

IN THEIR OWN WORDS AND ACTIONS: A CASE STUDY
OF STEM INTEREST AMONG RURAL YOUTH
IN AN INFORMAL PROGRAM

by

Elaine Marie Westbrook

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DEDICATION

I want to dedicate this dissertation to my parents, Gary Cunningham, Ann Duncan, and my Bonus-Mom Cheryl Riley. They were all influences in my life and helped inspire me to pursue this terminal degree. To my husband, Ira Westbrook, and all my children; Sav Gibbs, Hannah Gibbs, Gigi Gibbs, Rachel Westbrook, and Riley Westbrook, for their support through this adventure, as it seemed never-ending, and for all allowing me to grow through all our experiences from it, making me a better person. To my best friend, Dr. Camille Gasaway Pace, who would not let me quit when the road was rough and listened while we finished dissertations within a semester of each other. To my advisor, school mom, and friend Dr. Jayne Downey for helping me along the path to becoming the researcher and teacher I am today. Finally, to all the students and girl scouts that I have taught over the last two decades; they are the ones that have made the biggest impression in my life and directed my charge to bring equity to education.

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ABSTRACT

In order to develop science, technology, engineering, and math (STEM) knowledge and solutions that address global concerns, there is a need to develop pathways to strengthen STEM interest among rural youth, especially girls. Previous research suggests that informal STEM programs can stimulate participant interest due to the absence of pressures from external assessment (Rogoff, et al, 2016). However, little is known about which instructional methods in an informal STEM program focused on place-conscious programming in a rural community will support the development of youth STEM interest. The purpose of this study was to examine the impact of three instructional methods (hands-on, role models, and culminating projects) on STEM interest development for rural youth, ages eight to twelve, in an informal place-conscious STEM program. Data were collected through observations, focus group interviews, and STEM interest surveys. Participants included youth (N=26) in grades 3rd through 5th grades attending two local schools in one rural community. Results indicated STEM interest increased through collaborative work, new knowledge, and action research. Results also showed gender differences in STEM interest development. Girls' STEM interest was heightened through seeing the personal relevance to their community, whereas boys' STEM interest was heightened through actively working together. This study contributes to the empirical literature regarding STEM interest, informal education, and instructional methods for rural youth. Recommendations are made for future studies.

CHAPTER 1

INTRODUCTION

Over 50 years ago, educational policymakers in the United States increased their attention and funding towards strengthening education in the science, technology, engineering, and math (STEM) disciplines. At that time, the focus was geared toward developing a better understanding of “changing societal contexts such as communicable diseases and manufacturing demands” (National Academies of Sciences, 2019, p. 23). One example of this can be seen in the vaccinology work of Maurice Hilleman, who, during the period of 1940 to 2000, developed nine of the 14 pediatric vaccines routinely administered in the United States (Offit, 2007). Hilleman grew up on a chicken farm in rural Montana. He attended college and earned a Ph.D. in microbiology and chemistry and later used his poultry knowledge to aid in the development of vaccines. In a similar fashion, the U.S. continues to seek ways to strengthen STEM knowledge and contribute to solving global STEM-related issues.

Background

Despite over 50 years of effort, growth in students’ STEM knowledge has not reached desired outcomes. For example, according to the most recent 2020 *Science and Engineering Indicators* report, data from the 2019 Trends in International Mathematics and Science Study (TIMSS) indicated that 8th-grade math and science scores showed no improvement compared to previous years TIMMS, and the U.S. remains squarely in the middle of the international pack (National Science Foundation, 2020). These results are mirrored in the National Assessment of Educational Progress (NAEP), which reported declining mathematics results for 4th, 8th, and 12th-

grade students in the United States (The National Assessment of Educational Progress, 2017). These international and domestic studies indicate that the United States has room to improve students' STEM knowledge. A primary concern is students' stagnant and declining STEM scores, that could be contributing to the national shortage of diverse STEM professionals. Another indicator of the overall STEM professional shortage is reported in *STEM jobs:2017 Update*, employment and occupation opportunities in the STEM sector outgrew those in non-STEM by over 20 percent, and three-quarters of STEM occupations require at least some college (Noonan, 2017). Additionally, there remains a particular shortage of diverse individuals entering the STEM fields, particularly computer science and engineering (Hill et al., 2010; National Science Foundation, 2018). This critical deficiency needs to be addressed because women, as well as other underrepresented individuals, could provide a more diverse viewpoint on the current global developments of STEM demands and offer a more varied approach to solutions and applications.

Increasing Students' Interest in STEM

In 2010, the President's Council of Advisors on Science and Technology (PCAST) developed the *Prepare and Inspire* report indicating a significant gap in levels of interest and achievement for underrepresented groups in STEM disciplines. These findings were mirrored in the 2015 Programme for International Student Assessment (PISA) results, which found that high performing girls were not as interested in physical/technological sciences as they were in life sciences (Tang & Zhang, 2020). These findings on STEM interest provided an important insight for policymakers, educators, and STEM leaders and served as a springboard for further research of the development of students' level of interest in STEM.

Interest has been defined by Harackiewicz et al. (2016) in their manuscript describing educational interest interventions as:

... a powerful motivational process that energizes learning, guides academic and career trajectories, and is essential to academic success. Interest is both a psychological state of attention and affect toward a particular object or topic, and an enduring predisposition to reengage over time (p.1).

Purposely, researchers proposed a four-phase model of interest development, mapping out the four phases of triggered situational interest, maintained situational interest, emerging individual interest, and well-developed individual interest, which progresses over time (Hidi & Renninger, 2006). Situational interest develops first; it can be short-lived and externally introduced (Hidi & Renninger, 2006; Krapp, 1999). It can lead to individual interest, which is more enduring, intrinsically driven, and typically results from an initial situational interest (Hidi & Renninger, 2006; Krapp, 1999). Studies have also found that specific instructional interventions can increase students' situational interest and change a student's disposition towards a subject (Rotgans & Schmidt, 2018).

Researchers' empirical and experimental studies have furthered the knowledge of interest and how interest plays a key role in strengthening the learning process (Krapp, 1999).

Conversely, researchers have also found that a lack of interest can result in apathy, unsuccessfulness, lack of engagement, inattentiveness, unskillfulness, and stagnation (Hidi, 1990). However, STEM interest may be increased through a combination of informal contexts and place-conscious curriculum design (Vaziri et al., 2020). This combination could result in shrinking the equity and diversity gap for STEM pursuits by targeting a different audience (Vaziri et al., 2020).

Pursuing A Younger Audience

Some researchers have suggested that increasing STEM interest before secondary school will help girls maintain STEM interest as they transition to upper grades and experience adolescent pressures (Maltese & Tai, 2010). One previous approach to increasing students' STEM interest and career exploration was to expand high school programs to include middle school participants through experiences outside the classroom (The President's Council of Advisors on Science and Technology, 2010). Various organizations and clubs offering informal STEM programs included a particular focus on girls at the middle school level. This strategy design increased the number of girls interested in STEM, possibly leading to the pursuit of STEM careers (Usher et al., 2019). However, evidence suggests that girls' initial interest in science starts before middle school (Maltese & Tai, 2010). A study of 116 current and soon-to-be scientists examining initial interest in science experiences indicated that 65% were interested in science before middle school (Maltese & Tai, 2010).

