working with professionals, and (f) analyzing data in an Excel spreadsheet. Then the Excel spreadsheet was imported into JASP for further analysis. The participant means, standard deviations, and medians for each of the subscales were calculated. The median explains the 50th percentile value and is not as impacted by outliers or participants that selected the lowest or highest score compared to the mean (Cohen, 1987). Table 4.6 includes the descriptive statistics for each subscale.

Table 4.6. *Descriptive Statistics for Activity Survey*

Subscales	*M*	*SD*	*Mdn.*
Whole group	2.71	0.95	3.00
Small group	2.88	0.94	3.00
Role-playing	2.98	0.86	3.25
Active learning	2.79	1.06	3.00
Professionals	3.18	0.99	3.50
Analyzing	2.75	1.10	3.00

Note. Out of four-point Likert-type scale.

One way that researchers visually summarize and compare groups of data is by using a boxplot (Williamson et al., 1989). Figure 4.2 presents a boxplot summarizing each of the subscales for the activity survey. Boxplots are a data visualization tool that shows the first, second, and third quartiles as well as the range of data (Marmolejo-Ramos et al., 2010; Yi, 2019). This visualization uses dots to represent the responses of participants and shows the range of the most common data values. The box limits are set by the upper and lower quartiles. Inside of the box contains the middle 50% of the data or responses while the vertical line represents the median value (Williamson et al., 1989). Aligning all of the boxplots allows comparisons to be made between the subscales.

Boxplots show that the activity of working with professionals was favored among participants given that the data are very skewed to the right, and several participants rated they enjoyed it very much. In comparison, not much agreement was found among participants when it comes to analyzing data activities. They provided varied responses leading to a wide spread in the boxplot. Across all of the plots, it can be seen how varied participant responses were. The smaller the box, the more similar the participant responses were. The box being located farther to the right illustrates a more favorable response for the subscale being enjoyable to participants during a virtual field trip. For example, the box for role-playing is the smallest, suggesting that participants were in more agreement about their responses compared to analyzing which has a large spread of score responses.

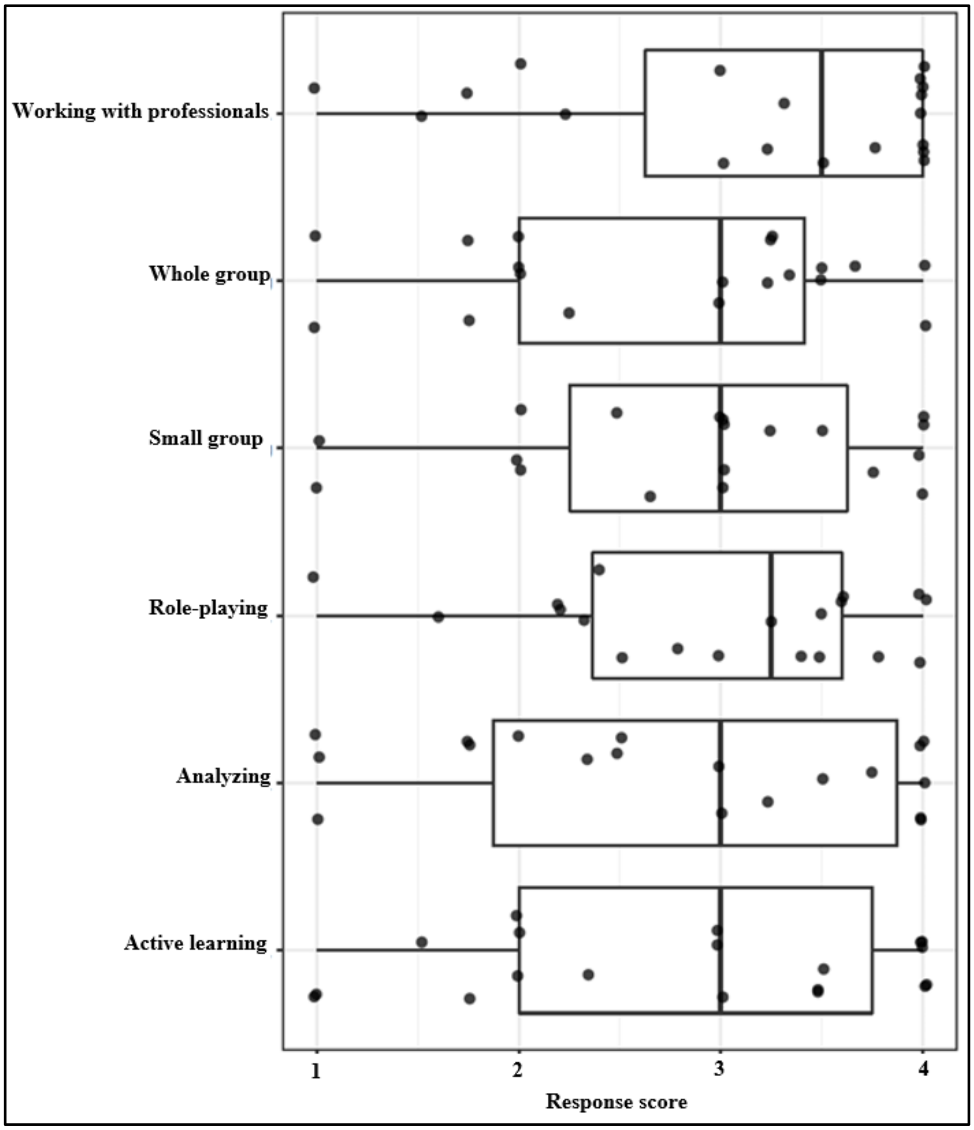


Figure 4.2. Boxplot with scores from Activity Survey

STEM Survey (RQ3)

The Common Instrument Suite 3.1 created by The PEAR Institute: Partnerships in Education and Resilience at Harvard Medical School and McLean Hospital was used to assess participants' interest in STEM through a pre-post format. The survey consisted of 11 questions that were analyzed to determine participants' interest in STEM. Responses to prompts ranged from (1) strongly disagree to (4) strongly agree. All questions were assessed using a 4-point Likert-type response from participants. Additional questions provided by the PEAR program included students rating their curiosity in science, technology, engineering, and math on a scale ranging from (1) not curious at all to (4) very curious (see appendix D for full survey). These additional four questions were combined to create a STEM curiosity subscale. Survey reliability was calculated using Cronbach's alpha (See Table 4.7) on STEM interest pre-survey ($\alpha = .89$) and post-survey ($\alpha = .94$) and shows high reliability for both by producing results above .80 (Cohen et al., 2007). The curiosity subscale survey reliability was also calculated using Cronbach's alpha for the pre-survey ($\alpha = .45$) and post-survey data ($\alpha = .56$). The alpha values do not show a high reliability for the test questions in the subscale (Drost, 2011; Gliem & Gliem, 2003). This was probably because of the low number of questions for the subscale.

Table 4.7. *Cronbach's alpha Reliability Scores*

	Pre	Post
	α	α
STEM Interest	.89	.94
STEM Curiosity	.45	.60

Descriptive Statistics

Data collected from the STEM interest survey were initially analyzed using descriptive statistics (see Table 4.8). Data from two participants, Abigail and Grady (pseudonyms), were removed from analysis due to response data being deemed outliers. In statistics, outliers are data that have abnormal distance from other scores collected from the same population (John, 1995), and in questionnaire data they are deemed as unusual with the potential to bias statistical results and lead to incorrect conclusions (Zijlstra et al., 2011). It was noted that both participants, Abigail and Grady, had selected the same response for the entire post survey, which suggests that they may have rushed through the survey and did not take the time to thoughtfully respond to the questions. Zijlstra et al. (2011) characterize this as extreme responding where the participant chooses all extreme answers. One way to alleviate this is by removing the extreme response answers from the data. Further analysis was performed using a sample of eleven remaining participants.

Participant response scores were analyzed by taking the mean and standard deviation of participants' pre- and post- survey scores for the STEM interest survey. There was a small increase in participant STEM interest from the pre-survey (M = 2.75, SD = .84) to the post survey (M = 3.12, SD = .98).

The means and standard deviations were also calculated for the STEM curiosity subscale. The means were calculated from the pre- and post-survey curiosity questions to create a pre-survey curiosity rating and a post-survey curiosity rating. Participant curiosity in STEM increased from the pre-survey (M = 2.75, SD = .78) to the post survey (M = 3.23, SD = .80). See Table 4.8 for STEM survey descriptive statistics.

Table 4.8. *Descriptive Statistics for STEM Survey*

	Pre		Post	
(*n*= 11)	*M*	*SD*	*M*	*SD*
STEM interest	2.75	0.84	3.12	0.98
STEM curiosity	2.75	0.77	3.28	0.80

Note. Out of four-point Likert-type scale.

Shapiro-Wilk Normality Tests

A Shapiro-Wilk test was used to examine if the data were normally distributed or not (Razali & Wah, 2011). Participant scores in each subscale (STEM interest and STEM curiosity) were analyzed to determine if the data was normally distributed (See Table 4.9). Using the statistical software JASP, the Shapiro-Wilk test was performed on the pre- and post-scores from the STEM interest survey. The test output provides a value, *W*, from a scale of zero to one (Razali & Wah, 2011). A *p* value of more than .05 is representative of normally distributed data whereas a *p* value of less than .05 provides evidence to support the data, with a 95% confidence, is not normally distributed (Razali & Wah, 2011). Interest in STEM ($p = .03$) indicates that the data is not normally distributed and must be analyzed using the Wilcoxon signed-ranks test while curiosity in STEM subscale ($p = .59$) produced values indicating a normal distribution of data. However, it was determined due to small sample sizes that Wilcoxon signed-ranks test be used to analyze the data due to small sample sizes.

Table 4.9. *Shapiro-Wilk Test of Normality for STEM*

	W	*P*
STEM interest	.84	.03*
STEM curiosity	.95	.59

Note. Significant results marked with a * suggest a deviation from normality.

Wilcoxon Signed-Ranks

Data from the STEM interest and curiosity subscales were analyzed within JASP using a Wilcoxon signed-ranks test (Goss-Sampson, 2018). To complete this statistical test, averages for participants' survey data were calculated for both their pre-survey and post-survey responses. Those scores were then compared using the Wilcoxon signed-ranks test. Results indicated that no statistically significant differences were found in participants' STEM interest ($W = 33$, $p = .24$) or STEM curiosity ($W = 37$, $p = .76$). The resulting statistics are displayed in Table 4.10.

Table 4.10. *Wilcoxon Signed-Ranks STEM Interest*

	Pre-survey		Post-survey				
Subscales	*Mdn.*	*SD*	*Mdn.*	*SD*	*W*	*df*	*p*
STEM Interest	2.82	.84	3.55	0.98	33	10	0.24
STEM Curiosity	2.67	.81	3.25	0.93	37	10	0.76

To summarize, participant responses from the science domain survey, the activity survey, and the STEM PEAR survey were analyzed in an effort to better understand the impact that virtual field trips have on participant interest in science and STEM. Surveys were divided into subscales for analysis. Initial analysis consisted of descriptive statistics and further analysis using the Wilcoxon signed-ranks test were conducted on the science domain and STEM survey responses to determine statistical significance. Following analyses, all subscales and data received from science domain, STEM interest, and STEM curiosity surveys produced non-significant results. However, quantitative data does not provide the complete picture and next the qualitative data findings and interpretations will be discussed.

Qualitative Findings and Interpretations

Qualitative data were collected for this study through open-ended response survey questions following each virtual field trip program, as well as two focus groups consisting of a total of seven participants. Open-ended questions allowed for all participants' thoughts to be gathered directly following the programs while focus groups allowed select participants to elaborate on their feelings and thoughts about their experiences. The smaller focus groups also provided the opportunity for follow-up questions so the researcher could learn even more about participants' interest in science domains, STEM, and program activities.

Participant Selection

Open-ended Questions

The use of open-ended questions embedded within the surveys allowed for the collection of thoughts and ideas from participants immediately following the programs and allowed for the collection of data from all participants, not just those assigned to be in a focus group. Questions prompted participants to respond to their favorite part of the program, their least favorite part of the program, and if they had anything additional they would like to add. Data collected from open-ended questions were combined into a single transcript in a Word document, which was then uploaded into the web-coding tool Delve for analysis.

Focus Groups

On the final day of research following the last virtual field trip and post-surveys, seven participants were chosen by the community center youth director and asked if they wanted to be part of the focus groups. Two focus-group interviews took place in Zoom.

Participants sat on the ground in front of the community center's laptop. Other camp activities continued to take place around the gym where the interviews took place.

The first focus group consisted of four participants, two females and two males, and was 15 minutes long. The second focus group consisted of three participants, two females and one male, and was 13 minutes long. The average age of the focus-group participants was 9.29 years old. Eighty-six percent were identified as White/Caucasian by their parents or guardians and 14% identified as African American/Black. The majority had completed third grade (n = 5) and the rest (n = 2) had completed fourth grade. Four of the participants attended the same local elementary school, which has booked virtual field trips through the science center in previous years, and the other three participants attended other local elementary schools. Five participants reported having previous STEM experience during or outside of school and four students had previous virtual field trip experiences. See Table 4.11 for interviewee demographic information.

Focus groups were recorded through Zoom as well as by the transcription app Otter. The app was run from a mobile device placed near the virtual field trip studio speaker in order to record participant responses. Transcripts of the interviews were processed within the Otter app on the device and downloaded to Word following the focus-group interviews. Then transcripts were reviewed for accuracy using the Zoom video recording of the interviews for clarification when needed. Edits were made to improve accuracy and to document in the transcript when the participants used body movements to respond to questions (e.g., nodding affirmatively). Names were changed within the transcripts to the pseudonyms assigned to the focus-group participants to protect the participants' identities (Kaiser, 2009). Due to not having contact with participants following data collection, member checking was not feasible for this study. The transcripts from both the open-ended responses and focus groups were uploaded into the web-coding tool Delve for inductive analysis.

Table 4.11. *Interviewees' Demographic Information*

Pseudonym	Age	Gender	Grade	STEM	VFT
Abigail	9	Female	3rd	School	No
Carol	10	Female	4th	Both	Yes *
Cam	10	Male	4th	No	Yes
Cindy	9	Female	3rd	School	No
Elise	9	Female	3rd	School	Yes*
James	9	Male	3rd	No	Yes
Tim	9	Male	3rd	Outside of school	No

Note. STEM indicates whether they have participated in STEM activities previously, with "Both" meaning prior participation in and out of school; VFT indicates whether they have previously attended a Virtual Field Trip, with * specifying that the VFT was through the science center.

Analysis of Qualitative Data

The coding process included two cycles of coding. Within each cycle, there were multiple rounds of coding consisting of open coding, in vivo coding, structural coding, as well as value coding (Saldaña, 2016). Following the initial coding, a total of 31 individual codes were generated. A total of 30 codes were used for focus-group transcripts and 21 codes were used for the open-ended responses, many overlapping with those used for focus-group responses (see Table 4.12 for summary of codes per qualitative data source). This process will be explained in more detail next.

Table 4.12. *Summary of Qualitative Data Sources*

Data Sources	Number of codes	Number of Codes Applied
Open-ended responses	21	71
Focus-group transcripts	30	339

First Cycle of Coding

During the first cycle of coding, two rounds of open coding were used. Open coding is the first step in qualitative research when transcript data are broken down or assigned codes to label them (Williams & Moser, 2019). Transcripts were analyzed sentence-by-sentence, question-by-question, and line-by-line. Within Delve, codes were linked to participant responses. Notes about the codes and the process of coding were documented in the researcher's journal (Schwandt, 1997) and within the Delve software tool.

In addition to open coding, three other strategies were used during the initial cycle of coding including in vivo coding, value coding, and structural coding. In vivo coding uses participants' direct words to create codes (Saldaña, 2016). For example, while coding the whole-group responses when referring to their favorite parts of programs being experiments, the word *experiments* was added as a code. This allowed the code to emerge from participant responses. Value coding was also used to code data using the participants' experiences, perspectives, feelings, opinions, and beliefs (Saldaña, 2016) about VFTs and program activities. Value codes included *favorite program, least favorite program*, *negative feelings*, *growth in interest*, *interacting with presenter*, and *value to virtual field trips*.

More than one code was applied to a quote multiple times, which Saldaña (2016) describes as simultaneous coding. For example, when James responded to his least favorite activity he said, "When we were doing the Fossil Finders and like our group was like didn't know anything about it and were off track with what we were supposed to be doing and stuff." This excerpt was coded with *Fossil Finders*, *least favorite activity*, and *small group* codes. When asked if their interest in science increased because of virtual field trips, Cam responded with, “So I was, I mean, when I was in school and they taught me science I was like this is lame, and then we did the virtual field trip, and I was like it’s not so bad”. Initial coding of this response was both *growth in interest* and *value to VFT*. When discussing favorite activities, Carol’s quote of, “I like graphs” was coded as *favorite activity* as well as *data*. The first round of coding resulted in codes ranging from the program discussed, the feelings about their interest, and activities.