STEM in Elementary Schools

STEM is an integrated approach to teaching more than science, technology, engineering and math together but rather “the teaching and learning of the content and practices of disciplinary knowledge which include science and /or mathematics through the integration practices of engineering and engineering design of relevant technologies” (Bryan et al., 2015, pp. 23-24). As Bryan et al. (2015) outlines characteristics of STEM integration; being anchored in science and math disciplines, including practices of engineering and engineering design, developing 21-st century skills, and solving a real-world problem or task. These are exemplified using an inquiry approach, engineering practices, mathematical reasoning, and personal skills. At

the elementary level, students are developing STEM understandings and how this contextually relates to their world. This is reiterated in *A Framework for K-12 Science Education* in 2012 that organizes outcomes over multiples years, emphasizing the depth of knowledge and providing “opportunities to experience how science is actually done” (National Research Council, 2012, p. 1). According to the latest *National Survey of Science and Mathematics Education* (NSSME+) report, science instruction in elementary classrooms is happening at best around 35% of total instruction time and only 18-27 minutes per day (Banilower et al., 2018). Additionally, the same report indicates math and science teachers who were previously in a science career overwhelmingly self-selected secondary education over elementary education (Banilower et al., 2018). This could indicate a significant gap in teaching confidence of STEM at the elementary level (Falk & Dierking, 2010). According to Falk and Dierking (2010), “[the] science learning community agree[s] that the quality of school science education is better at the secondary level than at the preschool and elementary levels” (p.487). Still, it does not address the gap of how to increase STEM interest, which was explicitly called for by The President’s Council of Advisors on Science and Technology (2010).

From Formal to Informal Contexts

One place where interest could be developed is in informal contexts where the learners operates outside of objectives and timelines and focuses on seeking knowledge in everyday situations. Furthermore, informal learning is not only about where the learning occurs but how it occurs (Rogoff et al., 2016). For example, informal learning occurs in various settings including everyday experiences; designed spaces, such as museums, science centers and zoos; non-school based programs; and various forms of media (National Research Council, 2009). Unlike formal

educational structures, research suggests that *informal* program designs stimulate participant interest due to the absence of pressures from any external assessment (Dierking et al., 2003; Rogoff et al., 2016). Informal programs aim to be interactive, meaningful, social, conversational, and, notably, build individual interest (Rogoff et al., 2016). In their report, *Learning Science in Informal Environments: People, Places, and Pursuits*, interest was added as part of a new strand for the framework, indicating informal contexts “can play a special role in stimulating and building on initial interest” (National Research Council, 2009, p. 4). The aforementioned international study based on PISA data additionally investigated informal science learning effects on science learning outcomes and discovered “prior informal science learning has a positive effect ...and direct influence on science performance” (Tang & Zhang, 2020, p. 598). Because informal learning has been shown to increase student interest and performance in science, developing informal curricula that aligns with science standards being taught in formal classroom settings could help support students’ STEM outcomes.

Additionally, in a meta-analysis of the effects of informal STEM programs, findings indicate a positive effect on STEM interest (Young et al., 2017). However, after separating summer camps from after school programs, researchers indicated, “summaries of the effects of after school program on STEM attitudes remain elusive” (Young et al., 2017, p. 64), leaving a gap in the literature to be addressed. Specifically, outcomes of after school STEM programs need to be adequately documented to generate “theoretical and practical knowledge” (Young et al., 2017, p. 64)

Rural Access

The majority of informal programs are geared primarily for urban and suburban middle school age groups (Hughes et al., 2013; Mohr-Schroeder et al., 2014). In addition, researchers have called for a broadening of participation to increase interest, particularly between “science-rich institutions and local communities” (National Research Council, 2009, p. 5). However, accessibility to informal programs in rural locations is difficult due to the distances traveled by the students from their homes to school, which is generally the informal programs' location (Showalter et al., 2019). It is also important to note; some informally structured programs fail to gather data from their rural participants for designing programming contexts, principally for STEM. The resulting informal programs can be inaccessible, and their contexts irrelevant to rural participants' STEM interests.

Place-Conscious Curriculum

To address a rural participant interest, curricula could have a place-conscious focus. Gruenewald (2003) defines place-conscious curricula as the inclusion of location factors that have sociological effects. Place-conscious curricula provide opportunities to bridge local STEM issues and institutional knowledge while nurturing local youth's interest (Buxton, 2010; Johnson et al., 2009). Furthermore, as noted by Butler and Sinclair (2020) in their analysis of place inquiry and spatial methods in education, educational studies should “allow for exploration of experiences of communities that are most often affected by inequality and spatial injustice” (p.84). In *A Framework for K-12 Science Education*, the framework's guiding principle identifies interest and life experiences as a way of “building prior interest....with an eye toward knowledge that students bring with them to school” (National Research Council, 2012, p. 28).

Rural children may bring a rich diversity to their understanding of STEM from their local rural knowledge. Previous research suggests that students may possess distinct funds of knowledge from their households and social networks (Moll et al., 1992) indicating rural students may have distinct rural funds of knowledge acquired from their community of families and networks. Rural funds of knowledge draw upon children's everyday experiences in their communities pertaining to “social, economic, and productive activities in a local region” (Moll et al., 1992, p. 139). Community practices can include “agriculture and mining, material and scientific knowledge, economics, medicine, household management, and religion” (Sherfinski et al., 2020, p. 3). For example, in the case of Hilleman’s vaccine development, he used funds of knowledge developed during his youth to warn farmers not to destroy their young roosters (Offit, 2007), as this would have depleted his access to chick embryos to grow viruses. This illustration demonstrates how rural funds of knowledge can relate STEM disciplines to elements of community and place, as well as being principally valuable in curriculum development.

Researchers acknowledge a need for instructional practice research to focus on “how to best develop and sustain students’ interest in science” (National Research Council, 2012, p. 314). Even though the educational research community has learned a lot about STEM education and interest, there is still a need to understand more about the types of curriculum and pedagogy in an informal program that will increase students’ STEM interest, particularly for rural girls, ages 8-12.

Purpose

In rural settings, cultural and social influences that are uniquely different from other areas could inform or shape the development of students’ STEM knowledge and STEM interest.

However, previous research focusing on place-conscious designs in rural locations has not explored how to increase students' interest in STEM. A place-conscious approach to curriculum and pedagogy aims to employ a multidimensional impression of a place and incorporate its uniqueness into educational practices (Gruenewald, 2003a). To fully implement a place-conscious curriculum, educators need to align the three components of *natural history*, *cultural journalism*, and *action research* in their planning and instructional design (Gruenewald, 2003a). Place-conscious approaches allow students to inquire about their surroundings, take action in their space, and consider its connections to the broader global community. *Natural history* orients students to subject-specific details about the community. To develop a deeper understanding of these details, students participate in cultural journalism. *Cultural journalism* is undertaken by engaging in interviews and story collections from local community sources. Through analysis of their new information and community details, students decide if they want to develop "*action research*." Action research could involve taking a social or political action to remedy a community issue with a developed understanding of the chosen subject.

Previous research tying place-conscious pedagogy and informal practices utilized various approaches including: examining subject context with hands-on experiments to explore the community's natural history; exploring cultural journalism through local videos and news stories from their community; and developing public service announcements to be locally distributed as their action research (Buxton, 2010). However, little is known about which instructional methods of an informal STEM program focused on place-conscious programming in a rural community will support the development of young girls' STEM interests. As previously reported, rural locations may lack programs that take into account the girl narrative about STEM and the

distinctiveness of their particular STEM background (Girl Scout Research Institute, 2012). Thus, this study will develop, implement, and assess the impact of a place-conscious, informal STEM program curriculum to increase STEM interest for rural youth. Drawing from research regarding best instructional practices in informal education, the study will examine the efficacy of three specific instructional methods to increase STEM interest: 1) participation in rural-based hands-on STEM activities (National Research Council, 2015b); 2) interaction with invited scientists and community members to share rural-based STEM knowledge (Kekelis & Joyce, 2014); and 3) participation in the development of rural STEM culminating projects (Buxton, 2010).

Research Questions

Given the need to understand the effectiveness of different instructional methods on STEM interest development for rural youth in an informal place-conscious STEM education program, the following research questions will guide this study.

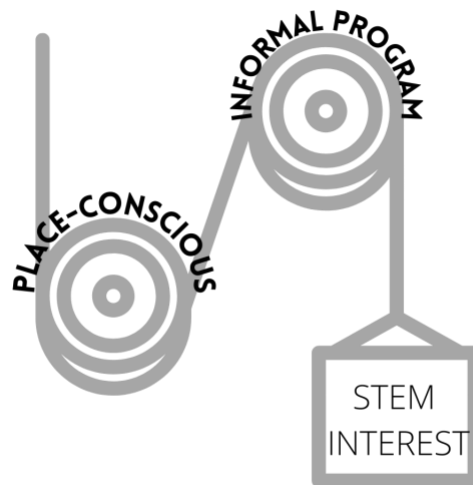
For rural youth, ages eight to twelve, in an informal place-conscious STEM program:

1. What do their words and actions tell us about the effectiveness of hands-on activities to increase STEM interest?
 - a. How does this differ for boys and girls?
2. What do their words and actions tell us about the effectiveness of role models to increase STEM interest?
 - a. How does this differ for boys and girls?
3. What do their words and actions tell us about the effectiveness of culminating projects to increase STEM interest?
 - a. How does this differ for boys and girls?

Conceptual Framework

The overall purpose of this study is to identify the impact of various instructional methods in an informal place-conscious STEM curriculum to increase rural youth's STEM interest. This study has been informed by several theories including those undergirding learning in informal contexts (Rogoff et al., 2016), the role of place-conscious pedagogy (Gruenewald, 2003a), and constructivist theories regarding how children develop STEM interest (Lent et al., 1994). (Figure 1.1).

Figure 1-1. Conceptual Framework Relating Place-Consciousness, Informal Program, and STEM Interest



By identifying place-conscious STEM factors prior to curriculum development, these STEM issues can be used to inform the informal STEM program's development. These STEM topic choices give a personal linkage to the participants' culture.

An informal program design allows for exploring youth STEM interest development based on instructional methods of an informal STEM program. These external factors of informal instructional methods could increase STEM interest in different ways. Informal contexts are less about didactic instruction and more closely structured to explore subjects (Rogoff et al., 2016) allowing interest to develop by extrinsic and intrinsic factors. Additionally, informal programs have indicated participants' benefits as feelings of accomplishment, building confidence, camaraderie, and exposure to new opportunities (Denson et al., 2015), which supports interest development, such as situational interest to individual interest (Hidi & Renninger, 2006).

Incorporating an informal program focusing on STEM topics addresses an academic topic without the pressures of formal academic contexts. STEM is an integrated approach and allows content to simultaneously explore connections to science, technology, engineering, and math. This could help illustrate the importance of each silo topic to one another. It also allows for exploration and inquiry in an informal environment by design.

Interest develops from the participant's interactions with the curriculum in the following ways. First, place-consciousness can develop situational interest with novel stimuli from each particular community, as well as influential community role models (Harackiewicz et al., 2016; Hidi & Renninger, 2006; Renninger, 2009). This can lead to personal interest through topics relevant to their community's culture and participant's prior community knowledge (Harackiewicz et al., 2016; Hidi & Renninger, 2006; Howley et al., 2011; Renninger, 2009). Additionally, the place-conscious design supports the development of "action research" (Gruenewald, 2003a), which achieves relevancy to a goal (Harackiewicz et al., 2016; Renninger,

2009). Secondly, informal attributes of problem discovery, collaborative groups, hands-on engagement, and role model interactions tie to factors increasing situational interest (Hidi & Renninger, 2006; Maltese & Tai, 2010; Renninger, 2009). Furthermore, personal interest could develop in informal contexts through positive emotions and information discovery about a topic (Hidi & Renninger, 2006; Renninger, 2009). Finally, combining informal learning practices with STEM content lends itself to situational interest through hands-on STEM activities and influential role models such as scientists (Krapp & Prenzel, 2011; Master & Meltzoff, 2020; Renninger, 2009; Rotgans & Schmidt, 2014). Similarly, prior knowledge could increase personal interest and raise competency and achievement in STEM topics (Howley et al., 2011; Renninger, 2009; Rotgans & Schmidt, 2014). Together, these components may increase youth interest in STEM.

Research Methodology

This study will employ a multiple methods case study design to explain how interest levels change during an informal place-conscious STEM program. An intrinsic case study design will employ a triangulation approach for data collection (Creswell, 1998; Tashakkori & Teddlie, 2010) during and immediately following each program instructional method. The case is bound by a geographical area that utilizes a local reservoir fed by an adjoining creek as a primary water source. This design will allow for an in-depth examination of the effects of utilizing a place-conscious curriculum on youth STEM interests through a detailed account by youth actions and statements coupled with non-participant observational data and triangulated with descriptive self-report survey data. This research study was conducted in two neighboring schools located within the rural region. This study engaged rural youth, ages eight to twelve, who live in the community

(Creswell & Clark, 2017). All participants engaged in the informal place-conscious STEM programs during the same school period but on different days, allowing the researcher to collect comparable data from both sites. This study employed three methods to collect data for analysis. Focus group semi-structured interviews served as a primary data source. Observational data from each informal instructional method were a secondary data source and supported focus group semi-structured interview data collection. Additionally, a self-report survey instrument was used to collect quantitative data. This design allowed for an in-depth examination of the effects of utilizing three instructional methods to deliver an informal place-conscious STEM curriculum on youth STEM interests through a detailed account triangulated with observational data and a descriptive self-report survey data analysis.

Positionality/Standpoint

I identify with place-based transience (Greenwood, 2015), as I have moved frequently and always absorbed new experiences with each new setting. I am familiar with the farming communities in the Piedmont of South Carolina as a child, Appalachia rural communities and schools in Virginia as a teenage student, and Montana rural classrooms as a higher educational academic professional. Through each I have grounded my identification with rural and developed my own funds of knowledge of each distinctive location. As Greenwood (2015) reflects on his place-based transience, “that heightened awareness and openness to the present moment” (p.14), I too reflect upon mine through my research journey.