The second round of initial coding consisted of structural coding. It allowed for responses directly related to research questions to be grouped together (Saldaña, 2016). This grouped the participant responses by research question as well as by program and activity mentioned. Structural coding led to the creation of multiple codes including *movement*, *small groups*, *Fossil Finders*, *Weather Watchers*, and *STEM*. During this process, participants’ responses were also coded by their pseudonym to allow for easier triangulation with their whole-group responses and quantitative data. Codes were created for each participant to correlate when they responded to questions. Coding by participant provided an easy way to sort through each participant’s responses and see if there was convergence with quantitative findings. See Figure 4.3 for an example of coding in Delve.

Second Cycle of Coding

The second cycle of coding consisted of reviewing the previous codes and looking for patterns and connections to the research questions (Saldaña, 2016). The goal was to “develop a sense of categorical, thematic, conceptual, and/or theoretical organization from your array of first cycle codes” (Saldaña, 2016, p. 234). During this cycle, codes were grouped into common categories using pattern coding where similar codes were grouped together in an attempt to narrow down the codes into categories (Saldaña, 2016). For example, *small group*, *whole group*, *movement*, *taking a role*, and *working with professionals* were all grouped under the category of activities. See Figure 4.4 for an example of the second cycle of coding completed in Delve. All participant pseudonyms were grouped under the category of *participants*, and individual programs were grouped under the category of *programs*. The category *value*, which originated from value coding, was also created to combine codes dealing with interactivity of virtual field trip programs, interaction with the presenter, and negative feelings. As each code and category was created, a description was included within Delve and the researchers' journal.

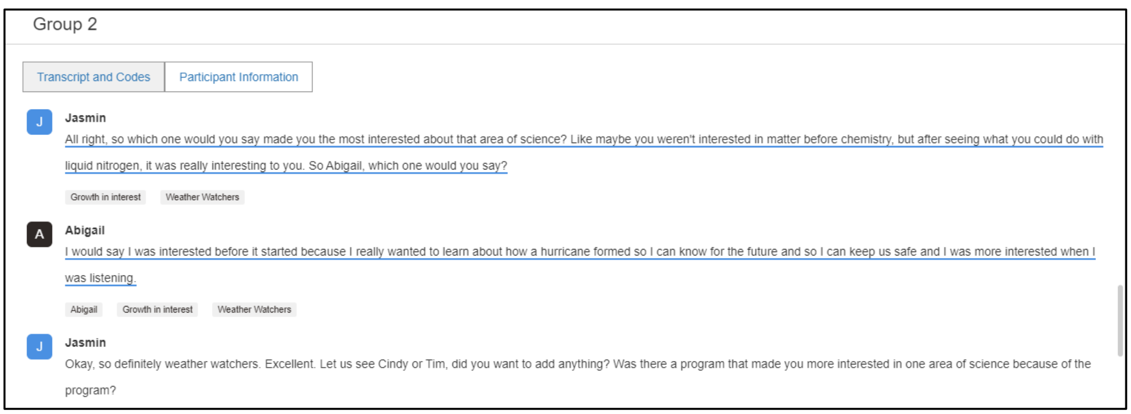


Figure 4.3. Example of Coding in Delve

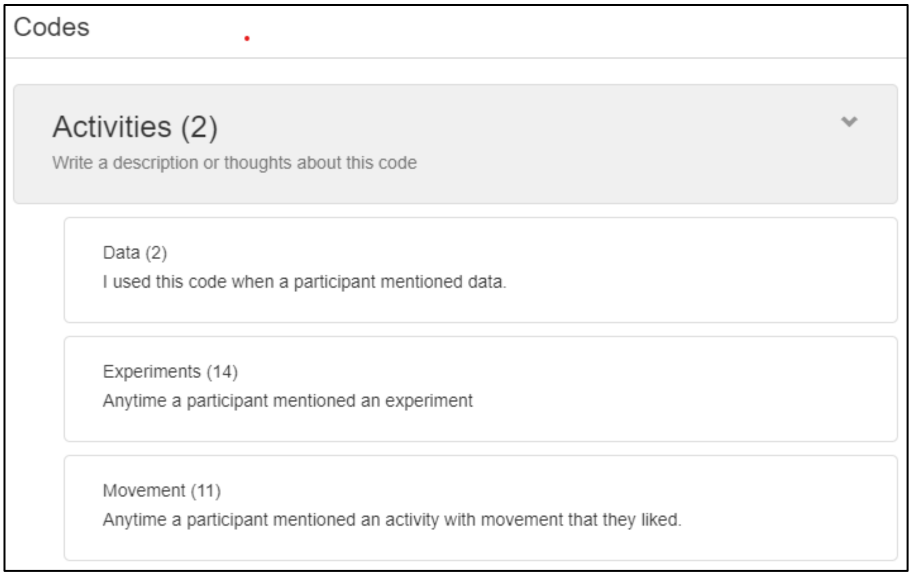


Figure 4.4. Example of Second Cycle of Coding Completed in Delve

Peer Debriefing

Multiple meetings were held with the dissertation chair throughout the coding process. Following the initial coding process, peer review (Mertler, 2017; Onwuegbuzie et al., 2010) was conducted with the help of the dissertation chair to eliminate and combine codes. For example, the code for *alternate to in person* was combined with *virtual field trips versus in person*. This change was made since both were very similar and referenced responses from participants bringing up differences between in-person field trips and virtual field trips. During these meetings, code definitions and excerpts were reviewed; the coding scheme was refined and checked for alignment with codes and categories. It was also decided that whole-group qualitative responses should be compared with the focus-group responses to develop a more thorough understanding of participant views and triangulate the data to check for convergence of findings (Heale & Forbes, 2013; Mertler, 2017). The whole-group responses were combined into a transcript within Word and then uploaded into Delve for easier analysis. Combining responses gathered during the focus-groups and whole-group, open-ended surveys led to more data to work with. Qualitative themes were developed and revised during these meetings, and their alignment between themes, categories, and codes was discussed.

Identifying Themes

Using an inductive approach, attempts were made to understand the impact that virtual field trip programs have on participants' interest in specific science domains, STEM, and their opinions on activities within the programs. In an inductive approach, themes are revealed through the researcher's consideration and interpretation of the data (Bernard et al., 2017; Fereday & Muir-Cochrane, 2006). Creswell's (2017) data analysis spiral was used to support data analysis, i.e., the inductive process entailed organizing raw data codes; condensing into categories; and finally widespread, encompassing themes. First, common response topics and ideas using codes were grouped. Codes were used to categorize data that are similar in meaning, allowing the researcher to organize data that relate to one another (Fereday & Muir-Cochrane, 2006; Stuckey, 2015).

Delve was used throughout making initial observations, coding transcripts, and creating themes allowing the ability to filter by code or theme to see specific responses. Using computers allows the data to be displayed in Microsoft Word ® documents, tables and/or graphs which can help researchers draw conclusions (Miles & Huberman, 1994). The codes were exported from Delve into a Word document. Under each code were snippets of participant responses pertaining to that code, which allowed each raw quote to be read through again and organized by category.

The primary goal in thematic analysis is to reduce the volume of information collected by identifying and organizing the data into important patterns or themes

(Mertler, 2017; Thomas, 2006). Through the coding process and using common participants' responses and expressed ideas, themes were revealed (Fereday & Muir-Cochrane, 2006). See Table 4.13 for a list of the quotes, codes, categories, and themes per research question. Codes not associated with the research questions are not included. Again, the direct information from the participants was analyzed for commonalities, which allowed common themes to emerge. Codes were also exported from Delve to an Excel document to observe the nested levels of codes allowing for themes to be seen (Figure 4.5). For example, *data* and *experiments* (codes) both fell under *activities* (category).

Table 4.13. Quotes, Codes, Categories, and Themes

Themes	Categories	Codes	Quotes/responses
Virtual field trips led to higher science domain interest in most participants. (RQ1)	• Programs • Interactive • Growth in interest	• Magic of Matter • Fossil Finders • Weather Watchers • Seasons Reality Check • Working with professionals • Experiments • Growth in interest • Negative feelings	• Cam: "The one when the liquid nitrogen and food coloring turned into a solid. I saw it and was like, wow!" • Cindy: "I was not excited about chemistry and then we did the VFT." • Researcher: "Did the Magic of Matter program make you more interested in Chemistry?" Tim: "Not really"
Prior interest in science domain triggered increase in science domain interest. (RQ1)	• Programs • Growth in interest	• Magic of Matter • Fossil Finders • Weather Watchers • Seasons Reality Check • Growth in interest	• Abigail: "I would say I was interested before it started because I really wanted to learn about how a hurricane formed so I can know for the future and so I can keep us safe and I was more interested when I was listening"

Themes	Categories	Codes	Quotes/responses
			• Researcher: "Were you interest in meteorology before?" Carol: "Yes" • Elise: "Um, I liked the Fossil Finders. Researcher: "Were you interested in geology before the Fossil Finders program?" Elise: "Yeah"
Participants prefer activities that involved actively learning in authentic scenarios and expressed dislike for activities that require them to be self-directed. (RQ2)	• Programs • Activities	• Interactive • Working with professionals • Taking a role • Favorite activity • Least favorite activity • Data • Small group • Negative feelings	• Cindy: "I liked being part of the fact checking team." • Lilly: "Learning about what it is like to be a fossil finder" (favorite activity) • Sherry: "Just sitting there" (Least favorite activity) • Zander: "Working with my group. They didn't include me" (Least favorite activity) • Abigail: "I would really appreciate having small groups if there's someone really smart and we can learn from them" • James: "When we were doing the fossil finders and like our group was like didn't know anything about it and were off track with what we were supposed to be doing and stuff."

Themes	Categories	Codes	Quotes/responses
Science virtual field trips support interest in STEM and encourage participants to take other STEM programs. (RQ3)	• STEM • STEM interest	• STEM • STEM interest • VFT increases STEM interest	• Researcher: "Do you think virtual field trips impact or make you change your interest in STEM?" Cam: "Yes, 100 million yes" (more interested in STEM now) Carol: "Yes" James: "Yes" • Researcher: "Did the virtual field trips make you more interested in STEM like science, engineering, technology, and math?" Elise: "Maybe"

	A	B	C	D	E
1	Order of Code in List	Nested Level	Code Name	Number o	Code Description
2	1	>	Activities	2	Anytime someone mentioned activities
3	2	>>	Data	2	Anytime a participant mentioned data
4	3	>>	Experiments	14	Anytime a participant mentioned an experiment
5	4	>>	Movement	11	Anytime a participant mentioned an activity with movement that they liked.
6	5	>>	Small groups	7	Anytime a participant mentioned a small group activity that they liked.
7	6	>>	Taking a role	12	Anytime a participant mentioned an role-playing activity

Figure 4.5. Example of Nested Levels for Codes and Categories

Themes

Themes started to develop from the codes and categories to create a better idea of the impact that virtual field trips have on participants' interest in science domains, STEM, and the activities they enjoyed most during the programs. Five overarching themes emerged following the qualitative analysis. These themes were developed using direct participant responses from both the whole-group, open-ended responses as well as participant responses from focus groups. Qualitative themes per research question are presented below.

RQ 1: Science Domain Interest

Theme 1: Virtual Field Trips Led to Higher Science Domain Interest in Most Participants. During the focus groups, participants were asked if they felt that virtual field trips helped them become more interested in science. Participants in both focus groups responded positively to virtual field trips increasing their interest in science and specifically in the domains of chemistry, geology, meteorology, and astronomy. Elise mentioned that virtual field trips are fun and interesting, and Cam followed up stating, "It interested me in a lot of things." Cam also mentioned during his focus group, "when I was in school and they taught science, I was like this is lame and then we did the virtual field trip, and I was like it's not so bad." When asked by the researcher if she became more interested in any of these topics because of the virtual field trips, Abigail replied, "more interested." Participant responses show an overall positive increase in science domain interest after virtual field trips in general.

Not all participants expressed an increase in interest in science domains after the virtual field trips every time they were asked. Tim nodded when asked if virtual field trips made him more interested in science initially, but later during the interview when asked if there was a program that made him more interested in one area of science he stated "um, no." When asked what topic he did not like he said "chemistry" and when asked if the Magic of Matter program made him more interested, he answered, "not really."

While reading the transcripts, as well as the snippets that were coded for *growth in interest*, *specific programs*, and *negative feelings,* it became apparent that participants associated the programs with the science domain they covered. Next, participants' interest in each science domain will be discussed in more detail.

Chemistry/Magic of Matter. During the focus group, Cindy mentioned that she was not interested in chemistry before the Magic of Matter program, and then she did the virtual field trip, and it made her, "Maybe a little more excited." Cam said how he liked the "Magic of Matter one with the liquid nitrogen and the food coloring turned into a solid, and I was like wow!" However, not all of the responses about Magic of Matter were positive. When asked if virtual field trip programs increased his interest in science, Tim responded "Yes," but later in the interview, Tim discussed how none of the programs really made him more interested. When probed further about his negative feelings towards virtual field trips, he replied "Chemistry." He disliked chemistry the most. When asked if Magic of Matter increased his interest in chemistry at all, he replied, "not really." This shows that participants had varying impacts from the virtual field trip experiences; however, the majority of participants had positive comments about their interest in chemistry following the Magic of Matter program. During focus group sessions, other participants did not mention Magic of Matter or chemistry program positively or negatively.

Geology/Fossil Finders. During the focus group, Cindy said that the Fossil Finders program was her favorite program of the week. When asked if she was interested in fossils before the program or if it was the program, itself that interested her, she replied, "It [the program] made me more interested." Abigail said that the Fossil Finders program made her more interested in geology as well. Similarly, Elise stated that Fossil Finders was her favorite program, and she was interested in geology before the program.

Cam, Elise, James, and Carol all said that they were more interested in Geology because of the program. Overall, the majority of participants spoke very positively about the Fossil Finders program in both the focus groups as well as the whole-group, open-ended surveys.

Meteorology/Weather Watchers. Abigail's favorite program was Weather Watchers, and she elaborated to say the Weather Watchers field trip made her more interested in meteorology. Abigail said "I would say I was interested before it started because I really wanted to learn about how a hurricane formed, so I can know for the future, and so I can keep us safe. I was more interested when I was listening." This shows the importance of programs covering topics on domains that are relevant and interesting to participants. Carol also mentioned that she liked Weather Watchers, and she was interested in meteorology prior to the program. Before the Weather Watchers program, James said that he was, "in the middle/kind of" interested in meteorology, and it was the program that made him more interested in meteorology.

Astronomy/Seasons Reality Check. Though this was one of the more favored programs from qualitative whole-group responses, focus-group participants did not spontaneously mention astronomy during interviews when prompted to discuss their favorite and least favorite programs. Prompts were not provided during the semi-structured interview to directly address astronomy but instead allowed participants to choose which program they wanted to discuss.

Favorite Programs and Least Favorite Programs. On the last day of the research, participants were asked to select their favorite and least favorite program for the week. All participants present, a total of 13, responded (Figure 4.6). Seven participants chose Fossil Finders, as the favorite program. Next, both Seasons Reality Check, and Weather Watchers were each chosen by three participants. The whole-group responses do align with focus-group participants for favorite programs. Four focus-group participants rated Fossil Finders as their favorite program while Weather Watchers came in second with two participants choosing it as their favorite and Seasons Reality Check rounded out the favorite programs by being chosen by one participant. This aligns with participant responses about their favorite programs during focus-group interviews, during which participants responded with positive feedback for the Fossil Finders program as well as the Weather Watchers program.

Participants were also asked to select their least favorite program. Magic of Matter came in the least favorite among nine participants of whole-group responses. Weather Watchers followed with two of the participants. Fossil Finders and Seasons Reality Check both received one vote as least favorite program. The focus-group responses were similar to the whole group for least favorite program, with Magic of Matter receiving six participant votes and Fossil Finders receiving one. See Figure 4.6 for favorite programs and least favorite programs.