I have background in STEM grounded in both industrial and academic careers. These career experiences have given me first-hand knowledge of gender inequity in STEM. I do not easily back down from a challenge and will pick up the fight for others. My personal experiences

as a female being bullied for being smart has driven me to invest in others that may not feel they are able to speak or act in defense. I am aware that professionals do not always recognize gender differences in educational settings. Admittedly, I want to find a pathway to better serve a diverse community's education through researched practices that empathize and promote all students through active engagement in informal and formal settings. I align with a STEM philosophy that recognizes and empowers all genders, races, and communities and their contributions to the STEM perspective.

Additionally, I have facilitated informal STEM education for over two decades. I understand and am aware that my previous experiences shape my view of this research study. I desire to deepen my understanding of the relationship between rural communities, STEM education, and informal programs. My desire is to understand more about the education of children with STEM experiences in an informal setting that may result in interest stimulation. This interest could persevere due to the relationship between their rural community and the STEM content, possibly furthering their STEM cultural connectedness.

As a practicum and student-teacher field supervisor, I have visited multiple rural schools to observe teaching, including science and math instruction. At various times, I have noted the lack of teacher confidence with STEM equipment, or simply the lack of STEM equipment, in some of these classrooms. I want to provide an opportunity for participants to view STEM as a more integrated topic within their community's socio-economic activities and possibly provide increased STEM opportunities to young students. I have become very familiar with the schools' connectedness and their rural communities in this study through many conversations with teachers, administrators, and community members. Our conversations have touched on the

community's desires for their youth. These desires include increasing STEM skills and community workforce retention. These together could help sustain rural communities.

I am hoping to improve my informal STEM curriculum through the integration of specific informal instructional methods. I piloted the incorporation of STEM professional role models in similar programming, with much success over the past decade. I noticed a significant difference when I utilized STEM role models with 3rd-5th grade participants versus middle-school-aged participants in my pilot work. I had previously only integrated STEM role models into informal programs with middle-school-aged and older participants. The younger participants displayed incredible interest and eagerness in a STEM session with a role model scientist. I am researching informal instructional methods (hands-on, role models, and culminating projects) within an informal place-conscious STEM program for youth ages eight to twelve to examine the impact on STEM interest.

Trustworthiness

To establish the data's trustworthiness, the researcher will address credibility, transferability, confirmability, and dependability (Shenton, 2004) and internal and external validity, reliability, and objectivity (Creswell, 2014). The overlap is in the data collection, analysis, and two schools of thought, quantitative and qualitative, on trustworthiness (Bloomberg & Volpe, 2018). *Credibility and internal validity* are addressed with the triangulation of data accompanied by thick description and member checks during interviews. Additionally, validity will be achieved through self-report data. These rural communities are unique, and the study results are not entirely *transferable* to other rural locations, even within Montana. The study intends to establish the possibility of taking this to a broader audience; thus, the researcher will

address transferability by accurately describing locations with enough detail to consider the area's features similar to other locations. Additionally, the data collection will be described in detail to inform practice and be reproducible. To address *confirmability and objectivity*, participants will endorse all interview data. Furthermore, the researcher will keep notes during the research project to check for bias during the study as well as during analysis to establish an audit trail of steps taken. Finally, the researcher will describe in detail the research design and implementation of the study to address *dependability*. Dependability is achieved by data source triangulation and an analysis audit trail to establish the main findings. Together all of these constructs will establish the trustworthiness of this multiple-methods case study.

Assumptions, Limitations, and Delimitations

This study assumed that all participants are willing to be involved in the program. Their families were supportive and willing to actively participate when collaboration was needed from participants (photo opportunities or stories about the community). The study was limited to the availability of its participants. At the time of this study, the world was dealing with the COVID-19 pandemic, and there were limitations to interactions with school settings and the participants. To delimit the study, the study's curriculum design had COVID-19 appropriate modifications in the case of school closures and the inability to hold face-to-face interactions. To limit the impact on individual participants, observations of program instructional methods were selected over individual interviews.

Significance of Study

The findings from this study may help to inform curriculum and pedagogy design decisions particularly for those informal program leaders who desire to provide equitable and meaningful informal STEM programs to underserved communities and individuals. Increased access to research-based informal place-conscious STEM programs may help to increase STEM interest and help maintain academic STEM focus during future instruction. Increasing STEM interest may lead to more diversified solutions to STEM-based issues resulting from targeting equitable participation in STEM education.

Operational Definitions

Informal (learning). Informal learning employs meaningful activities, builds a learner's interest, utilizes conversational dialogue, but does not use an external assessment (Rogoff et al., 2016).

STEM. An educational content focus includes science, technology, engineering, and math as an integrated and crosscutting unit (Kelley & Knowles, 2016).

Place-conscious. An approach to curriculum and pedagogy that takes into account geography, as well as other location factors that have sociological effects, including dimensions outlined by Gruenewald (2003a) referring to culture, ecology, pedagogy, ideology, and politics.

Interest. Researchers agree upon multiple characteristics of interest. Interest is content specific, is sustained through the interaction of a person and environment, has both cognitive and affective components, can be developing although a person is unaware of the development, and

has different physiological/neurological brain activations between learner brain activation and inactivation (Renninger & Hidi, 2011).

CHAPTER 2

REVIEW OF THE LITERATURE

To understand what is already known about place-conscious pedagogy and its effect on STEM interest in youth, this literature review synthesizes research findings regarding key aspects of place-conscious pedagogy including funds of knowledge, STEM learning in informal rural contexts, informal instructional methods, and STEM interest. This review also provides an overview of the history and intricacies of each factor and why these interactions could increase youth's STEM interest. Finally, this chapter reviews previous methods that have been used to study the development of STEM interest in youth and provide a rationale for the design and methods selected for the current study.

The Role of Place in Curriculum and Pedagogy

Curriculum designers have a variety of approaches from which to choose when constructing curriculum and selecting pedagogical materials. Early descriptions of place-based educational significance and its lack of use in educational contexts was interpreted by John Dewey:

the great waste in the school comes from...[the] inability to utilize the experiences he gets outside the school in any complete and free way within the school itself ...unable to apply in daily life what he is learning at school...[and] on another tack and by a variety of means, to arouse in the child an *interest* in school studies (1959, pp. 76-77).

As noted by Gruenewald and Smith (2014), place-based design has been widely adapted focusing curriculum on a place or community, albeit lacking human connections with a place. The place-conscious approach includes the cultural connections foregrounding the importance of

local geography while also considering additional location factors that have sociological effects (Greenwood, 2013). Place-consciousness correlates with pedagogy of place as referencing the ways in which a place can teach us about the world, how the occupants fit in the world picture, and how people identify themselves with a place (Gruenewald, 2003a).