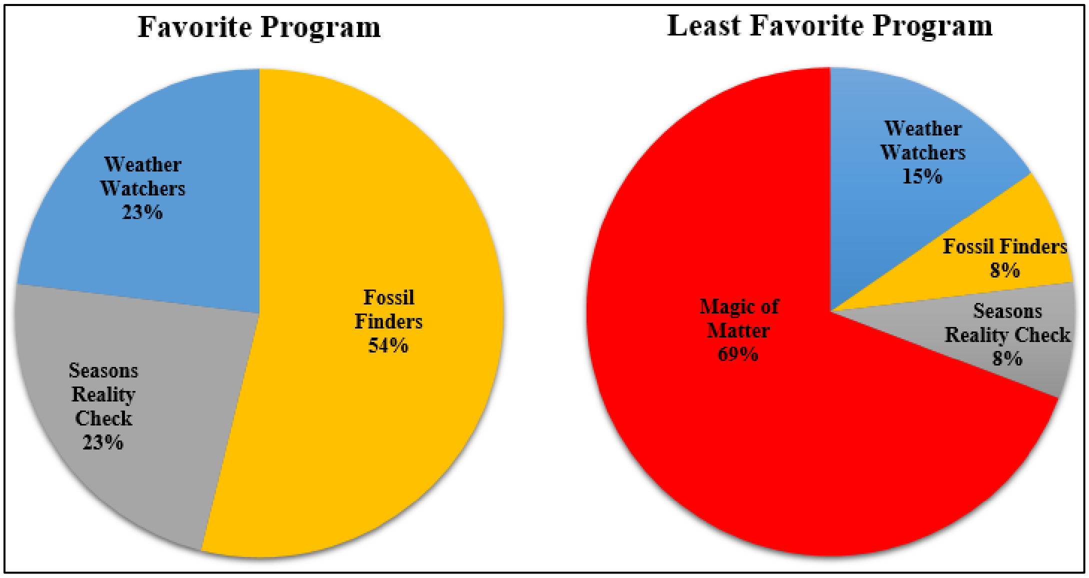


Figure 4.6. Favorite and Least Favorite Program Participant Responses

Theme 2: Prior Interest in Science Domain Triggered Increase in Science Domain Interest. A second theme emerged based on the trend of an increase in interest when participants already had previous interest in the topic. During the qualitative analysis process of interest in science, it became clear that some participants' prior interest for science domains may have played a part in their growth of interest in that science domain.

When asked about their favorite programs and if they were interested in the topic before the virtual field trip, many stated "Yes." For example, when Abigail was reflecting on her interest in meteorology, she said, "I would say I was interested before it started because I really wanted to learn about how a hurricane formed so I can know for the future, and so I can keep us safe, and I was more interested when I was listening." James, when reflecting on the Weather Watchers program, said that he was "in the middle/kind of" interested in meteorology before, but agreed that the program increased his interest. Elise mentioned that her favorite program was Fossil Finders and said, "Yeah," when asked if she was already interested in fossils and geology before the program. Elise agreed she felt that the program increased her interest in fossils. Later in the interview, she said that her least favorite program was Weather Watchers since she was not interested in meteorology. Carol responded that she liked the Weather Watchers program the best and when asked if she was interested in meteorology before, she said, "yes." Contrarily, Tim mentioned that his least favorite science domain was chemistry, and he did not become more interested in chemistry because of Magic of Matter, which he said was his least favorite program in his whole-group, open-ended survey.

RQ2: Enjoyment of Virtual Field Trip Activities

Participants Prefer Activities that Involved Actively Learning in Authentic Scenarios over Self-directed Learning Activities.

Participants expressed enjoyment from activities when they were working with professionals, role-playing, or involved in a scenario during a program, and were active in their learning. For example, participants worked with professionals during each program, including the researcher as the facilitator, a chief meteorologist during the Weather Watchers program, connecting with the Reality Check team, and working with the professors from Magic of Matter. During the Magic of Matter program, participants took on the role of being a test audience, while during the Fossil Finders program they were part of a fossil dig group. They also worked in small groups during each of the programs either analyzing evidence or constructing a response. Each virtual field trip program is comprised of similar activity types (whole group, small group, role-playing, active learning, working with professionals, and analyzing data) which allowed for comparisons to be made regarding activity types that participants enjoyed most.

Participants responded specifically to many of the activities throughout focus-group discussions and in whole-group survey responses. Commonalities were noted about enjoyment around activities that involved working with professionals, role-playing, active learning, and a dislike for activities that required participants to be self-directed. Next, specific activities will be discussed in more detail.

Working with Professionals. Working with professionals, from the virtual field trip teacher to a meteorologist and scientists, was an area of enjoyment for many of the participants. From watching the "news lady," to interacting with the virtual field trip teacher, and learning what it was like to be a Fossil Finder, participants expressed enjoyment when working with professionals. When asked if working with professionals may support understanding possible careers available in science, Cindy and Abigail responded "Yes" while Tim responded "No". Cam stated that working with professionals "interested me in a lot of things." When probed to elaborate on which one he would like to do when he grows up, he replied "I'd say Magic of Matter one with the liquid nitrogen." Carol mentioned that interacting with the presenter kept her interest, too. Her favorite part of the program was "when the professors were doing the balloon thing". Tim noted that his favorite part of the Magic of Matter program were the "experiments" that the professors did. Cam shared his reaction to the experiment the professors displayed by stating "the food coloring turned into a solid; I was like wow!"

During the Magic of Matter open-ended responses, participants were very favorable to experiments the professors displayed using liquid nitrogen. Seven participants' responses included liquid nitrogen or the balloon experiment the professors did as their favorite part in the program. Five participants mentioned that they liked everything or all of the experiments the professors shared. Alex, following the Fossil Finders program, responded that his favorite part of the program was, "Seeing the whale ear" that was shown by the virtual field trip teacher to participants. Following Weather Watchers, participants (*n* = 8) seemed to enjoy the studio tour and meeting with the meteorologist from their responses for their favorite part of the Weather Watchers program. Finally, for the last program, Seasons Reality Check, Sherry mentioned how she enjoyed "learning how stuff worked [seasons]" from the researcher and Reality Check Team. Alex mentioned his favorite part was "When they [Reality Check team] went in the room, and we could see the earth." This referenced working with the Seasons Reality Check team when they visited the planetarium to explain how direct and indirect light causes seasons.

Role-playing. All virtual field trip programs had a scenario associated with them to provide an authentic story and a purpose for participants. They positively ranked activities dealing with role-playing in the programs. Thirteen participants responded to the survey question asking for their favorite activity with the specific demonstration they enjoyed during the Magic of Matter program. The scenario for the program was for them to provide feedback for the professors. Sherry continued the role-playing during her open-ended survey and stated her favorite experiments the professors did with liquid nitrogen as "the 3rd one [water in the balloon] and the 2nd one [air in the balloon]." Lilly shared that her favorite part of the Fossil Finders program was "looking at how it is like to be a fossil finder". During the open-ended survey for Fossil Finders, two participants, Cam and Coby, responded that they liked finding the different fossils and learning how to be a fossil finder. Four participants, Cam, Coby, James, and Sherry, enjoyed taking a role and being the reporter. James mentioned that he felt smart because he was able to tell his group information and enjoyed being a reporter. When asked if they liked taking a role during programs, Cam, Elise, and Carol all said “Yes!” Cindy, when asked her favorite role, loved the Seasons Reality Check program and stated that it was her favorite: “I think it was this one [Seasons Reality Check] because I liked becoming part of the fact checking team.”

Movement/Active Learning. Movement and active learning also seemed to be enjoyable for participants during the programs. From enacting the high winds and pressure during a hurricane in Weather Watchers to dancing out the particles of matter in different states during Magic of Matter, activities that involved movement seemed to be enjoyable for most participants. Abigail enjoyed movement during the Fossil Finders program. She stated, “I liked acting like trees.” Cam, Carol, Elise, and James agreed that movement was enjoyable during programs by stating, “Yes,” when asked by the researcher if they enjoyed moving during programs. On the other hand, Cooper expressed his dislike for activities involving movement. Cooper’s least favorite part of the Fossil Finders program was “pretending to be a tree.” Several participants expressed their dislike for just sitting and not actively doing something or thinking about something during the program. Sherry and James both listed their least favorite activity during multiple programs as “just sitting there.” James also listed his least favorite part of programs were when he was just “waiting around.”

Data and Small Groups. Participants expressed not enjoying small group portions of the program when they had to work independently from the virtual field trip teacher’s direct guidance. Martin said he did not like working in small groups because his groupmates did not include him. Abigail also said she did not enjoy the time in small groups and elaborated by saying, “I would really appreciate having small groups if there’s someone really smart, and we can learn more from them.” James shared a similar perspective and experience during his small group time saying, “When we were doing the Fossil Finders and like our group was like didn’t know anything about it and were off track with what we were supposed to be doing and stuff.” Coby responded that he did not like the maps and satellite (data) portion of Weather Watchers, while both Kim and Grady listed they did not like “having to talk in front of people.” On the other hand, during the open-ended responses, James mentioned that he felt smart because he was able to tell his group information and enjoyed being a reporter. Sherry, Coby, and Cam all shared their enjoyment of being able to present information to the whole group during the Fossil Finders program as well.

RQ 3: STEM Interest

Science Virtual Field Trips can Support Interest in STEM and Encourage some Participants to take other STEM Programs.

Throughout the programs, we discussed STEM and how virtual field trips incorporate STEM by combining technology and science as well as math by using graphs and data. During the focus groups, participants were asked, “Are you more interested in STEM after attending the virtual field trips?” The responses were all positive. Cam responded, “Yes, 100 million yes.” James agreed that he thinks that the virtual field trips increased his overall interest in STEM.

Elise was slightly hesitant but said, “Yes, a little bit, yes,” when asked if the virtual field trips made her want to take another science class or STEM camp in the future. Carol also said “yes” when asked if she would want to take another STEM program in the future. James replied, “a little bit” and Cam nodded when asked if he was interested in taking another class. However, Abigail, Tim, and Cindy all shook their heads when asked if they were interested in taking another science camp or learning any more about STEM.

Triangulation of Quantitative and Qualitative Data

Survey data for science domain interest, virtual field trip activities, and STEM interest and curiosity were analyzed along with the focus-group interview and whole-group, open-ended survey responses. By comparing quantitative responses with qualitative responses, a better understanding can be gained (Heale & Forbes, 2013) about the impact that virtual field trips have on participants’ interest in science domains and STEM, as well as understanding activities they enjoy during the virtual field trips. In order to get a more thorough picture, focus-group participants’ descriptive quantitative data was compared with their qualitative responses. It was also assessed how the subset of the focus-group quantitative data compared with the whole-group quantitative data per research question. These findings were then compared with the qualitative data collected. To triangulate findings, participant responses were coded in Delve by their pseudonym to allow data retrieval and comparison with their corresponding quantitative data. See Table 4.14 for an alignment of quantitative and qualitative data with themes. Alignment will be discussed by research question next.

RQ1: Science Domain Interest

Overall, focus-group participants responded favorably about virtual field trips improving their interest in science. Quantitative data showed that the majority of participants' interest levels either remained the same or increased for the science domains, but several participants' interest for multiple domains declined. Next, individual science domains will be discussed.

Chemistry

Quantitative responses showed an overall increase in interest in chemistry for both whole group and focus group. Four focus-group participants showed growth in their interest ratings for chemistry following the research. However, three participants showed a decrease in their interest in chemistry levels. Qualitative responses from participants suggested an increase in chemistry, and participants expressed interest in the experiments demonstrating changes of matter. One participant, who showed negative change for quantitative interest ratings from pre- and post-survey responses, said she liked the entire Magic of Matter program during the focus-group interviews. Another participant, who expressed that Magic of Matter was his least favorite program and did not increase his interest in chemistry during the focus group, showed an increase in his quantitative interest rankings.

Geology

The whole-group quantitative data revealed an overall increase in interest for geology; however, the mean interest level changes across the focus group shows a decrease for geology. Two focus-group participants showed increases in their geology interest following quantitative data collection, while three participants' interest remained the same (ranking of four) for pre- and post-survey responses. Two focus-group participants showed a decrease in their interest in geology following their surveys. Qualitative data suggested that participants were interested in geology, and over half of the participants listed Fossil Finders as their favorite program and expressed that the program increased their interest in geology.

Meteorology

Quantitative data showed an overall increase in interest for meteorology for the whole group, though the mean interest level changes across the focus group shows a decrease. Two focus-group participants' interest increased while two remained the same and three showed a decline for their quantitative data. Qualitative data suggested that participants' interest grew after the Weather Watchers program for meteorology. Three participants even chose Weather Watchers as their favorite program. One participant, who replied negatively during focus groups about her interest in meteorology, rated it very high quantitatively; therefore, her quantitative and qualitative data are not in alignment.

Astronomy

Whole-group quantitative data showed the highest growth in interest levels for astronomy but focus-group, quantitative data shows a decrease for astronomy. Five focus-group participants rated their initial interest in astronomy with the highest rating possible. One participant's interest grew while four participants interest stayed the same and two participants showed decreases in their interest ratings. Qualitative whole-group responses relayed participants' interest in learning about seasons and astronomy. Though astronomy was not directly discussed during the focus group, qualitative whole-group responses showed that three participants felt it was their favorite program of the week.

RQ2: Virtual Field Trip Activities

For activities, a theme emerged during focus groups about participants enjoying activities that involved active learning in authentic scenarios, which proved to be consistent with quantitative data for whole-group response averages as well as the quantitative data. Both the focus-group participants and whole-group quantitative data showed that working with professionals, role-playing, and active learning were favorite activities during the programs. Participants expressed a dislike for activities that required them to be self-directed during focus-group interviews; however, quantitative data suggested that participants enjoyed small-group activities more than whole-group program activities. Next, specific activity types will be discussed.

Working with Professionals

Quantitative data suggests that the most enjoyable activities during a virtual field trip were when participants were reflecting on their time working with professionals. Both focus-group participants (M = 3.36) and whole-group participants (M = 3.88) ranked activities with professionals as their most enjoyable. Qualitative data revealed that many participants enjoyed working with professionals during the programs. Focus-group participants reflected positively when discussing program activities when working with professionals and felt it helped them understand possible professions within science.

Role-playing

Both the whole-group (M = 3.55) and focus-group (M = 2.89) ranked role-playing as their second favorite activity during the virtual field trip programs. Through using scenarios during the programs, participants were invited to take an active part in the program by taking a role. Role-playing also ranked very positively for focus-group participants. Participants expressed their enjoyment when they were called in to support and had a purpose for their learning. Carol stated that she enjoyed taking a role during the programs and her activity survey response reflected that by her responding with all fours for activities where she took a role during the programs. Select participants expressed a dislike for taking a role when they were uncertain what they were supposed to do, had to speak in front of the group, or if they had to work with others in a group.

Small Group and Whole-Group Activities

There were instances of divergence between qualitative and quantitative response data for participants' enjoyment of activities during focus groups and survey responses in some areas. Qualitative focus-group and open-ended response analysis for research question two's theme (i.e. Participants prefer activities that involved actively learning in authentic scenarios and expressed dislike for activities that require them to be self-directed) showed some divergence. Participants expressed dislike for small-group activities during focus groups and whole group open-ended responses. Though all activities were rated above neutral, quantitative data showed focus-group participants ranked small-group activities (M = 2.86) more favorably than whole-group activities (M = 2.49) aligning with whole-group survey responses: small-group activities (M = 2.88) and whole-group activities (M = 2.71). Quantitative data suggest that participants preferred small-group activities to whole-group activities during virtual field trips contradicting focus-group, qualitative responses.

Another example of qualitative and quantitative data divergence was during the quantitative data collection when Abigail responded with a four when asked if she enjoyed working in small groups during Magic of Matter's program, yet, in the focus group, she stated she did not like working in small groups. Cindy also stated that she did not like working in small groups but in all programs responded with a four when asked to respond about her experience with the small-group activities. James responded that he was frustrated during the small-group time in the Fossil Finders program yet responded positively (three) in the activity survey for working with his dig group.

RQ3: STEM

Quantitative data support the qualitative theme for research question three: Science virtual field trips can support interest in STEM and encourage some participants to take other STEM programs. The STEM interest data showed an increase in interest for both the qualitative responses as well as the quantitative data. There was an increase in interest for both the focus-group subset as well as the whole-group responses, showing that participants' interest in STEM increased after attending virtual field trips. This also applies to their curiosity about STEM. The focus-group subset showed an increase in STEM curiosity as well as the whole group. Focus-group participant responses agreed with their quantitative survey data in many areas. Participants shared their interest in STEM had increased due to the virtual field trips and more than half shared an interest to take another STEM program in the future. See Table 4.14 for a triangulation of quantitative and qualitative evidence.

Table 4.14. *Triangulation of Qualitative and Quantitative Evidence*

Themes	Qualitative Evidence	Quantitative Evidence
VFTs led to higher science domain interest in most participants.	• Cam: "My favorite was Fossil Finders". Researcher: Were you interested in geology before the Fossil Finders program?	Mean change scores increased for the whole group across all domains: chemistry, geology, meteorology and astronomy science domains. Focus-group

Themes	Qualitative Evidence	Quantitative Evidence
	Cam: "Um, kind of but not like super, super, super, between the middle" • Cindy: "I was not excited about chemistry and then we did the VFT." Researcher: "Did it make you more excited about chemistry?" Cindy: "Maybe a little more excited" • Tim: "Not really" (when asked if the Magic of Matter program made him more interested in Chemistry)	participants' interest in chemistry showed an increase, however, interest in geology. meteorology and astronomy decreased. It was noted that 71% of focus-group participants rated their initial interest in astronomy as a 4.
Prior interest in science domain triggered increase in science domain interest.	• Abigail: "I would say I was interested before it started because I really wanted to learn about how a hurricane formed so I can know for the future and so I can keep us safe and I was more interested when I was listening" • Carol stated she was interested in meteorology before and liked the weather watchers program the best. • Elise liked the Fossil Finders program and stated that she was interested in geology before the program started.	Science domain interest had an overall increase across all domains for the whole group and slight declines for meteorology and astronomy for focus groups (see above). There was not a good way to determine initial interest and growth due the survey scale being fixed at 1-4.

Themes	Qualitative Evidence	Quantitative Evidence
Participants prefer activities that involved actively learning in authentic scenarios and expressed dislike for activities that require them to be self-directed.	• Cindy: "I liked being part of the fact checking team." • Lilly: "Looking at how it is like to be a fossil finder" (favorite activity) • Sherry: "Just sitting there" (Least favorite activity) • Zander: "Working with my group. They didn't include me" (Least favorite activity) • Abigail: "I would really appreciate having small groups if there's someone really smart and we can learn from them" • James: "When we were doing the fossil finders and like our group was like didn't know anything about it and were off track with what we were supposed to be doing and stuff."	Participants in the whole group enjoyed working with professionals the most of all the activities (*M* = 3.18). This aligns with focus-group responses as well (*M* = 3.36). Role-playing was highly rated for both the whole group (*M* = 2.98) and focus group (*M* = 2.89). Small-group activities (*M* = 2.88) were ranked more favorably than whole-group activities (*M* = 2.77) for the whole group. This aligns with the focus group (*M* = 2.86) which was also ranked small-group activities above whole-group activities (*M* = 2.49). This provides evidence that participants enjoyed the small-group activities more than the whole-group activities during virtual field trip programs.
Science virtual field trips can support interest in STEM and encourage some participants to take other STEM programs.	• Cam: "Yes, 1,000 million yes" (more interested in STEM now) • Carol: "Yes" (take another STEM program in the future). • James: VFTs increased interest in STEM. • Elise: "VFTs may increase interest in STEM"	Participants' interest in STEM and curiosity in STEM increased. The whole group had a higher increase in STEM interest compared to the focus group's increase. STEM curiosity also increased for whole-group and focus-group participants.

Chapter Summary

This chapter reviewed the analysis and findings for the quantitative and qualitative data collected during this study. Analysis of quantitative data was conducted through descriptive statistics, paired samples *t*-tests and Wilcoxon signed-ranks test based on normality of data sets. Qualitative data were collected through open-ended surveys from all participants and focus groups comprised of select participants.

Descriptive statistics for RQ1 showed an increase in interest in science domains among most participants; however, changes were determined not to be statistically significant. This mean increase in science domain interest for all participants diverged slightly when analyzing focus-group participants' quantitative data as a subset. Qualitative data showed an increase in interest across science domains. RQ2 addressing enjoyment of activities during programs showed that working with professionals, taking a role (role-playing in a scenario) during the programs, and remaining active proved to be activities that participants enjoyed. Quantitative and qualitative data showed that participants ranked activities when they were involved in the program, (e.g., being the group reporter, being called in to support during a crisis, or becoming a member of a team) more enjoyable than other activities. During focus groups, participants expressed a dislike for small-group activities; however, the quantitative data showed that participants enjoyed small-group activities over whole-group activities. Finally, RQ3 regarding participants' interest and curiosity in STEM showed that most participants felt an increase in interest and curiosity in STEM following virtual field trip programs. Descriptive statistics showed an increase for participants' interest and curiosity in STEM following virtual field trips, but the results were determined to not be statistically significant. Qualitative data provided evidence that most participants were more interested in STEM following the virtual field trip programs and over half would be interested in attending STEM programs in the future.

CHAPTER 5

DISCUSSIONS, IMPLICATIONS, AND LIMITATIONS

The purpose of this action research was to determine the impact of virtual field trip programs on elementary students' interest in science domains and STEM fields. Activities within the programs were also assessed to determine how the format of programs affected participant interest. The study focused on the following research questions: (1) Do virtual field trip programs affect participants' interest in specific science domains and why?, (2) Which activities are most interesting for students during a virtual field trip program offered by the science center and why?, and (3) Do virtual field trip programs affect participants' interest in STEM fields and how? This chapter discusses the implications and limitations of this study and how the findings relate to the impact that virtual field trips have on participants' interest in science domains and STEM. The chapter shares the (a) discussion, (b) implications, and (c) limitations of this study in the following sections.

Discussion

Quantitative and qualitative data were triangulated in an attempt to understand the impact that virtual field trips have on participants' interest in science domains and STEM. This study also utilized quantitative and qualitative data to evaluate which activities participants are most interested in during virtual field trip experiences. Quantitative data from this study were cautiously accounted for since they were determined to not be statistically significant. The findings from this study suggest that virtual field trips are promising educational strategies to positively influence participants' interest in science domains and STEM. Findings also provide evidence to support which activities participants found most interesting. The qualitative findings support that participants felt virtual field trips led to higher interest in science domains and STEM. The following sections discuss the findings for RQ1, RQ2, and RQ3 in light of related literature.

RQ1: Do Virtual Field Trip Programs Affect Participants' Interest in Specific Science Domains and Why?

Declining science interest levels in students transitioning from elementary to middle school has been a big concern for teachers and administrators (Jack & Lin, 2017; Tröbst et al., 2016). Lack of interest has been determined to be a major problem for online instruction (Hatta et al., 2020). Yet interest is very important and has been linked to academic achievement (Grabau & Ma, 2017). There should be a focus on increasing and assessing interest to determine success of lessons and programs (Hehr, 2014). Individual lessons and programs have been found to have an impact on students' situational interest, which is defined as a temporary state sparked by a situation, task, or object that generates an immediate affective reaction (Hidi, 2001; Krapp, 2002). Situational interest has been shown to support the development of individual interest and is even considered a necessary condition for individual interest to emerge (Rotgans & Schmidt, 2017). Prior research conducted on elementary students' interest in science showed that their situational interest and individual interest increased when presented with a scenario or problem they needed to solve in groups (Rotgans & Schmidt, 2017).

Multimedia environments have been found to be a natural fit for good science teaching, offering opportunities for active learning (Plass et al., 2012). Virtual field trips have been linked to increased student achievement (Haris & Osman, 2015), and this study extends previous studies on the impact virtual field trips have by focusing on participants' interest. Quantitative findings for RQ1, though not statistically significant, suggest that virtual field trips increased science domain interest in most participants. The amount of growth varied by science domain, which supports previous studies indicating that students view science domains differently (Wang & Berlin, 2010) specifically when reflecting on their interest for individual science domains (Hardy, 2014; Jansen et al., 2014).

When researching possible ways to maintain student interest in science, Tröbst et al. (2016) found that instructional practices, using a constructivist approach, supported students' interest levels in science. The shift in science education to move towards hands-on, active learning lessons where students are the constructors of their understanding (Tröbst et al., 2016) has been shown to have a positive impact on promoting academic performance (NAEP, 2015). Previous studies on providing students with opportunities to connect with science concepts through authentic activities suggest that students' interest in science increases (House, 2006; Swarat et al., 2012) as well as their interest in STEM career choices (Cwikla et al., 2009; Roberts et al., 2018).

An important finding pertaining to RQ1 is that participants expressed increased interest following programs when they had prior interest in the science domain. Pre-survey results showed 85% of the participants responded to the questions relating to their interest in chemistry as somewhat agree to strongly agree. Initial geology interest was also high for participants following the pre-survey, and over 38% of participants ranked every geology question as the highest possible score. Within chemistry, 46% of participants listed their interest in chemistry during the pre-survey as somewhat agree to strongly agree.

During focus groups, many participants expressed their initial interest in the science domain for their favorite program and expanded that the program increased their interest in that domain. The increase in interest when participants had more prior knowledge or initial interest may be explained by Renninger, Bachrach, and Hidi's (2019) work, who found that initial or triggered situational interest can support middle school learners engaging with science content in an informal learning environment. Along these lines, previous research found that seventh graders' interest in science and hands-on activities played a more important role in their development of interest in climate change than their perceptions of climate change risk (Carman et al., 2017). Their previous findings demonstrate the importance of student interest and activity types when creating quality lessons.

Hands-on activities that allow students to see the phenomena clearly and concretely have been found to increase student interest (Renninger et al., 2019). Previous findings have indicated that moving beyond textbooks and worksheets by utilizing technology increases students' interests (Puspitarini & Hanif, 2019). There previous studies support findings from this study that utilizing pre-materials, lessons plans, or videos provided to the class before attending a virtual field trip program can trigger participants' initial interest. Lee, Stern, and Powell's (2020) study indicated that "pre-visit preparation and planning can help students formulate reasonable expectations, potential questions, and hypotheses based on their prior-knowledge" (p. 991). Teachers' preparation and reflection following field trips have a large impact on the experience (Behrendt & Franklin, 2014).

Each of the virtual field trip programs used for this study had minimal pre-materials provided for teachers to use beforehand. Video trailers were provided for the Magic of Matter and Seasons Reality Check programs. Fossil Finders pre-materials provide a list of vocabulary words for teachers to review before the program, and Weather Watchers had an application for the students to fill out to join the Weather Watchers team. Teacher program guides for Magic of Matter (see Appendix E), Fossil Finders (see Appendix F), Weather Watchers (see Appendix G), and Seasons Reality Check (see Appendix H) were all printed along with any materials needed for the programs before the study and dropped off at the sports community center. It was not possible to determine during this study if all participants completed the pre-materials provided to the sports community center.

Chemistry

Quantitative data revealed that participants had a positive increase in their interest in chemistry when comparing their pre- and post-survey data. Thirteen participants were present for the pre- and post-surveys for chemistry. A positive change in chemistry interest was found between pre-surveys (M = 2.68, SD = 1.17) and post-surveys (M = 2.83, SD = 1.04). The questions *I like chemistry* in the pre-survey (M = 3.0 SD = 1.33) and post-survey (M = 3.5, SD = 1.29), and *I want to learn more about chemistry* in the pre-survey (M = 3.0, SD = 1.38) and post-survey (M = 3.5, SD = 1.17) showed the largest increase. This indicates that participants' interest grew in chemistry, and they want to learn more about it in the future. These quantitative findings align with the qualitative data showing participants' increased interest in chemistry and interest in the experiments during the Magic of Matter program. Participants explained that they were interested when watching the professors from the program use liquid nitrogen to demonstrate matter changing states as they removed heat by placing the balloons in liquid nitrogen. Even though the non-statistically significant quantitative findings do not align with previous research, the qualitative findings do align with previous findings from a study out of Pakistan that showed high school students expressed the most interest for chemistry when doing experiments (Akram et al., 2017). However, not all feedback from this study was positive. One participant, Tim, stated that the program did not increase his interest, and yet, his quantitative findings showed growth in his interest in chemistry from the pre-survey (M =3.4) to the post-survey (M = 4). Finally, the majority of the participants listed Magic of Matter as their least favorite program when compared with other programs. The Magic of Matter program relied heavily on movement and watching professionals compared to the other programs, which provided more hands-on problem-solving opportunities.

Geology

Participants showed the second highest interest growth in geology with an increase from the pre-survey (M = 2.63, SD = 1.16) to the post-survey (M = 2.82, SD = 1.25) though this change was not statistically significant. Twelve participants were present for both the pre- and post-surveys on their interest in geology. Three participants rated their pre- and post-survey interest in geology as all fours and therefore, did not show any growth in interest. Qualitative findings showed participants felt their interest in geology grew because of the Fossil Finders program, and the majority of participants chose it as their favorite program. The qualitative findings align with previous research conducted by Mills et al. (2020) suggesting that engaging with educational technology can increase situational interest in geology which is a predictor of academic achievement (Rotgans & Schmidt, 2011). Mills et al. (2020) also found that middle school students' individual interest in geology increased due to their situational interest being activated through the use of Slowmotion, an app that students use to create stop-motion videos.

Meteorology

Participants' quantitative responses for meteorology also indicated a growth in interest, though not statistically significant. Fourteen participants responded with their pre-survey interest (M = 2.73, SD = 1.21) and their interest levels increased according to their post-surveys (M = 2.77, SD = 1.21). Compared to other science domains, meteorology had the least change from pre- to post-surveys. This is possibly because three participants listed their initial interest and their post interest as all fours. While this shows they had very high interest in meteorology initially and following the program, it makes it impossible to observe change in survey data. Qualitative data from conversations during the focus group included participants discussing the Weather Watchers program very favorably. During focus groups, participants discussed how the program made them more interested in meteorology, especially when they already had an initial interest. Previous research on middle school students' interest in climate change showed the value of utilizing multimedia tools to increase student interest (Nussbaum et al., 2015). This previous study used a game simulation intervention to connect students with a local, relevant problem for them to solve. They focused on the effects of a drought on a nearby lake. Findings showed that participants' interest in meteorology increased when the scenarios and problems were relevant for the students. Nussbaum et al.'s (2015) findings align with qualitative findings from this study showing increased interest for students when programs and scenarios were relevant to them.

Astronomy

Participant interest grew the most in astronomy from pre-survey scores (M = 3.03, SD = 1.19) to post-survey scores (M = 3.25, SD = 1.04). Six participants listed all fours for the pre-survey and six participants listed all fours for their post-survey responses. The average pre-survey response (M = 2.83, SD = 1.40) for the question *I feel excited when we start a new astronomy lesson in school* increased when participants responded in the post-survey (M = 3.33, SD = 1.23). Focus-group participants did not discuss astronomy directly during the interview; however, three participants listed it as their favorite program of the week. During whole-group, open-ended responses following the program, participants mentioned they enjoyed going to the planetarium with the Reality Check staff team and learning how the Earth's tilt creates the seasons. Multiple participants mentioned they enjoyed everything, and a few mentioned they did not have a favorite part of the program. Increase in interest follows previous research on the use of technology in the form of augmented reality to support student interest in astronomy (Önal & Önal, 2021). Though this study does not use augmented reality, the findings from that study suggest the students who engaged with the augmented reality lessons increased in their astronomy interest and achievement compared to students who didn't receive the intervention (Önal & Önal, 2021). This supports the use of technology used in meaningful ways to increase students' interest.

RQ2: Which activities are most interesting for students during a virtual field trip program offered by the science center and why?

Quantitative and qualitative findings provide insights about participants' ratings for each type of activity offered during the programs. While all activities, on average, were rated above neutral, participants ranked the activities as follows: working with professionals (*M* = 3.18, *SD* = 0.99), role-playing (*M* = 2.98, SD = 0.86), small-group activities (*M* = 2.88, *SD* = 0.94), active learning (*M* = 2.79, *SD* = 1.06), analyzing (*M* = 2.75, *SD* = 1.1), and finally whole-group activities (*M* = 2.71, *SD* = 0.95). Triangulation with qualitative findings showed that participants enjoyed working with professionals and being actively involved in authentic scenarios. Although quantitative findings were not statistically significant, potentially due to the small sample sizes, they do provide further evidence to support previous researchers' claims that participants like hands-on activities, utilizing authentic situations, and scenarios (Behrendt & Franklin, 2014; Proudfoot & Kebritchi, 2017). These activities have been linked to increasing students' situational interest (Palmer et al., 2017). The findings from this study corroborate previous findings by Anwer (2019) that indicate students enjoyed when teachers were enthusiastic, provided hands-on activities, group work, and activities that relate to the real world. Holstermann, Grube, and Bögeholz's (2010) research found that the quality of the hands-on experiences showed a positive correlation with students' interest in the activity.

Findings from this study also identified the importance of program activities being relevant to participants. In a study conducted by Jack and Lin (2017), secondary school students were asked how teachers could make science learning more enjoyable and interesting. They suggested that teachers apply current knowledge and daily life experiences into their lesson activities to make them more meaningful for students. Nussbaum et al.'s (2015) findings also suggested that presenting students with problems and scenarios that are relevant to them increased their interest.