Definition

Place-consciousness expands upon the definition of place-based by considering the multidimensions of the location by contextualizing the location with occupant effects. Specifically, a place-conscious approach outlines how a community interrelates with its inhabitants and how that transfers to a global familiarity (Azano et al., 2020). Place-consciousness is dimensional, which leads to “a place” being unique on multiple layers. These layers can be incorporated into instructional methods to focus on place-conscious in the curriculum design. Place-conscious dimensions include an emphasis on culture, ecology, pedagogy, ideology, and politics (Gruenewald, 2003a). Furthering this dimension of personal identification is cultural experiences happening in places by those occupants. Another dimension of the sociological structure of place describes historical events in places that shape the people's beliefs, thoughts, and actions and form an ideological dimension. Additionally, political dimensions can sometimes focus on the margins of space, specifically, who is left out or not represented in this place within the context of a larger space or global community. Finally, ecological dimensions focus on the local knowledge and detailed accounts of a particular place. These interrelated factors can be highlighted in place-conscious pedagogy.

Pedagogy Framework

Gruenewald and Smith (2014) tackles place-conscious realization through interdependence, “a lived experience of all people in all places, best understood through the study of the commons that we share with human and nonhuman others” (p. xxi). This takes place-conscious design in a reciprocal loop from local origins to global connections and back to local contexts. A primary focus of place-conscious pedagogy is to take a multidimensional and multicultural impression of a place and incorporate the uniqueness into educational practices. Paul Theobald defends this in his essay addressing the shortcomings of education by suggesting place as a “lens through which to view the utility and practicality of traditional school subjects and ...as a catalyst” (2006, p. 315). This catalyst could be a positive shift forward in the reaction of learners with content. To fully embrace a place-conscious pedagogy, educators should be mindful of aligning three factors: natural history, cultural journalism, and action research (Gruenewald, 2003a). These are illustrated in Buxton’s (2010) empirical research study where youth explored the function of water in human locales through an informal STEM curriculum designed with place-conscious principles. Applying place-conscious pedagogy allows educators and students to inquire about their surroundings and act in their space, whether “local, regional, or global” (Gruenewald, 2003b, p. 637).

Natural History. Gruenewald (2003a) refers to natural history as a person’s “firsthand experience with the living world outside the classroom” (p. 637). Natural history can be established by asking students subject-oriented questions about their community. Greenwood (2013) uses the question, “What happened here?”, to guide the inquiry of historical discovery (p.97). For example, in a research study conducted over a one-week summer camp located in a

southern coastal area, campers explored “local environmental challenges with implications for human health and well-being” (Buxton, 2010, p. 120). The students could connect the importance of water to their local environment and compare those findings with global water issues. Buxton’s (2010) findings indicate a significant increase in the students’ scientific understandings. Studies such as this suggest that through the vision and exploration of their local places, youth can build deeper understandings to the STEM content under investigation.

Cultural Journalism. Teachers employing place-conscious pedagogy should engage students with cultural journalism, defined as “creating connections between teachers, students, and the cultural life of the communities that school serve” (Gruenewald, 2003b, p. 638). Cultural journalism can be a link between young and older members of the same community, where the younger students gather direct knowledge from the more experienced members on a particular topic (Gruenewald & Smith, 2014). Students must consider more than just observations of their surroundings. Students need to understand their surroundings' local history, specifically from the community members that live there. The *Foxfire Project* achieved this outcome with students engaging in interviews and collecting the stories of their local traditions from the elders in their community (Wigginton, 1991). This information needs to be publicized so that the material that students gather can connect back to the community. In Buxton’s (2010) research about environmental issues, participants viewed a locally made documentary film about water, which additionally provided information about water challenges in other global locations. Students gained information about water as a resource, application, and source through this journalism basis and discussion. Cultural journalism creates a connection between the educational domain and the cultural life of the community.

Action Research. To bring the connection full-circle, students should observe their communities, hear cultural and historical accounts about their observations, and then decide if they want to act. This is considered as an ethical dimension, guided by the question, “What should happen here?” (Greenwood, 2013, p. 97). As illustrated in Buxton’s (2010) research, this was the crux of what the study was trying to accomplish through the “Social Problem Solving through Science Project”. After the participants spent a week learning about water quality and differences between their local and other global communities, they were invited to make a public service announcement to educate a broad audience. This served as a springboard to conduct interviews about the science content they had learned. These final steps illustrate Gruenewald’s statement, “the significance of action research for place-based education is its potential to engage teachers and students as problem solvers and place-makers” (2003, p. 640). Buxton’s work clearly outlines how a STEM based curriculum could be developed with place-conscious pedagogy.

Funds of Knowledge

To illustrate the connection between a place and its members, one could gain insights by using local funds of knowledge. Funds of knowledge are described as the skills and awareness developed over time and within a society to allow an individual or household the ability to function within the culture (Moll et al., 1992). It has been noted that the participation gap of current students could be reduced by “reclaim[ing] local knowledge and the educational value of experiences in local communities” (Gruenewald & Smith, 2014, p. 355). The gap is referring to students who are not interested in educational content and therefore not participating or

achieving in classrooms. Funds of knowledge can be leveraged to help individuals gain insight and make connections to educational content.

Construction of Knowledge. Azano (2011) describes place-based pedagogy using community knowledge to help students relate to content. The teacher in their study progressed to having students “construct their own understandings of place” (Azano, 2011, p. 1). This connection resulted in students feeling more connected to the curriculum. Previously students felt out of place with the content they were studying. However, by tapping into their “funds of knowledge” grounded in their cultural background and local community, they were able to connect with content in the classroom. In a similar fashion, an empirical study of rural children’s science and engineering knowledge investigated children’s ideas through local photographs (Avery & Kassam, 2011). The researchers were analyzing the children’s conception of science and engineering content. The children were using their funds of knowledge to identify science and engineering examples and photograph them. These illustrations demonstrate the funds of knowledge are foundational in forming individual understandings and comfort with more formal educational content.

The core of gaining insight into funds of knowledge and deeper understanding is through the community. One approach to connecting with the community might be a “Rural Community Walk” (Downey, 2021). This structured learning experience can help to cultivate funds of knowledge within a place by examining preconceptions and developing new understandings about place and community. Researchers recommended that for those seeking to develop a place-conscious program, funds of knowledge afford a deeper understanding of the participant and community member perspectives (Avery & Kassam, 2011; Azano et al., 2020; Downey, 2021).

Furthermore, as noted by Bang and Medin (2010), there is a “critical departure from the deficit lens which views community-derived knowledge as an impediment to learning academic STEM content” (p.1009). These funds of knowledge could be applied in an informal STEM program and provide opportunities to connect with youth’s own experiences (Renninger et al., 2015).

Increasing Community Connections

In research examining place-conscious capacity in Appalachian communities, higher education sought ways to engage students with community-driven goals (Johnson et al., 2009). As stated in the study’s place-conscious conceptual model, “this approach emphasizes teaching and learning opportunities built around knowledge (1) that is relevant to students and (2) of practical value to the community” (Johnson et al., 2009, p. 184). The first project revitalized the community theater while infusing academic disciplines and supporting the traditional curriculum. Subsequently, community teachers expressed a desire for place-conscious professional development to further this approach in their classrooms. A second project based on interests from the community and local school district focused on student retention. The overall place-conscious approach to both projects was identifying important issues in each community, as well as providing university support to resolve those issues. This model approaches each rural community and its unique characteristics by recognizing the “viability of resident resources” and the commitment from the higher education organization (Johnson et al., 2009, p. 187). This harmonization between higher education and the communities they serve could be a springboard for foundational educational projects.