Their emphasis on perceptions of activities having an influence on participant interest also aligns with previous research done by Sağir, (2018) that examined fourth-grade students' perspectives of activities through self-reported surveys analyzing their interest towards science, anxiety towards science, and their attitudes towards science. Jack and Lin's (2017) as well as Sağir's (2018) studies that focused on students' opinions suggested that student perceptions and activities can influence their levels of interest, anxiety, and attitude towards science. The findings from previous research on the impact that activities can have on students' interest and the importance of students' perspectives laid the groundwork for the significance of activities during virtual field trips for this study.

Constructivism

The findings from this study align with previous research on constructivist lessons and scenario-based learning having a positive impact on students' interest (Behrendt & Franklin, 2014; Carino, 2019; Kolb, 1984; Mestre, 2005; Proudfoot & Kebritchi, 2017). The constructivist framework believes learning is an active process where students construct their own knowledge based on their experiences (Cetin-Dindar, 2016). Previous studies have focused on lesson activities, the importance of students' perceptions of activities, and how they influence student interest. Behrendt and Franklin's (2014) previous research produced findings to show that authentic learning opportunities and experiential activities increased students' interest in the topics. Proudfoot and Kebritchi's

(2017) study also produced findings to support the use of authentic situations having a positive impact on students' STEM interest and achievement. Their study utilized a mobile STEM lab for fifth grade students to embark on a mission to support their community through a hurricane scenario-based eLearning lesson.

Findings from this study also corroborated previous research indicating students preferred active learning and partaking in activities when learning science (Fernández-Novell & Domenech, 2018). Shahali et al.'s (2019) study conducted on students' interest toward STEM suggested that teaching and learning practices should focus more on active learning approaches, aligning with a constructivism framework. Extending the previous findings that active learning can support student learning, a study out of India produced findings to support that the integration of technology and active learning can support learning outcomes in students (Singhal et al., 2020) This corroborates findings from Plass et al. (2012) that multimedia environments are a natural fit for active learning opportunities for students.

Scenario-based

Utilizing a scenario-based (role-playing) approach where students take on a role in the lesson has shown to be a successful way to increase student interest for elementary students utilizing a mobile STEM lab (Proudfoot & Kebritchi, 2017). Further, a study conducted on the impact of scenario-based learning on fourth graders' academic achievement in science produced findings indicating a large growth for students in the experimental group utilizing scenario-based methods when compared to a control group utilizing traditional teaching methods (Aslan, 2019). This aligns with the findings for this study that participants liked working with professionals and role-playing. This study's qualitative findings indicates that participants enjoyed working with people in authentic roles (professionals) when participants had a role in the program.

The scenarios for the virtual field trips focus on authentic activities where participants take on a role. Previous research on goal-based scenarios, developed by Robert C. Shank, also align with the use of scenarios and programs where participants take a role (Campbell & Monson, 1994). These findings build upon previous research focused on how student-centered activities can have a positive effect on student interests (Kang & Keinonen, 2018). Jack and Lin's (2017) study focused on secondary students' perceptions of how primary science instruction could be improved. Their study brought further evidence of the importance of allowing students to make connections with the real world and daily life activities supporting the use of authentic scenarios in the programs.

Finally, a study conducted on the effect of student-centered approaches on students' interest in science found that using activities that students find relevant positively affected student interest in science (Kang & Keinonen, 2018) which corroborates previous findings by Nussbaum et al. (2015). These previous studies support attempts to make each of the scenarios used for the virtual field trip programs relevant for participants. The qualitative evidence from this study also indicated the importance of providing relevant situations. One participant mentioned she was more interested in Weather Watchers and therefore in meteorology, because she wanted to know how to keep her family safe during extreme weather. This aligns with previous research and findings from this study that indicate providing tasks that are relevant for participants increased their interest (Kang & Keinonen, 2018; Nussbaum et al., 2015).

Hands-on Learning

Providing high quality, hands-on lessons where students can experience science can be a challenge for teachers in the classroom, and there is a lack of hands-on learning in the classrooms, specifically low-resource classrooms (Jones et al., 2019). However, quality field trips can offer opportunities for students to engage in science in a meaningful way. For example, a study focusing on urban city students' engagement in science found that field trips and experiential learning opportunities had a positive influence on students' science content knowledge and engagement in science (Djonko-Moore et al., 2018). While not all students have the opportunity to partake in experiential learning field trip opportunities due to various challenges, K-12 teachers can utilize virtual field trip programs to achieve similar results without having to leave their classrooms. Virtual field trips can support teachers by providing high-quality lessons with hands-on activities to support their students' learning and interest in the domain.

Virtual field trip programs can provide authentic use of charts, graphs, graphic organizers, and manipulatives for students to use during programs. Meaningful hands-on activities have been linked to triggering student interest when used to support the lesson content (Renninger et al., 2019). It was also noted in the previous study that activities less desirable to students, like handling a skull, did not trigger their interest as much. The findings of this research corroborate with previous research focusing on how hands-on activities in science can positively impact student interest (Grabau & Ma, 2017) and the importance of students' perceptions of the activities (Jack & Lin, 2017).

Group Activities

Due to the nature of virtual field trips, whole-group activities are necessary. It is difficult for the virtual field trip teacher to present information for the scenario while the kids are working in groups. Virtual field trips at the science center open the scenario as a whole group and intermittently come back to confirm the progress of small groups. The classroom teacher has minimal supervision of participants during typical programs. While some researchers have found positive benefits linked to whole-group instruction (Capie & Tobin, 1981; Mestre, 2005), the results from this study show that participants preferred small-group activities where they can take a role. This aligns with Godwin et al. (2016) findings that suggest whole-group lessons may not be the most effective way to engage students. Other studies have linked the use of small-group work to increased student interest (Gillies, 2008; Hampden-Thompson & Bennett, 2013).

Qualitative data collected for this study revealed that some participants expressed negative feelings when reflecting on small-group work during the programs. Participants expressed uncertainty for what they were supposed to be doing as well as not getting along with their groupmates. Their perceptions could be attributed to the non-formal classroom setting and lack of support from the assistants at the sports community center for participants during small-group time. Timostsuk and Jaanila's (2015) research stressed the importance of teacher support within the classroom during activities to ensure students' success. The implementation of virtual field trips for this study did not feature teacher support on site with the participants, and it relied on the researcher as the main instructor. This is atypical for a virtual field trip program. Typically, the classroom teacher books the program and prepares the students and materials for the program. The sports community center, where the study took place, was unable to provide a teacher to work with the students before the program due to other activities planned. The director, who set up the programs and received communication before the connections, oversaw all campers for the week. She had responsibilities for other campers during the study and may not have passed along all information about the programs to the assistants.

RQ 3: Do Virtual Field Trip Programs Affect Participants' Interest in STEM Fields and How?

There is a plethora of previous research findings available related to increasing students' interest in STEM fields. Much of the research is focused on getting students interested in STEM in hopes they will pursue a STEM career in the future (Mohd Shahali et al., 2019). Previous studies have indicated that student interest and engagement have been linked to both achievement and career aspirations (Jones et al., 2019; Potvin & Hasni, 2014). Prior research on utilizing videos of professionals in STEM fields has shown to have a positive impact on students' interest in STEM careers (Wyss et al., 2012).

The integration of quantitative and qualitative findings from this study indicate that virtual field trips can support participants' interest and curiosity in STEM. Participants' initial interest in STEM increased from pre-survey (M = 2.75, SD = 0.87) to post-survey (M = 3.12, SD =0.98), and participants' curiosity showed an even higher increase from pre-survey (M = 2.75, SD = 0.77) to post-survey (M = 3.28, SD = 0.80). Unfortunately, these changes did not prove to be statistically significant. With only 11 participants, it is difficult to produce statistically significant findings (Fan, 2001; Morgado, et al., 2017). However, the qualitative data suggested that participants' STEM interest increased following virtual field trip programs. Participants shared their increased interest in STEM and desire to continue STEM activities because of the virtual field trips during interviews.

Even though the non-statistically significant quantitative findings do not align, the qualitative findings align with previous research stating that STEM learning builds student interest by using real-world scenarios (English, 2017) while incorporating hands-on activities (Carino, 2019). Research has also shown that field trips, after school programs, and camps in informal environments, like science centers, have been very successful in increasing student interest in STEM (Roberts et al., 2018). The qualitative findings from this research also align with Sontgerath and Meadow's (2018) study utilizing the STEM PEAR Common Instrument Suite Survey 3.1, the same instrument utilized to measure STEM interest and curiosity for this study. The study provided evidence that using an informal learning environment, focused on project-based curriculum utilizing teamwork, can increase participants' interest in STEM (Sontgerath & Meadows, 2018). Exposing students to STEM activities that increase their interest has been shown to have a positive impact on their future career choices (Denson et al., 2015). Utilizing authentic situations, including scenarios for lessons, has previously been shown to have a positive impact on students' STEM interest and achievement (Proudfoot & Kebritchi, 2017) aligning with the qualitative findings from the current study. Previous studies have also provided evidence to support using technology-supported learning tools to positively impact participants interest (Potvin & Hasni, 2014).

Implications

This research has implications for me, for teachers and science centers, and scholarly practitioners and researchers. The data collected through this study supports me as an action researcher and scholar, the science center virtual field trip department, virtual field trip program creators, and program facilitators for virtual field trips. The following sections will address this study's implications in detail including (a) personal implications, (b) implications for the virtual field trip department, (c) implications for promoting science and STEM interest in elementary grades, and finally (d) implications for future research.

Personal Implications

Through the process of this study, I have learned a lot about myself as an educator, as a scholarly practitioner, and as a person. These lessons support my future personal and professional goals. During this section, I focused on the implications of this study to me: (a) approaching a problem as a scholarly practitioner, (b) being flexible and adaptive, and (c) sharing and communicating findings.

Approaching a Problem as a Scholarly Practitioner

This research project has taught me how to approach a problem from a scholarly perspective. Three years ago, when I joined the science center as the virtual field trip teacher, I had no idea what a virtual field trip was. The department consisted of three successful social studies programs and one unsuccessful science program offering. Within the first year, I was tasked to redo the science program and create additional programs with minimal direction and a lot of creative freedom. Being a department of one in a new position, I struggled. I was not sure what made a virtual field trip successful, nor how to create original science programming that was standards-based, interesting, and enjoyable for students. Fast-forward three years and, to be honest, I was still struggling. There are many components that go into creating a virtual field trip: storyline or scenario, science standards, activities, movies or guest videos, and overall design of the program. I received feedback from teachers occasionally, but rarely heard directly from students about their thoughts and feelings about the program or if they enjoyed it.

Through the guidance of instructors and the course work, my dissertation chair, and personal research, I have developed a deeper understanding of data collection and analysis interpretation. I have increased my critical thinking skills due to this process. This entire process has shown me how to be comfortable outside of my comfort zone. I have had to walk away and let data marinate in my head before jumping to conclusions. Another lesson learned is that it is never too late to review more studies to learn about methods, analysis, and findings. Through review of previous studies, I have understood more about the implications of my findings. I have had to be okay with taking my time to figure out how to do something and rely on others as well as my own research to implement a new data analysis technique. There were multiple times in this process when I started over again with the data to review my data analysis with fresh eyes and ensure I was looking at it with an open perspective. My dissertation chair has helped me look at the data from new angles to see different connections. I have had to focus and look at data objectively and not personally. Through this process, I have grown as a person and as a scholarly professional.

Being Flexible and Adaptive

This research process has taught me to remain flexible, learn from previous mistakes, accept changes, and embrace the uncertainty. Action research is deeply personal. The lessons being evaluated are mine; I have a vested interest in the success of this research both personally, academically, and professionally. Maintaining integrity was of utmost importance. From the study method, communication with the site and participants, to the collection and reporting of data, I have made every attempt to uphold professional communications and methods. From the proposal writing to the implementation, many changes were made due to the pandemic. This process taught me to remain calm and problem solve methodically. Through this research process, I was able to break down my problem and discover how to ask questions, how to investigate the questions, and how to analyze the findings from the investigation. I have realized the value of both quantitative and qualitative feedback to support quality data for analysis. Most importantly, this process has taught me the importance of reflection following each research cycle. Utilizing an action research mindset has showed me that research is an iterative cycle, and more information can be gained through continued research.

Sharing and Communicating my Findings

Through writing my dissertation to presenting my findings to stakeholders, I have had to focus on the big ideas and hone in on the meaningfulness of this research to those to whom I am presenting. I have found that through presenting and discussing my research, I have come to a greater understanding of the findings and how they impact science and STEM interest. While talking with stakeholders, it will be important to not make generalizations since this was a small action research study and none of the quantitative findings were statistically significant. However, presentations will focus on the impact the study had for the participants and share plans and aspects to include for future programs including scenario-based, hands-on activities that bring in professionals to support the lesson.

Implications for the Virtual Field Trip Department

This research holds great insight into the virtual field trip department at the science center. Findings will help determine how to improve and create future programs, as well as potentially secure funding for the department through grants that require evidence of impact. This research will also open up opportunities for conferences and presentations to other virtual field trip content providers on the findings of this research. Findings indicate that focus-group participants connected the science domains directly with the programs, and they seemed to show higher interest in their favorite programs or programs they already had an initial interest in. It is very important that we create engaging and enjoyable programs for participants. If a program is not enjoyable, it may have negative implications for participants' interest in that science domain.

There are no plans to alter the lessons used for this study at this time. While planning future lessons, virtual field trip programs will include multiple types of activities aligning with current and previous findings in an effort to maximize participant interest. Working with professionals is another activity that should be continued and implemented with virtual field trips. Continuing to offer scenario-based lessons with the virtual field trip teacher facilitating and taking the role of a professional in the scenario was also determined to be beneficial. Additional pre- and post-materials will be provided for the virtual field trips to support both teachers and the students before and after the programs.

Participants with initial interest in the science domain showed more interest in the lesson and therefore their interest increased. Though this was not able to be determined through quantitative analysis, the focus-group participants said their interest grew because they already had prior interest in the domain. Previous research has shown that prior knowledge impacts the trigger phase of situational interest (Schraw & Lehman, 2001); Although, a study by Rotgans and Schmidt (2011) was unable to replicate statistically significant findings when measuring the variability of prior knowledge on situational interest levels of students. Future virtual field trips could focus on including pre-materials to activate prior knowledge, prepare participants for the program, and trigger situational interest.

Findings from the study provide evidence to support that participants enjoy working with professionals, which provides an opportunity to highlight diversity among scientists by reaching out to different organizations that partner with the science center. Furthering partnerships with science and STEM professionals in the workforce broaden the science center's reach and provides an opportunity for local businesses to get involved. Findings from the research also suggest that participants are more interested when engaged in a scenario-based program allowing them to take a role. This has always been important when planning programs and now there is data to support this choice. Through involving local professionals, they can also provide ideas and suggestions for authentic scenarios. By creating lessons with an authentic scenario and allowing participants to take on roles, the lessons highlight careers in science and problem solving in authentic situations which supports the idea of situated cognition which means that "knowledge is situated, being in part a product of the activity, context, and culture in which it is developed" (Brown et al., 1989, p. 32). The work of Brown, Collins, and Duguid (1989) supports the use of scenarios where participants take a role in the program to situate their learning in a meaningful way.

Implications for Promoting Science and STEM Interest in Elementary Grades

This research also sheds light on the impact programs can have on participants' interest in science and STEM. The findings from this study contradict previous statistically significant findings that suggest constructivist environments can support student interest (Behrendt & Franklin, 2014; Carino, 2019; Kolb, 1984; Mestre, 2005; Proudfoot & Kebritchi, 2017). This study attempted to extend the instructional method and environment to include virtual field trips and indicate that they can be successful in promoting interest for participants in both science and STEM. Virtual field trips provide an opportunity to integrate authentic learning situations with hands-on activities regardless of participant location. Though the quantitative findings did not prove to be statistically significant the qualitative findings.

STEM in particular has not been a focus for the department, but this study suggests that future programs can highlight STEM fields and careers. We need to begin targeting STEM in the elementary years to prepare students for future careers (Madden et al., 2016). CoSTEM and the National Science and Technology Council (2013) suggest that opportunities need to be given to students to engage in STEM activities in hopes of developing their interest in STEM. Virutal field trips are a method of implementing this goal nationally.

Implications for Future Research

The pandemic has raised awareness of the power and limitations of virtual video-conferencing for both personal and educational audiences (Hatta et al., 2020). There is very little research on the impact of virtual education experiences using synchronous connections on participants' interest and engagement in general and specifically in science (Hehr, 2014). Synchronous education is an area that has seen tremendous growth with very little pedagogy and previous research to build on. This new frontier of virtual education could really support many disciplines as well as students from around the world having access to high quality education. Though it is necessary to know what makes a virtual field trip of highest quality and what impacts the virtual field trips have on participants. It would be worth investigating if providing pre-materials to teachers for implementation before the program would support a general level of prior knowledge that may support interest in participants. The pre-materials could potentially provide a trigger for participants' interest in the science domain before connecting with the virtual field trip program as well as develop a level of previous knowledge to support participants' situational interest during the programs (Rotgans & Schmidt, 2011).

This study has completed my first cycle of action research, though as an action researcher there are more cycles in the process (Mertler, 2017). Replicating this study with more participants in a traditional classroom setting may bring additional information and potentially statistically significant results. The classroom setting, which is more authentic to implementations throughout the school year, could affect group work and support students with prior knowledge by implementing the programs when the students are studying the domains. In a study examining the impact of using videos of STEM professionals to increase student interest in STEM, they concluded that presenting the STEM professional from the domain being taught in the classroom provided more relevance for the students and could increase their interest (Wyss et al., 2012). In the future, gaining more knowledge from teachers would also be beneficial for the creation of future virtual field trips, for example, educational standards they would like to see covered. It would be informative to investigate the impact of utilizing pre-activities before participants connect with the program to see if they support their prior knowledge and/or trigger situational interest for them. Future studies could also include a broader range of audiences beyond elementary age. Researchers could look into impacts in other subject areas beyond science and the impact of synchronous versus asynchronous connections. Identifying the impact that a story-based approach has versus a lecture style format on students' interest would provide valuable findings for new programs. In future research studies, the collection of data could also include qualitative feedback from participants directly following the program. Though a lot of data was gathered from the quantitative data collection, the use of Likert-type scales to assess participant interest may not have been as effective and accurate at assessing their interest when compared to qualitative discussions. Due to the limited number of research studies on virtual field trips and their impact on students, there is potential for future research.

Limitations

As with any research study, there are limitations associated with this study. Those are (a) methodological limitations, (b) changes due to COVID-19 pandemic, and (c) study location and implementation.

Methodological Limitations

Action research takes place within the practitioner's sphere of influence (Mertler, 2017). My sphere of influence, as a virtual field trip teacher, includes thousands of students I teach over the course of a year. That being said, I only interact with many of the students for 30-45 minutes. This makes it a challenge to develop relationships with students. The virtual field trip programs are also standards-based and only a few are offered for each grade level, meaning that classrooms will usually not connect with me more than once in a year. The environment this research was conducted in was different from a classroom setting. Typically, classrooms schedule virtual field trips for science domains they are actively studying, so theoretically students would have prior background knowledge before attending the program as well as the ability for the teacher to make classroom connections to the standards. Previous research on STEM interest for middle school found that aligning the video to the curriculum being taught in the classroom provided relevance for the students (Wyss et al., 2012). The participants for this study, hypothetically, had not developed relationships with their peers before the research was conducted since it started on the first day of a weeklong summer camp. This could have contributed to some of the struggles participants had during group work. They were also not being taught the subject domain at the time of our connections. The virtual field trip programs were designed to be delivered in a traditional classroom setting when students were studying the domains. The students had also been previously schooling from home for the past three months due to the pandemic, which could have contributed to gaps in their knowledge. Participants' understanding of the vocabulary used during the study may have provided another challenge. For example, participants may not have understood what geology means because it may not have been a common scientific term for third and fourth graders.

When identifying the best way to collect data from students for this study, it was determined that the best opportunity to gain quality feedback was for students to partake in multiple virtual field trips over the course of a week at a summer camp. This allowed me to develop a relationship with the students and have them reflect on four unique experiences through virtual field trips. Due to the nature of a virtual connection, relationships were not able to be developed with the students, unfortunately. Attention was also paid to the requirements of the staff at the sports community center. It was important to make the process as easy for them to implement as possible. All surveys had to be electronic due to participant privacy and not having the opportunity for the sports community staff to complete proper training.

Previous research has identified that distractions can be a big problem for participants during virtual communication (Purwanto et al., 2020). It was noticeable that distractions were an issue during the implementation of programs. At times, participants were distracted due to the activities taking place around them. The staff at the community center were working with other campers during the focus groups and did not oversee the participants at all times. As a result, sometimes participants were not fully paying attention. Teacher support during activities has been proven to support students in their success during activities (Timostsuk & Jaanila, 2015), which was not available during this study.

Data collection was limited to surveys and focus groups for this study. This provided a challenge since I was not able to delve deeper into responses or attain open feedback from participants directly following the programs. Participants were asked to complete Likert-type surveys, which proved to be a challenge for some of the participants. Likert items can be challenging even for adults to understand and are subjective by nature (Marci et al., 2020). Additionally, research has shown that younger students typically select extreme answers, which impacts the study findings (Chambers & Johnston, 2002).

On the first day of research, I explained to participants how Likert-type scales work. They were asked how much they liked chocolate. To show their response, they had to put their hands on their heads, shoulders, hips, or knees, demonstrating their level of agreement with the statement, *chocolate is the best food*. This allowed me to make a Likert-type item more relevant to the participants and for them to provide an opinion on something physically that most participants have a strong opinion about. Though this was an effective introduction to Likert-type items, it is possible that participants struggled with their feelings about individual questions. The surveys were not read aloud, which proved to be an issue for a few participants. I was not able to explain specific vocabulary when participants had questions due to the virtual nature of the program and set-up, though every attempt was made for them to access me for questions during the survey implementation. Surveys were collected on the first day of research and following each program. This could have had an effect on participants' responses. Participants responded to all pre-surveys on the first day while the post-surveys were spread out over the remaining four days of the study.

Surveys utilized to assess participants' interest were adapted from other surveys which could have had an impact on participant responses. The science domain survey was modified from the subscale of *Emotion* and the STEM survey was modified from the subscale of *Engagement.* Interest, though related to both emotion and engagement, is a separate construct and there may be more appropriate surveys to use for future research so these constructs are not confused.

During analysis, it was observed that participants who showed high initial interest did not show growth in interest due to the 4-point Likert-type scale. If a participant responded with a four for the pre-survey, it was not possible to measure growth due to the limitations of the survey instrument. It was more difficult to identify changes before and after virtual field trip programs, possibly due to the limited scale range of three points (participants chose one, two, three, or four). This may also have contributed to the data not being statistically significant since the change in pre- and post-scores were limited to a range of three points. The surveys used also contained minimal questions on each topic to reduce survey fatigue. This may have also contributed to the quantitative data not being statistically significant (Morgado et al., 2017) and could be improved by adding more questions to the survey for future research to improve survey reliability (Morgado et al., 2017).

This study design was also limited to the number of students in the summer camp. Smaller numbers also made it a challenge for the data to show statistically significant changes. Descriptive statistics showed an increase in means across the subscales; however, the low number of participants made it difficult to show statistically significant gains (Morgado et al., 2017). Finally, the participants were signed up for a summer camp advertised as providing fun activities without an academic focus. For the research, they were required to sit down for portions of their afternoon to do classroom activities. This may have contributed negatively to their attention, enjoyment, and engagement with the programs.

Changes due to COVID-19 Pandemic

This study underwent tremendous changes due to the COVID-19 Pandemic. The location of the research had to be changed from the science center to the local sports community center. The original proposal for the research included students partaking in a camp at the science center in person and connecting with me for the virtual field trips through our studio. This would have allowed me to develop connections with students while not teaching the virtual field trip programs and get qualitative feedback more easily. It would have also controlled the collection of data by using the science center devices and provided an opportunity for me to communicate with the participants for a longer period of time. For example, I could have read the questions to the participants for the surveys, answered any questions they had, and provided definitions if there were unknown words. Unfortunately, I was not able to meet the participants in person for this study.

Due to the pandemic, not all participants were present every day, and the community center was only able to accommodate a certain number of participants due to social distancing requirements. This made it more challenging for participants to develop relationships with their peers, and also left a limited sample size to pull from for many of the surveys. Future research should seek a larger sample size to increase the credibility of the results and support the analysis (Morgado et al., 2017).

The environment for the programs at the sports community center was in a large multipurpose gym that had been divided to accommodate social distancing from multiple other camp groups. Tablets were used to collect survey data for students; however, Wi-Fi was an issue and some of the tablets were unable to connect to the sports center's hotspot, so some participants had to share tablets to answer the surveys one after the other following the program. I was not aware of this issue until the collection of data following the initial program, and I was unable to do anything to fix the issue. The assistants for the camp were also camp counselors and not teachers. They had other responsibilities while the virtual field trip programs were being presented, and they were not always present to encourage participants to pay attention, manage behavior, and implement activities. Another main limitation for the environment was the lack of seats and tables. Participants were seated on metal bleachers, which complicated the implementation of some of the activities and group work.

Closing Thoughts

It is the vision of the science center to be the pinnacle of innovative learning, an engine for community engagement, and a national leader in science education (Roper Mountain Science Center, 2018). Virtual field trips are a promising method of achieving this vision by providing global programming. To support sustainability and growth in the department, it must produce high-quality science education programs that are standards-based and interesting to students. And yet, the science center had not acquired feedback from students following the programs. Additionally, there has been limited research conducted on the impact that virtual field trips have on participants' interest.

Science and STEM interest has been a focus for the educational community for over fifty years (Richardson, 1971), yet students continue to lose interest in science and STEM especially at the upper elementary level (Osborne et al., 2003; Toma & Greca, 2018). It has been shown that students with an interest in science and STEM are more likely to pursue a career in a science or STEM field (Ahmed et al., 2017; Unfried et al., 2015), which has been an area of deficit for our country's growing STEM workforce needs (CoSTEM & National Science and Technology Council, 2013). In an effort to support students' interest in science and STEM, emphasis has been placed on methods of instruction and the learning environment for the students (Groen, 2009; Nolen, 2003). Previous research has shown that field trips can have a positive impact on students' interest in science by providing real-life experiences that are relevant for students (Behrendt & Franklin, 2014; Klemm & Tuthill, 2002). Not all schools have the ability to partake in traditional field trips; however, with the advances in technology, virtual field trips provide an option for teachers to offer a similar experience (Stoddard, 2009). Previous research on students attending a virtual field trip with an aquarium produced findings to suggest that virtual field trips can impact students' interests (Ba & Keisch, 2004). Are synchronous virtual field trips a successful way to interest students in science domains and STEM?

To address this problem, I developed this study to assess the impact of virtual field trips on participants' interest in science and STEM. Through this study, findings have shown that virtual field trips can impact participants' interest in science and STEM, though they were not statistically significant. The implications of this study suggest a need for future research in the area of synchronous virtual field trips. Future research could include additional participants within their own educational setting as well as expanded grade levels and subject areas.

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APPENDIX A

CONSENT FORM AND IRB APPROVAL

UNIVERSITY OF SOUTH CAROLINA

CONSENT TO BE A RESEARCH SUBJECT

Link to online consent form: https://forms.gle/yPHGKBoLijkqc5Qe9

THE IMPACT OF VIRTUAL FIELD TRIP PROGRAMS ON PARTICIPANT INTEREST IN SCIENCE DOMAINS AND STEM FIELDS

Principal Investigator Name: Jasmin Poor

Faculty Mentor Name: Dr. Lucas Vasconcelos

KEY INFORMATION ABOUT THIS RESEARCH STUDY:
Your child is invited to volunteer for a research study conducted by Jasmin Poor. I am a doctoral candidate in the Educational Technology Program at the University of South Carolina. The purpose of this research study is to determine the impact that virtual field trip programs have on 3rd and 4th graders' interest in specific science domains and STEM fields. This study will be conducted during camp hours using Zoom video conferencing and will involve approximately 10-24 subjects.

The following is a short summary of this study to help you decide if your child should be a part of this study. More detailed information is listed later in this document.

This study will be completed over the course of one week with an approximate length of 15 minutes per day with an additional session on Friday. On Monday, we will do introductions, initial interest surveys, and getting-to-know-you activities. Tuesday through Friday will consist of one virtual field trip program presentation each day with a survey following the program. On Friday, there will be interview session with the participants for them to express their opinions about their experiences throughout the week.

PROCEDURES:
All activities will take place during the regular camp day. If you agree to allow your child to participate in this study, your child will do the following:

1. Complete two online surveys about their interest in specific science domains and STEM.
2. Complete a short interest survey following the Magic of Matter program.
3. Complete a short interest survey following the Fossil Finders program.
4. Complete a short interest survey following the Weather Watchers program.
5. Complete a short interest survey following the Seasons Reality Check program.
6. Potentially take part in a smaller focus group focused on participant feedback about the programs.

DURATION:
Participation in the study will take place during the week of July 13th at the YMCA Program Center during camp hours. The study will take no more than 120 total minutes throughout the week-long camp.

RISKS/DISCOMFORTS:
Risks for participants are unlikely but may include (a) fear that outcomes of the study may influence their academic grades and (b) feeling of discomfort during the survey and/or interviews. Measures will be taken to ensure participants their grades will not be impacted and attempts will be made to make them comfortable during interviews.

If involved in Focus Groups:
Others in the group will hear what you say, and it is possible that they could tell someone. The researcher will ask that study participants, and all other group members, respect the privacy of everyone in the group.

Loss of Confidentiality:
There is the risk of a breach of confidentiality, despite the steps that will be taken to protect participants' identities. Specific safeguards to protect confidentiality are described in a separate section of this document.

BENEFITS:
There is no direct benefit for the participants of this study. Study findings will provide a better understanding of how virtual field trips impact student interest in science and STEM. Moreover, study findings will inform future virtual field trip program development.

COSTS:
There is no cost for participants to be included in this study.

PAYMENT TO PARTICIPANTS:
Participants will not be paid for their participation in this study.

CONFIDENTIALITY OF RECORDS:
Information obtained about your child during this research study will remain confidential. All data collected will only be accessible by the researcher and the major professor and will be stored in a password-protected computer and in One Drive. After data collection, pseudonyms will be used to replace participants' real names, which will be destroyed. Data for this study will be destroyed after 3 years.

UNIVERSITY OF SOUTH CAROLINA

CONSENT TO BE A RESEARCH SUBJECT

Link to online consent form: https://forms.gle/yPHGKBoLijkqc5Qe9

THE IMPACT OF VIRTUAL FIELD TRIP PROGRAMS ON PARTICIPANT INTEREST IN SCIENCE DOMAINS AND STEM FIELDS

Principal Investigator Name: Jasmin Poor

Faculty Mentor Name: Dr. Lucas Vasconcelos

VOLUNTARY PARTICIPATION:
Participation in this research study is voluntary. Your child is free not to participate, or to stop participating at any time, for any reason without negative consequences. In the event that you do withdraw your child from this study, the information they have already provided will be kept in a confidential manner and used for research purposes. If you wish to withdraw from the study, please call or email the principal investigator listed on this form.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. If I have any more questions about my participation in this study, I am to contact Jasmin Poor at 864 355- 8930 or email jpoor@greenville.k12.sc.us.

Concerns about your rights as a research subject are to be directed to, Lisa Johnson, Assistant Director, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-6670 or email: LisaJ@mailbox.sc.edu.

I agree to allow my child to participate in this study. I have been given a copy of this form for my own records.

If you wish for your child to participate, you should sign below.

______________________________ ________________
Signature of Parent/ Guardian Date

____
Parent/Guardian Email

______________________________ ________________
First name of Minor Age of Minor

UNIVERSITY OF
SOUTH CAROLINA

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
APPROVAL LETTER for EXEMPT REVIEW

Jasmin Poor
214 Dothan Ct
Greenville, SC 29607 USA

Re: **Pro00100925**

Dear Mrs. Jasmin Poor:

This is to certify that the research study ***The Impact of Virtual Field Trip Programs on Participant Interest in Science Domains and STEM fields.*** was reviewed in accordance with 45 CFR 46.104(d)(1), the study received an exemption from Human Research Subject Regulations on **6/11/2020**. No further action or Institutional Review Board (IRB) oversight is required, as long as the study remains the same. However, the Principal Investigator must inform the Office of Research Compliance of any changes in procedures involving human subjects. Changes to the current research study could result in a reclassification of the study and further review by the IRB.

Because this study was determined to be exempt from further IRB oversight, consent document(s), if applicable, are not stamped with an expiration date.

All research related records are to be retained for at least three (3) years after termination of the study.

The Office of Research Compliance is an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). If you have questions, contact Lisa Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,

Lisa M. Johnson
ORC Assistant Director and IRB Manager

APPENDIX B

WELCOME SURVEY

Welcome Survey- Getting to know you:

Thank you so much for helping us learn about how virtual field trip programs interest students. We have a fun week planned. You will get to become a member of a fossil digging team and help answer a question about what causes Earth's seasons. We will be meeting every day through Zoom video conferencing rooms. You will be able to see and interact with other students as well as the instructor. To get us started, we want to learn a bit more about you.