Increasing Student Interest

Analogous to previous studies, researchers examining the incorporation of cultural science knowledge into traditional western instruction found students more interested in the lesson when a place-conscious based approach was used (Lee et al., 2012). The empirical study participants were fourth-grade students from an indigenous Taiwan elementary school. The students were of Amis descent, an Indigenous tribe of Taiwan. The researchers wanted to document culturally relevant evidence related to Amis time and measurement knowledge, student preconceptions of time, and what students learned from a trans-cultural time module, as well as, the impact this approach would have on students' interest in science. The ethnographic investigation applied a cross-cultural-scientific pedagogy to examine the effects on science engagement and knowledge. Previously, the students were disconnected from their science lessons. Utilizing the Amis cultural background on time and incorporating the western knowledge of time into a place-conscious science unit resulted in the students being more engaged in their learning. These students gained the ability to identify and incorporate their indigenous or western methods for keeping time, depending on which was more useful at the moment. Lee et al. (2012) emphasizes that teachers acquiring a local cultural understanding of a concept and incorporating it with a different scientific understanding enables their students to use "their experiential knowledge as resources for academic achievement" (p. 1198). Of equal importance, their teacher noted that students were more interested than previous classes of similar students in the science lesson through the inclusion of their own culture.

Increasing Community Involvement

In another study connecting place-conscious instructional methods to math in a rural setting among seven states in the United States, Howley et al. (2011) discovered three themes from their qualitative study. Themes of “relevance” of math to real-world, “sustainability” by efforts of the educator, and “social-class differences” in student’s outcomes emerged from the data. Students were more motivated when community connections were made during math instruction. Teachers that were supported were better able to sustain this approach. They felt at ease using a place-conscious approach and confidence in their community’s future. However, there was a divide between how the teachers viewed their local community residents, as locals or bedroom commuters; likewise, school communities characterized students as college-bound or community workers. These community views theoretically separated those who viewed education as a way to attain a higher status and those who could prepare students for their community’s needs. All sites, except one, provided the basics of a place-conscious approach through community member involvement beyond traditional academics outside the school structure or a school building, but only one qualified for the “why.” Their purpose was deliberately sustaining and revitalizing the community for the immediate and long-term. The researcher's recommendations were to start small and look to broaden involvement, using local applications to all content, as noted: “look for your approval from the community” (Howley et al., 2011, p. 122).

Increasing STEM Outcomes

Place-conscious pedagogy demonstrates the ability to infuse natural history, cultural journalism along with funds of knowledge, and action research into STEM curriculum that

captures an individual's attention and potentially increases their interest. Additionally, place-conscious pedagogy could arouse interest by focusing on an individual's interest in their own community context, thus influencing their situational interest (Rotgans & Schmidt, 2018). Place-conscious contextualization of STEM connections has been shown to increase interest and close the gender gap in interest (Häussler, 1987). As Azano (2011) states, students are more engaged if curricula is relevant to them and "affirms their competencies" (p.2). These empirical studies point to a direction of increasing STEM interest through place-conscious inclusion of STEM content with similar ways of knowing.

STEM Learning in Informal Rural Contexts

STEM learning has been studied in multiple contexts such as race (King, 2017), education level (Kitchen et al., 2018), and location (Archer et al., 2012). The contexts most relevant to the current study of youth's STEM interest development, are informal contexts and rural contexts. Renninger and Hidi (2011) recommended that studies of youth's STEM interest development need to outline the "characteristics of the learning context" (p. 168).

STEM Learning in Informal Contexts

In 2003, the National Association of Research in Science Teaching (NARST) formed an Ad Hoc committee to develop a policy statement which would outline a more recognized definition for informal science education and provide a deeper understanding of what is meant by an informal learning context (Dierking et al., 2003). The outcome of this effort defined informal science learning as activities that "[occur] outside the traditional, formal schooling realm" (Dierking et al., 2003, p. 108). Subsequently, in *Learning Science in Informal Environments*:

People, Places, and Pursuits (National Research Council, 2009), informal science learning was outlined to happen in everyday experiences, designed spaces, programs, and media. Along the same lines, the Center for the Advancement of Informal Science Education (CAISE) defined facets in informal science as learning beyond the classroom with a limited-duration program in collaboration with other institutions and often results in resources that can be used by others (Miller, 2012). The National Research Council (2015a) notes most definitions focus on science institutions, such as museums or science centers; however, community-based programs are gaining recognition as essential infrastructure for STEM learning.

In addition to defining distinctions between informal science settings, the committee also identified a need to provide guidance for the evaluation of informal science programs. Dierking et al. (2003) note that science learning outside of school, such as community programs, are lacking empirical studies when compared to museum-like settings. In informal program evaluation guidelines, particular attention is paid to “cultural competency,” attention being given to the location of participant representation and the influence effects on the assessment protocol (Allen et al., 2008, p. 73).

In developing informal programs, it is typical to employ meaningful activity, build a learner’s interest, and not assess achievement (Rogoff et al., 2016 & Erickson, 2016). However, Eshach (2006) cautions to not design for “edutainment” and sites Dewey’s reasoning “if the experience is mainly fun, the learner may have learned something, but not necessarily what the teacher or museum educator had planned” (p.172). Informal education can be thought of as all learning that happens outside of a formal classroom setting through “everyday experiences, designed settings, and programs” (National Research Council, 2009). In the same report, the

NRC identifies informal education participants' experience as awareness, interest, motivation, social competencies, practices, knowledge, habits of mind, and identities of the area studied. Concluding that informal education is not driven by summative assessments but rather by student interest, engagement, and identity. Therefore, informal education design should be informed by setting specific learning goals, being interactive, providing multiple learning pathways, encouraging knowledge reflection, including learning extensions, and offering community partnerships (National Research Council, 2009).

STEM Learning in Rural Contexts

Globally, rural locations may hold the key to developing diversified STEM individuals because of their unique experiences with their environmental surroundings (Gruenewald & Smith, 2014). Admittedly, rural is not easily defined, and often the definitions lack specifics (Hawley et al., 2016). Defining rural with a description beyond statistical information illustrates that rural is more than population size or a geographical parameter. Researchers in the U.S. tend to choose from one of the many standard government definitions provided by agencies such as the U.S. Census, U.S. Department of Education, U.S. Office of Management and Budget, U.S. Department of Agriculture, or the Economic Research Service. Each agency's definition of rural was created to meet a specific need. Therefore, researchers need to account for their study's purpose in selecting the most appropriate criteria to accurately describe *each* rural context. More recently, researchers have been attentive to multiple aspects of rurality that shed light on both the common and distinct features of rural places. Hawley et al. (2016) have written about recommendations for defining and describing rural, recognizing that it is crucial to ensure the construct is not too broad, not too specific, identified correctly, and is multidimensional.