1. First Name:
2. Last Name:
3. I am a () Boy, () Girl, (Other)
4. I think the group that is most like me is: (African American, Black), (American Indian, Native American, or Alaskan Native), (Asian, Asian-American), (Caribbean Islander), (Latino or Hispanic), (Middle Eastern or Arab), White, (Caucasian -non-Hispanic), (Prefer not to Answer), (Not listed)
5. Age:
6. Elementary School
7. Grade Completed 2019-2020 (3^{rd}) (4^{th})
8. Have you participated in STEM (science, technology, engineering, and mathematics) activities before? Please select all that apply. (Yes, during school), (Yes, outside of school), (No, I have not done any STEM activities.)
9. Have you ever attended a virtual field trip before? (Yes, in my classroom with Local Science Center), (Yes, at my school), (Yes, while schooling at home), (No)

   If Yes answer selected for question 9 the survey will populate the following long answer questions.
10. Think about a virtual field trip you have done. What was the virtual field trip about?
11. What was your favorite part of the virtual field trip?
12. What was your least favorite part of the virtual field trip?

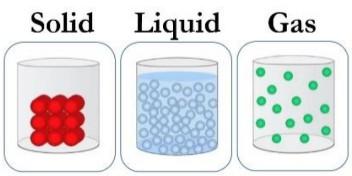
APPENDIX C

SCIENCE DOMAIN PRE-SURVEY

Please remember these things-
-This survey is not a test, and this means there are no "right" or "wrong" answers.
-This is all about your experiences, thoughts, and feelings.
-Please take your time and answer the questions as honestly as you can.
If you have any questions, please ask for help.

Thank you for your participation and for sharing your thoughts about STEM!
Please rate your interest in the following questions- (All questions will be evaluated on a 4-point Likert survey response- (1) Strongly Disagree to (4) Strongly Agree

Chemistry-
Chemistry: The study of matter and the changes that it undergoes.



1. I like chemistry.
2. I am interested in chemistry.
3. I feel excited when we start a new chemistry lesson in school.
4. I want to learn more about chemistry.
5. I want to know all about chemistry.

Section 2:
Geology-
Geology deals with the history of the earth and its life, especially as recorded in rocks.

1. I like geology.
2. I am interested in geology.
3. I feel excited when we start a new geology lesson in school.
4. I want to learn more about geology.

5. I want to know all about geology.

Section 3:

Meteorology-

Meteorology is the study of the Earth’s atmosphere and, in particular, its climate and weather.

1. I like meteorology.
2. I am interested in meteorology.
3. I feel excited when we start a new meteorology (weather) lesson in school.
4. I want to learn more about meteorology.
5. I want to know all about meteorology.

Section 4:

Astronomy-

Astronomy is the study of objects in our solar system and beyond.

1. I like astronomy.
2. I am interested in astronomy.
3. I feel excited when we start a new astronomy lesson in school.
4. I want to learn more about astronomy.
5. I want to know all about astronomy.

APPENDIX D

STEM PEAR COMMON INSTRUMENT SUITE SURVEY 3.1

Site Name: ________________

What is TODAY's date? (*the day you are taking the survey*) [ ][ ] Month [ ][ ] Day [ ][ ] Year

What is your student ID number? ___________

How old are you? [ ][ ] Age

pear

Common Instrument Suite Survey 3.1

Your Experiences, Thoughts, and Feelings about STEM

Dear student,

Your program would like you to take a survey that asks you questions about how you feel about STEM – especially how you feel now compared to how you felt at the beginning of the program. When we say STEM, we mean all of these things: science, technology, engineering and math.

We want to learn about your experiences with STEM activities everywhere you do or think about STEM: afterschool, on TV, on the internet, in museums/zoos, in the summer, at home or anywhere!

Please remember these things:

- This survey is not a test, and this means there are no "right" or "wrong" answers.
- This is all about your experiences, thoughts, and feelings.
- Please take your time and answer the questions as honestly as you can.
- This survey is voluntary, and this means you can stop at any time.

We use the survey to help afterschool programs become more interesting and exciting, but we do not share your answers. If you have any questions, please raise your hand and ask for help.

Thank you for participating and sharing your thoughts about STEM!

How do you feel about STEM?

Please pick the bubble that matches how you feel about STEM.

	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I get excited about STEM.	◯	◯	◯	◯
2. I like to participate in STEM projects.	◯	◯	◯	◯
3. I want to understand STEM.	◯	◯	◯	◯
4. I like to see how things are made.	◯	◯	◯	◯
5. I get excited to learn about new discoveries.	◯	◯	◯	◯
6. I pay attention when people talk about the environment.	◯	◯	◯	◯
7. I am curious to learn more about cars that run on electricity.	◯	◯	◯	◯
8. I am interested in STEM inventions.	◯	◯	◯	◯
9. I would like to have a STEM job in the future.	◯	◯	◯	◯
10. I enjoy playing games that teach me about STEM.	◯	◯	◯	◯
11. I like to make things.	◯	◯	◯	◯

How curious are you about these topics?

Please pick the bubble that matches how curious you are about these things.

	Not at All Curious	Not Very Curious	Fairly Curious	Very Curious
12. Science	◯	◯	◯	◯
13. Technology	◯	◯	◯	◯
14. Engineering	◯	◯	◯	◯
15. Math	◯	◯	◯	◯

How did you feel about STEM before this program?

Please pick the bubble that matches how you felt before this program.

	Strongly Disagree	Disagree	Agree	Strongly Agree
16. Before joining this program, I was interested in STEM and STEM-related things.	◯	◯	◯	◯
17. Before joining this program, I participated in STEM activities outside of school.	◯	◯	◯	◯

Student Information			
I am a:	◯ Boy		◯ Girl
	◯ Not Listed (please specify) ____________		◯ Prefer not to answer
I speak a language OTHER than English at home:	◯ Yes	◯ No	◯ Prefer not to answer
This school year (2019-2020), I am in grade:	_______		

I think the group that is most like me is: *(You can pick one or more groups)*

- ◯ African-American, Black
- ◯ American Indian, Native American, or Alaskan Native
- ◯ Asian, Asian-American
- ◯ Caribbean Islander
- ◯ Latino or Hispanic
- ◯ Middle Eastern or Arab
- ◯ Native Hawaiian or Other Pacific Islander
- ◯ White, Caucasian (non-Hispanic)
- ◯ Prefer not to answer
- ◯ Not Listed (please specify) ________________

1

[1] Letter of permission to use the Pear Common Instrument STEM Engagement

From: "Meisels, Hannah" <HMEISELS@MCLEAN.HARVARD.EDU>
Date: Wednesday, February 26, 2020 at 12:57 PM
To: "Poor, Jasmin" <jpoor@greenville.k12.sc.us>
Cc: "Hoots, Sara Meyers" <shoots@mclean.harvard.edu>
Subject: Re: [EXTERNAL Email] Re: CIS-S STEM related attitudes

Hello Jasmin,

We are pleased to provide you with materials for data collection. Attached you will find the PDF of the survey version you selected along with the excel spreadsheet for data entry (***See the "Comments & Codings" section for the data dictionary to ensure that you are entering appropriate values***).

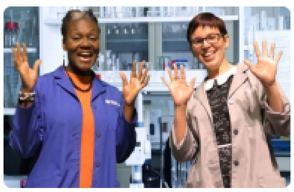
Please share this file with me once your data collection has been completed so that we can upload it to our growing national database. Let me know if you have questions!

Best wishes,
Hannah

APPENDIX E

MAGIC OF MATTER PROGRAM GUIDE

Teaching Guide: The Magic of Matter



Thank you for choosing The Magic of Matter! We invite you to watch a new magic show come to life as our scientists explore the magic of matter. Students will join in the show as our scientists look for new ways to explore how the addition and removal of heat energy effects the states of matter.

Pre Activities:

Vocabulary Review- solids, liquids, gases, melting, freezing, condensing, boiling, evaporating, burning, friction, and electricity

- The Magic of Matter Promo Video. This video will get the students geared up for our show.
    - **https://tinyurl.com/RMSCMagicOfMatter**

Before the Program Instructions:

- Talk with the students about the program- "Roper Mountain Science Center is getting ready for a new magic program on matter. They've asked classrooms to watch the program and provide suggestions."
- Play The Magic of Matter Promo video before the program.

Instructions for Day of the Program:

- Arrange students in 4 – 5 groups
- Each group and student will ideally be visible from the webcam.
- There are no materials needed during the program, but if the students would like notes or a notebook to write on that is fine.

Post Activity

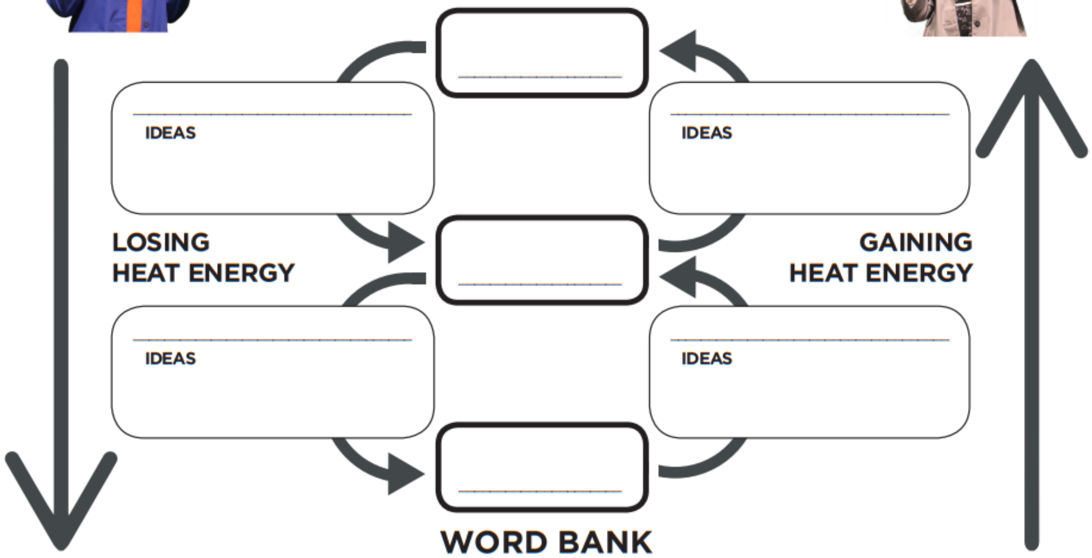
- Complete The Magic of Matter Suggestions sheet.
    - Encourage students to support Professors Roper and Matter develop new ideas for their magic show on the changes of states of matter.
- Have students create their own magic with the transformation of matter (Flip grid works well). Have them explain how heat (thermal energy) effects matter.
- **Career Connection**
    - Scientist
    - Engineer
    - Magician

The Magic of Matter Suggestions

Matter is ______________________________

Help Professors Roper and Mountain come up with new ideas for their show.

DIRECTIONS: Fill in the blanks from the word bank and write some examples for experiments that the professors could use for their show.



WORD BANK

Gas • Liquid • Solid • Condensing • Melting • Freezing • Evaporating/Boiling

APPENDIX F

FOSSIL FINDERS PROGRAM GUIDE

Teaching Guide: Fossil Finders

Join our team as we use evidence from fossils to understand what environments were like long ago. Students will be sent out in groups to uncover fossils. The excavators dig, fossil experts will identify the fossils, and ecologists will identify the environment the organism once lived in. The group will use this fossil evidence to infer what the dig location was like in the past.

Pre Activities:

- Vocabulary Review- paleontologist, ecologist, fossil, evidence, habitat, ecosystem, marine, sedimentary rock, minerals, characteristics, organisms
- Review regions of South Carolina

Before the Program Instructions:

- Print out fossil packet and assemble (**staple each corner and then cut out**)
- Print 8 Habitat Expert sheets and 8 Fossils Expert Sheets (2 for each group)

Instructions for Day of the Program:

- Arrange students in 4 groups
- Each group and student will ideally be visible from the webcam.
- Distribute pages face down to each group
- Assign group roles- Reporter (1 per group), Habitat Experts (1-3 per group), Fossil Experts (1-3 per group), Excavators (1-3 per group)

Post Activity

- Trilobite Mold and Cast Lesson- This PowerPoint with videos will provide an opportunity for students to apply their knowledge to fossils found in Morocco.
- Press Release- Have groups create a press release on the findings from the lesson
- Fossil Expert Sheet- Allow students to explore the additional fossils found in the Carolinas to gather evidence about what the habitat of the Carolinas was like long ago.

- **Career Connection**
  - Paleontologist
  - Ecologist

APPENDIX G

WEATHER WATCHERS PROGRAM GUIDE

Teaching Guide: Weather Watchers

Thank you for choosing our Weather Watchers program! During this program students join our Weather Watchers team where they consult on weather related issues. They work in teams to analyze data and make safety predictions based on past hurricanes in South Carolina. This fun and fast paced weather VFT is sure to be a favorite among students.

Pre Activities:

- Vocabulary to review- climate, hurricane, safety, barometric pressure
- Record weather data for your area and compare with historical data
- Weather Watchers Application

Before the Program Instructions:

- Print out 4 copies of each storm. Each group will receive data from one storm. PLEASE NOTE- DO NOT pass these out until instructed to do so. Also please do not let the students see the pages.
- Each group will need copies of the Prepare sheet.
- Print out your weather name tag and wear it during the presentation.
- Acquire post-it notes for each student

Instructions for Day of the Program:

- Arrange students in 3 groups – assign each group a storm- Please don't tell them☺.
- Each group and student will ideally be visible from the webcam.
- Distribute Post-it and pencils for each student
- Please assign a spokesperson for each group

Post Activities

- Review SC Hurricane Plan http://scemd.cdn.missc.net/Public+Information/Publications/Hurricane_Guide/2017/Hurricane+guide+for+website.pdf
- http://www.nws.noaa.gov/om/hurricane/resources/hurricane-brochure17.pdf
- Develop letter to the Mayor to include a pamphlet about safety during a hurricane.
- http://www.weather.gov/jetstream/ (further information for teachers)
- Reflect on hurricane season- why is it June-November?
    - Observe hurricane graphics over years to see when most hurricanes hit
- **Career Connection**
    - Meteorologist
    - Storm analyst
    - Data analyst

Roper Mountain Science Center

Weather Watchers Job Application

WEATHER WATCHERS

Thank you for your interest in Weather Watchers! We are a group of dedicated scientists working to support our clients with weather related issues. We pride ourselves on providing thorough advice to our clients by using multiple tools and previous data to support our suggestions.

Name:	
Age:	☐ Male ☐ Female

What is a meteorologist?

____

____

What is your favorite type of weather?