Multidimensional constructs should utilize the following to provide sufficient details regarding the rural location: population, settlement structure, landscape, economy, institutions, and socio-culture dimensions (Brown & Schafft, 2011). For example, one study defined rural areas with minimal criteria as “communities of less than 1,000...communities between 1000-5000...and communities between 5,000-25,000” (Jacobs et al., 1998, p. 688), leaving out any other narrative details about the rural communities. In another study on rural high school seniors, rural is defined “as any person or group of persons residing within a county in which the cities have populations of less than 50,000” (Anderson & Brown, 1997, p. 307). In contrast, the author for a study of rural high schools using place-conscious education defined rural very articulately in this very in-depth definition:

BVHS sits off a two-lane road, flanked by expansive fields dotted with churches, barns, and cattle. Along the winding state, highway are an assortment of ranch-style houses, trailers, and historic farmhouses interspersed with local businesses, such as a family-owned convenience store and a flea market site. With the football field in the foreground, the high school is perched on a hill at the base of the Appalachian Mountains, looking across the highway onto miles of meadows and cow pastures... According to the 2000 report from the U.S. Census Bureau, Slocum’s population was approximately 1,300 and Sweet Bay’s was 2,000 (Azano, 2011, p. 3).

This definition of rural, by Azano (2011), gives the reader a picture of the area in the study and insightful details that differentiate this rural area from other rural areas.

However, to develop informal learning programs in rural communities, other rural circumstances need to be considered. STEM researchers need to examine the community’s ability and desire to support informal programs (Ginorio et al., 2002). The setting may be in a school, or another community building and may happen after school or in the summer (National Research Council, 2009). It may be part of a larger organization or specifically focused on providing a community service (National Research Council, 2009). Some rural areas may

struggle with issues such as access to technology, transportation, or programs and factors can constrain how informal STEM programs are delivered (Kastelein, 2018). Rural informal STEM programs must take these circumstances into account when planning programs within these communities. An example, in a current study investigating rural participation in STEM, Vaziri et al. (2020) were interested in identifying supports and barriers of young rural students in order to gain an understanding of how engineering could support their community. One support was the creation of informal STEM activities. Additionally, the study outlines the students' STEM interest should support the K-12 levels, develop interest outside a formal classroom, and relate to their local community values (Vaziri et al., 2020). These indications point to developing informal STEM programs while using a lens of rural context.

Instructional Methods for Informal STEM Learning

Previous research has identified several instructional methods that have generated positive outcomes in informal programs (National Research Council, 2015a; Shah et al., 2018). Three of the most studied instructional methods are: hands-on activities (Holstermann et al., 2010), interaction with role models (Kekelis & Joyce, 2014), and development of culminating projects (Buxton, 2010).

Hands-on Activities.

Instructional resources for informal programs characteristically contain hands-on activities, regardless of environment type (Allen et al., 2008). The activities can be described as those which require a participant's active physical involvement, and/or manipulation (Flick & Lederman, 2004). Participants are characterized as "cognitively and affectively engaged" with

hands-on and interactive science experiences (Eshach, 2006, p. 1383). Additionally, research has shown that situational interest/short term interest, can be fostered through hands-on activities and can lead to maintained individual interest (Palmer et al., 2017; Renninger & Hidi, 2011). In a recent study, the incorporation of hands-on activities into the program was described by one study participant as bringing science content to life (Roberts et al., 2018). In a study on “doing science” with ten and eleven-year-old participants, science interest was linked to science activities' hands-on instructional methods (Archer et al., 2010). Likewise, hands-on activities have been shown to create interest in students' of all ages by allowing them to physically explore concepts (National Research Council, 2009).

Some studies have found while an informal environment incorporating stand-alone hands-on experiences showed a significant increase in science interest, they could not maintain long-term effects (Holmes, 2011). Furthermore, there has been speculation of girls having a lower active participation in hands-on activities when boys are in the same group. However, in a study investigating gender differences in elementary-level science instruction, girls were as likely as boys to manipulate equipment at times of an audit, every two minutes, during their hands-on activity (Greenfield, 1997). Greenfield (1997) described their behavior as “...willingness and ability to participate fully...and even [noted] their positive attitudes”, which could have resulted from girls' early exposure to hands-on science experiences (p. 270). An international research study comparing elementary inquiry methods in Lithuania and the U.S. found that U.S. facilitators would not implement a hands-on inquiry approach if they did not have enough equipment for every participant (Hansen & Buczynski, 2013). However, in Lithuania, if a facilitator had even one set of equipment, they would demo the experiment and

pass it around for every participant to examine more closely (Hansen & Buczynski, 2013). Finally, another study incorporating cultural practices with science instruction, the researchers noted that hands-on activities were better able to relate science concepts with place-conscious cultural knowledge than textbook science content (Bang & Medin, 2010). Additionally, Avery notes in her discussion on place-conscious education the importance of using “hands-on, real world learning experiences” to connect with local rural knowledge (Avery, 2013, p. 31). These empirical studies of hands-on activities illustrate the importance of their inclusion to developing STEM interest while incorporating place-conscious context and could be of significance for girls in particular.

Interaction with Role Models

Research has demonstrated that role models influence the development of sustained STEM interest (National Research Council, 2009). Many programs evaluated for increasing STEM interest included a STEM role model, specifically a role model qualified as a subject area expert and educated in cooperative learning approaches (National Research Council, 2009). Furthermore, the same report concluded role models and other social supports “play a critical role in supporting science learning” including supporting interest, building relationships and collaborations, developing community science knowledge, and building enthusiasm (National Research Council, 2009, p. 302). Likewise, research recommends having scientists involved in the development and implementation of informal science programs as their involvement contributes to participants’ increased STEM interest (Rennie, 2014; Renninger et al., 2015).

Role Models and Identity. Research examining the inclusion of scientists as role models, found that participants need to perceive these individuals as similar to themselves, where role

models share their same gender, culture or community values, or have similar hobbies and interests (Britner & Pajares, 2006; Renninger et al., 2015). Giving children the ability to see themselves pursuing the same hobbies as scientists provides an opportunity to connect on a more social level (Tyler-Wood et al., 2011). As noted by Renninger et al. (2015), in their research on establishing early science interest, students indicated they could not imagine themselves as scientists. Therefore, a proposed solution was to include scientist experiences, in which the students were able to get to know these role models on a more personable and less professional level (Renninger et al., 2015).

Role Models and Early Connections. Role model scientist interventions provided evidence of triggering science interest at the primary school level (Renninger et al., 2015). Providing participants with the ability to interact with a scientist as a form of role model, mentor, or community expert allowed participants to view science as interesting and acceptable in a socio-cultural context (Rennie, 2014). In longitudinal research with ten-year-olds, studying “doing” science versus “being” a scientist, children identified as a scientist due to interest in science and activities with science outside of formal schooling (Archer et al., 2010). In another study of children and scientific aspirations, a participant chiefly identified that meeting with a role model, a scientist, as the reason she became very interested in science (Archer et al., 2012).

Role Models for Girls. In the same vein, female mathematicians identified a role model who nurtured their interest in math at an early age (Zeldin & Pajares, 2000). Similarly, one research study examined the differences in informal STEM interests. This was accomplished with female STEM professionals' predominate involvement comparing two informal STEM

camps, a coed group with an all-girl group (Hughes et al., 2013). Both groups' results indicated significant positive STEM interest changes for females but not males (Hughes et al., 2013).