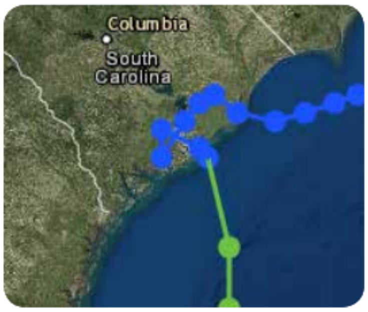
____

____

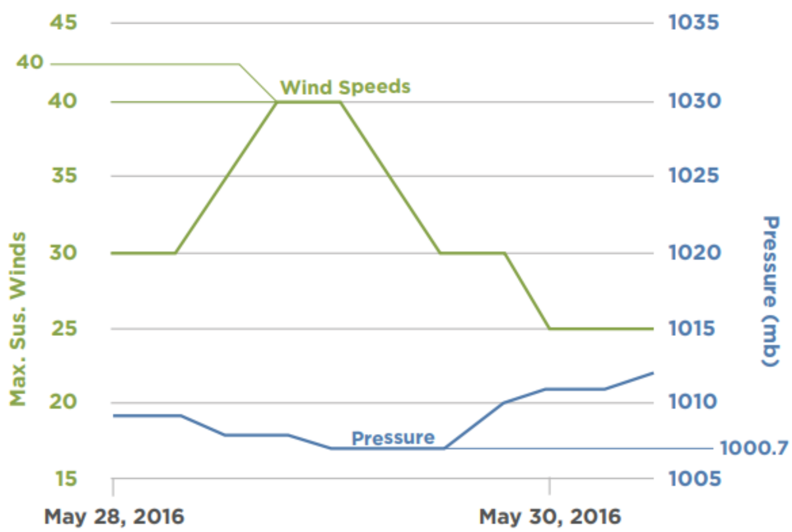
WEATHER WATCHERS

Bonnie

May 28-30, 2016
Total Rainfall: 4.84in
Category: ______



Type	Category	Pressure (mb)	Winds (mph)
Depression		-	<39
Tropical Storm	TS	-	39-73
Hurricane	1	>980	74-95
Hurricane	2	965-980	96-110
Hurricane	3	945-965	111-130
Hurricane	4	920-945	131-155
Hurricane	5	<920	>155



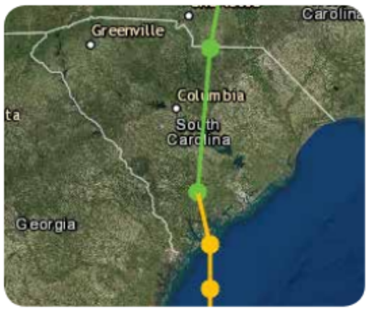
WEATHER WATCHERS

Bob

July 25-25, 1985

Total Rainfall: 5in

Category: ______



Type	Category	Pressure (mb)	Winds (mph)
Depression		-	<39
Tropical Storm	TS	-	39-73
Hurricane	1	>980	74-95
Hurricane	2	965-980	96-110
Hurricane	3	945-965	111-130
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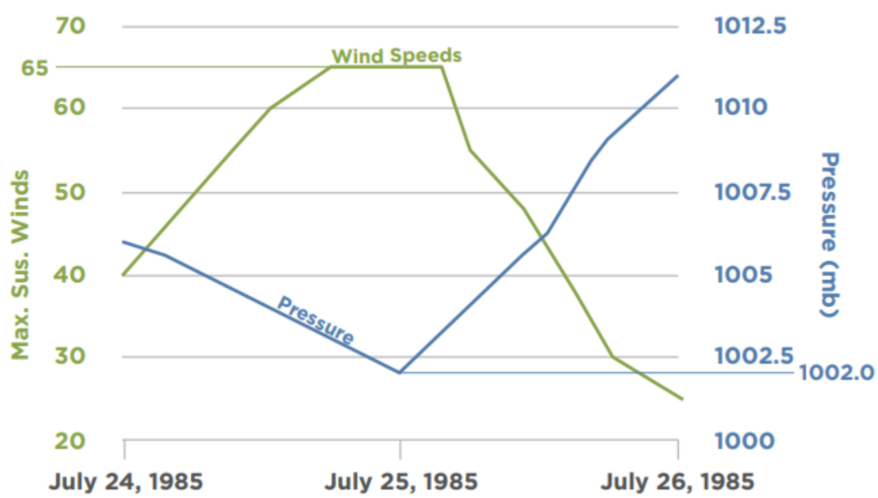
Hurricane	5	<920	>155

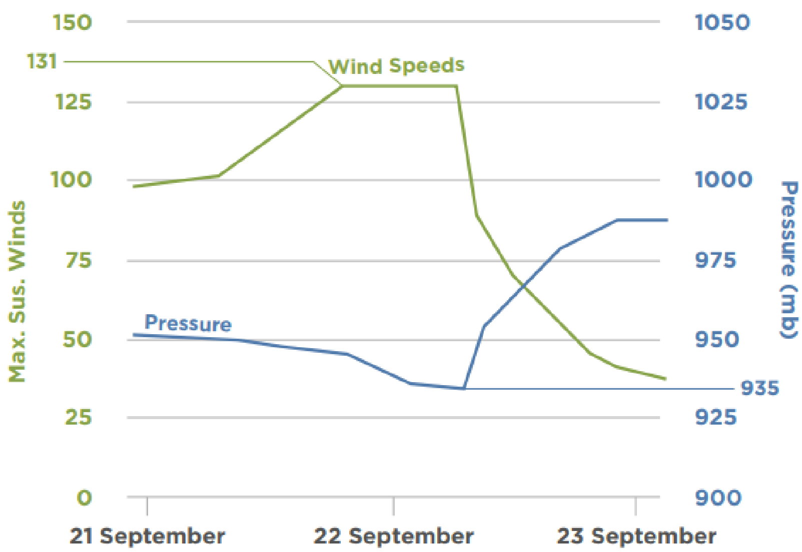


WEATHER WATCHERS

Hugo

September 21-22, 1989
Total Rainfall: 8.1in
Category: ______

Type	Category	Pressure (mb)	Winds (mph)
Depression		-	<39
Tropical Storm	TS	-	39-73
Hurricane	1	>980	74-95
Hurricane	2	965-980	96-110
Hurricane	3	945-965	111-130
Hurricane	4	920-945	131-155
Hurricane	5	<920	>155



PREPARE

This page is a excerpt from the *South Carolina Guide*, a publication produced by the South Carolina Emergecny Management Division.

Hide from the wind...

The Saffir-Simpson Hurricane Wind Scale estimates potential property damage based on a hurricane's sustained wind speed. Hurricanes reaching Category 3 and higher are considered major because of their potential for significant loss of life and property damage. Category 1 and 2 storms are still dangerous, and require preventative measures.

Category 1: Very Dangerous Winds will Produce Some Damage

Winds: 74-95 mph

Buildings could have damage to roof, siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles can result in power outages that could last for several days.

Category 2: Extremely Dangerous Winds will Cause Extensive Damage

Winds: 96-110 mph

Buildings could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.

Category 3: Devastating Damage will Occur

Winds: 111-129 mph

Buildings may sustain major damage, including loss of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.

Category 4: Catastrophic Damage

Winds: 130-156 mph

Buildings can sustain severe damage with loss of roof structure and some exterior walls. Trees will be snapped or uprooted and power poles downed, isolating residential areas.

Catastrophic Damage: Power outages will last weeks to possibly months. Most of the area may be uninhabitable for weeks or months.

Category 5: Catastrophic Damage

Winds: More than 157 mph

A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas.

Catastrophic Damage: Power outages will last weeks to possibly months. Most of the area may be uninhabitable for weeks or months.

APPENDIX H

SEASONS REALITY CHECK PROGRAM GUIDE

Teaching Guide: Roper Mountain Reality Check

Join our Roper Mountain Reality Fact Check Team. Our episode will tackle one student's tough question about the cause for seasons. We will compare temperatures and amounts of sunlight received for different parts of the world to determine the cause of the seasons.

Pre Activities:

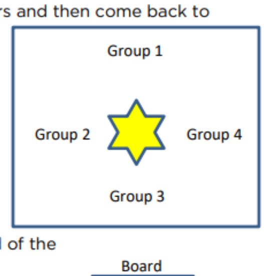
- Show Roper Mountain Reality Check promo video. Explain to the students that they will be joining the team to support with answering a student's tough science questions.
- Vocabulary- season, temperature, sunlight, axis, revolution, orbit, sphere, North Pole, South Pole, latitude, longitude

Before the Program Instructions:

- Print 12 Sunlight, 12 Temperature, and (6- cut apart)Map sheet pages (3 for each group)
- Talk with the students about the program. Remind students of their roles during the program. They will be part of the fact checking team. Their job will be to analyze data to provide evidence for what causes the seasons.
- Have an object ready in the room to represent the Sun (yellow paper, basketball)

Instructions for Day of the Program:

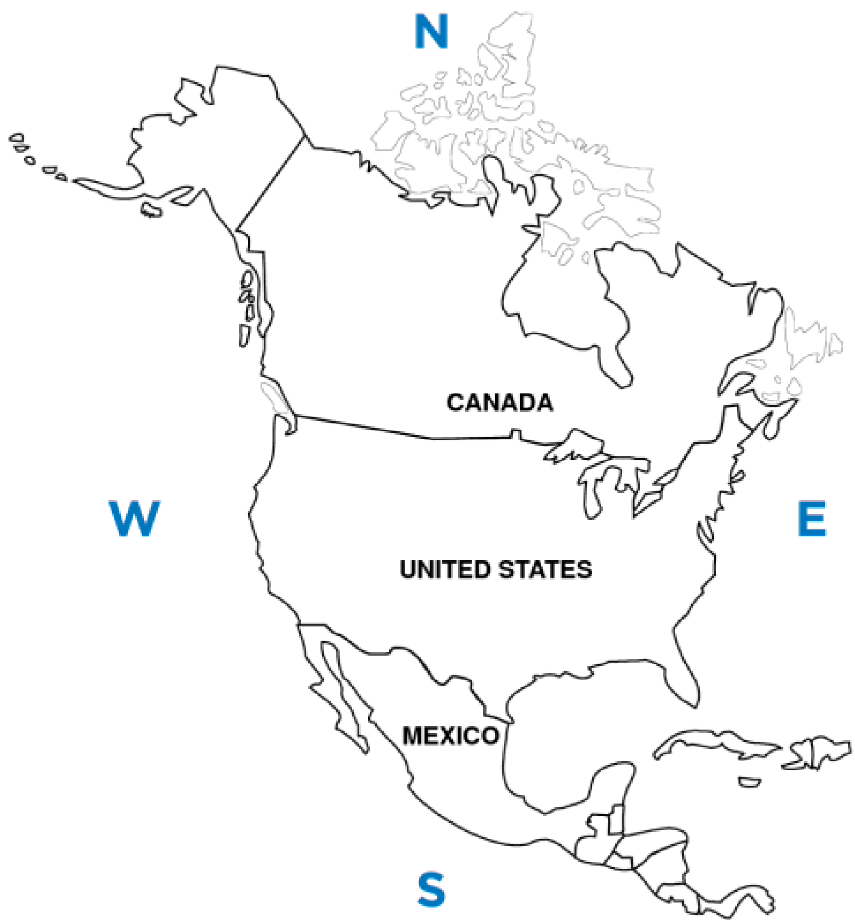
- Arrange students in 4 groups and number them 1-4. Assign partners or group of 3 within each group. They will analyze data in partners and then come back to their larger group during the program to share what they discovered.
- Each group and student will ideally be visible from the webcam.
- Distribute 3 copies of each data sheet (map, amount of sunlight and temperatures) to each group face down. Please ask students not to touch them until told to do so.
- Place object to represent the sun in the very middle of the room. Students will be moving towards the end of the program to locations around the room.



Post Activity

- Dipper Finder Activity – This activity shows students how to locate select constellations in the sky. It also illustrates how we can identify that the tilt of the Earth remains relatively constant pointing towards the North Star regardless of season or orbital path location.
- Light intensity activity- You will need a flashlight for each group. Determine if the distance of 6 inches will work with your flashlights and adjust distance, if necessary. This is designed to show students how angles of sun affect the amount of energy the Earth receives.
- **Career Connection –** Astronomer, Climatologist, Researcher, Scientist, Engineer

Reality Check: Seasons



APPENDIX I

MAGIC OF MATTER SURVEY

Please remember these things-
-This survey is not a test, and this means there are no "right" or "wrong" answers.
-This is all about your experiences, thoughts, and feelings.
-Please take your time and answer the questions as honestly as you can.
If you have any questions, please ask for help.

First Name:

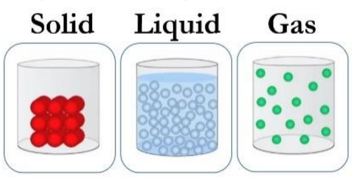
Please rate your interest in the following activities- Pick the bubble that matches how you felt about the activity. (All questions will be evaluated on a 4 point Likert survey response- (1) Did Not Enjoy Very Much to (4) Enjoyed Very Much

1. Discussion about all matter having mass and shouting out answers with the large group
2. Defining matter in small groups
3. Taking the role of a test audience
4. Dancing as particles of matter as a large group
5. Connecting with the professors
6. Providing suggestions for new experiments

Please answer the following questions about the Magic of Matter program. (Long answer)

7. What was your favorite part of the Magic of Matter program?
8. What was your least favorite part of the Magic of Matter program?
9. Would you like to add anything else about the Magic of Matter program?

Section 2:
Chemistry-
Chemistry: The study of matter and the changes that it undergoes.



Please rate your interest on the following questions. Pick the bubble that matches how you feel about the statements. 4 point Likert survey response- (1) Strongly Disagree to (4) Strongly Agree

6. I like chemistry.
7. I am interested in chemistry.
8. I feel excited when we start a new chemistry lesson in school.
9. I want to learn more about chemistry.
10. I want to know all about chemistry.

APPENDIX J

FOSSIL FINDERS SURVEY

Please remember these things-
-This survey is not a test, and this means there are no "right" or "wrong" answers.
-This is all about your experiences, thoughts, and feelings.
-Please take your time and answer the questions as honestly as you can.
If you have any questions, please ask for help.

First Name:

Please rate your interest in the following activities- Pick the bubble that matches how you felt about the activity. (All questions will be evaluated on a 4 point Likert survey response- (1) Did Not Enjoy Very Much to (4) Enjoyed Very Much

1. Talking as a large group about the petrified wood in Arizona.
2. Working with a small group on assigned dig site.
3. Taking on the role of an expert within your group.
4. Enacting tree petrification process.
5. Working with scientists at Science Center.
6. Compiling evidence to make conclusions using charts.

Please answer the following questions about the Fossil Finders program. (Long answer)

7. What was your favorite part of the Fossil Finders program?
8. What was your least favorite part of the Fossil Finders program?
9. Would you like to add anything else about the Fossil Finders program?

Section 2:

Geology-

Geology deals with the history of the earth and its life, especially as recorded in rocks.

Please rate your interest in the following questions- (All questions will be evaluated on a 4 point Likert survey response- (1) Strongly Disagree to (4) Strongly Agree

6. I like geology.
7. I am interested in geology.
8. I feel excited when we start a new geology lesson in school.
9. I want to learn more about geology.
10. I want to know all about geology.

APPENDIX K

WEATHER WATCHERS SURVEY

Please remember these things-
-This survey is not a test, and this means there are no "right" or "wrong" answers.
-This is all about your experiences, thoughts, and feelings.
-Please take your time and answer the questions as honestly as you can.
If you have any questions, please ask for help.

First Name:

Please rate your interest in the following activities- Pick the bubble that matches how you felt about the activity. (All questions will be evaluated on a 4 point Likert survey response- (1) Did Not Enjoy Very Much to (4) Enjoyed Very Much

1. Whole group discussion about Hurricane Gaston
2. Working in a small group on (Hugo, Bob, Bonnie)
3. Taking on the role of the Weather Watchers team and making suggestions to the mayor
4. The emergency scenario- being called in to support with Hurricane Roper
5. Enacting out hurricane winds and pressure- High winds/low pressure
6. Christy Henderson studio tour
7. Using graphs, radar, satellite images, and maps

Please answer the following questions about the Weather Watchers program. (Long answer)

8. What was your favorite part of the Weather Watchers program?
9. What was your least favorite part of the weather watchers program?
10. Would you like to add anything else about the Weather Watchers program?

Section 2:

Meteorology-

Meteorology is the study of the Earth’s atmosphere and, in particular, its climate and weather.

6. I like meteorology.

7. I am interested in meteorology.
8. I feel excited when we start a new meteorology (weather) lesson in school.
9. I want to learn more about meteorology.
10. I want to know all about meteorology.

APPENDIX L

SEASONS REALITY CHECK SURVEY

Please remember these things-
-This survey is not a test, and this means there are no "right" or "wrong" answers.
-This is all about your experiences, thoughts, and feelings.
-Please take your time and answer the questions as honestly as you can.
If you have any questions, please ask for help.

First Name:

Please rate your interest in the following activities- Pick the bubble that matches how you felt about the activity. (All questions will be evaluated on a 4 point Likert survey response- (1) Did Not Enjoy Very Much to (4) Enjoyed Very Much

1. Whole group seasons discussion and analysis of Vostok
2. Constructing a response to the student about what causes seasons
3. Taking on the role of the fact-checking team member for Local Reality Check.
4. Enacting Earth's rotation
5. Connecting with Reality Check Team
6. Using graphs and tables of sunlight and temperature to support answering what causes seasons

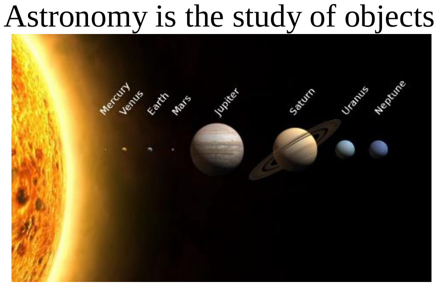
Please answer the following questions about the Seasons Reality Check program. (Long answer)

7. What was your favorite part of the Seasons Reality Check program?
8. What was your least favorite part of the Seasons Reality Check program?
9. Would you like to add anything else about the Seasons Reality Check program?

Section 2:

Astronomy Survey-

Astronomy is the study of objects in our solar system and beyond.



1. I like astronomy.
2. I am interested in astronomy.
3. I feel excited when we start a new astronomy lesson in school.
4. I want to learn more about astronomy.
5. I want to know all about astronomy.