Role Models for Rural. A review of rural science education recommended nurturing dialogue between individuals in the community and their connection to STEM to increase students' value of rural knowledge and their connection with the STEM context (Avery, 2013). Children's typical daily interactions with their rural community role models are where they most often learned science concepts (L. M. Avery & K.-A. Kassam, 2011). Role models in some programs were valued elders from the local indigenous community and their science knowledge was highly respected by the children (Bang & Medin, 2010). In another study incorporating indigenous elders as role models and knowledge keepers, researchers aimed to increase science interest by incorporating the local indigenous science knowledge with western science content (Lee et al., 2012). Lee et al. (2012) broadly concluded that this approach "promotes student interest" (p.1198). In a study focused on rural girls and science, participants were paired with female scientist role-models for an informal science two-week camp experience (Ginorio et al., 2002). The research results indicated that the participants' science interest increased. However, due to the brevity of the experience, science interest was not sustained due to participants' unsupportive school community for their newfound science interest (Ginorio et al., 2002). In a second phase, the school counselors and teachers were invited to participate and the results indicated a sustained interest (Ginorio et al., 2002). This illustrates the need for support through involvement of the individual's community. Additionally, Ginorio et al. (2002) indicated a need for increased community science knowledge to demonstrate the benefits of STEM for the community at large.

Development of Culminating Projects.

Historically, inquiry-based scientific education was geared towards student interest projects, including projects of social and scientific relevance (Flick & Lederman, 2004). A national report on science and engineering indicated that cognitive engagement through artifact creation led students to high levels of interest in science (National Academies of Sciences, 2019). In Buxton's (2010) research on social problem solving through science, participants created public service announcement posters to inform their community of topics investigated over the week-long camp. The study concluded that the intervention resulted in increased science interest.

In a study exploring science interest and its connections to informal effects, the case study participant intensely pursued a school science project at home and developed a fascination with microbiology (Bricker & Bell, 2014). Furthermore, in a study designed to discover how and when scientists were first interested in science, results indicated science projects triggered their childhood interest, and this science interest was maintained into adulthood (Maltese & Tai, 2010). These studies illustrate the importance of projects to developing STEM interest in children.

Additionally, the National Science Foundation indicated culminating projects could strengthen STEM interest in underrepresented populations, such as girls (*Science and engineering indicators 2016 (Report No. NSB- 2016-1)*, 2016). A research study was focusing on 4th and 5th-grade girls who utilized science projects for participants to “share research findings through innovative methods that have a strong verbal component” (Tyler-Wood et al., 2011, p. 47). When the same research participants were contacted following high school, the participating girls had positive STEM feelings that were equivalent to those of undergraduate science majors

and higher than those of non-science majors (Tyler-Wood et al., 2011). In a national report by Girl Scouts, girls interested in STEM had a significant positive response to science projects (Girl Scout Research Institute, 2012).

Similarly, in rural science educational pedagogy, photo-documentation provided a way for participants to share their local knowledge and connect science content to their community (Avery, 2013). Along the same lines, a research study with rural girls and science projects that were student-designed and involved community issues led to maintained STEM interest in participants (Ginorio et al., 2002). Some families support their child's science interest by providing science projects in which children informally develop a more profound interest (Archer et al., 2012).

STEM Interest

Informal learning programs "allow for the extended pursuit of learning agendas, the refinement of interests, the sharing of relevant learning resources and feedback, access to future learning experiences, and opportunities to be identified as having *science-related interests*" (National Research Council, 2009). Interest is an essential component to attract members to a group and is a typical evaluation by informal programs. Yet, there needs to be a recognized definition of interest to guide program implementation and evaluation.

Dewey was among the first to recognize interest as a driving factor for learners to engage with "self and world" as an interactive process (Glassman, 2001). Interest, an influential factor in learning and education, has been explored for over 100 years yet remains elusive to researchers. A resurgence of interest research has been predominately geared toward interest generation with text (Hidi, 1990). In research, interest has been described as having affective and cognitive

components which help to increase student motivation to learn, and increase understanding of the content (Silvia, 2008).

Schiefele and Csikszentmihalyi (1994) investigated the relationship of interest and quality of experience with content, including science and math, and found that interest factors of intrinsic motivation, positive affect, concentration, and feelings of excitement predicted positive experiences. Moreover, this outcome occurred regardless of the participant's ability or achievement motivation (Schiefele & Csikszentmihalyi, 1994). In another example, an international study investigating science interest employed cognitive content questions embedded with affective questions examining several science domains' context and content (Drechsel et al., 2011). Interest has been described as a combination of affective and cognitive factors.

Four-Phase Model

Theoretical models have identified two categories of interest; *situational* interest which is defined as “increased attention, effort, and affect...in a particular moment” and *individual* interest, which is defined as “to re-engage with a particular object or topic over time” (Harackiewicz et al., 2016, p. 2). Researchers have also created theoretical models for how situational and individual interest develops over time. The *four-phase model of interest development* (Hidi & Renninger, 2006) includes: triggered situational interest, maintained situational interest, emerging individual interest, and well-developed individual interest. The first phase, *triggered situational interest* “results from short-term changes in affective and cognitive processing” by personal relevance, typically external supports, includes group work or puzzles, and may lead to reengagement with the content (Hidi & Renninger, 2006, p. 114). This is

characteristically followed by phase two of *maintained situational interest*, which is more focused, persistent, and may reoccur. It is sustained “through meaningfulness of task and personal involvement,” maybe externally supported, can involve “project-based learning and cooperative group work,” and could lead to more developed interest (Hidi & Renninger, 2006, p. 114).

In the third phase, there is a shift to internal feelings, self-generated pursuit with role model and learning condition support, and is designated as *emerging individual interest* (Hidi & Renninger, 2006). This individual interest is more internally driven and moves away from external motivators. The final phase of *well-developed interest* is more enduring, with the individual seeking to re-engage with the content and valuing the knowledge gained. This is typically self-generated but may still need sustenance and can be supported through interactions and challenges to their previous knowledge (Hidi & Renninger, 2006). At this stage, challenging material is more easily accepted and sought after to deepen the content knowledge previously acquired. This model for interest development does not have a concrete timeline but rather distinct characteristics.

Research Examining the Four-Phase Model of Interest Development

Interest development from one empirical study states it can transition from situational interest to individual interest in as little as four weeks (Rotgans & Schmidt, 2017). Interest starts with the sparking of inquisitiveness, which can persist if supported by outside factors and develops cognitive connections to other information. Internally driven factors, such as curiosity and value, help sustain this individual phase of interest. At the highest level of interest, individuals will seek information, ask questions, and pursue creativity challenges.

These study findings are incongruent with Palmer et al. (2017) study investigating repeated situational interest experiences in science classes. Participants sustained individual science interest after ten months. The majority of the participants entered the study with “negative or neutral dispositions towards science” (Palmer et al., 2017, p. 746). Researchers suggested techniques such as hands-on activities to help sustain science interest. Furthermore, in the Rotgans and Schmidt (2011) study focused on situational interest, participants were given five situational interest measures including one pre- and four post- tests after specific activities had transpired over a one-day active learning session. The participants’ interest significantly increased after a real-world phenomenon was revealed and it remained stable at that level throughout the rest of the day. There was a slight increase in interest at the end of the project when the participants made presentations of their findings. (Rotgans & Schmidt, 2011).

A later study by Rotgans and Schmidt (2014) on situational interest, produced conflicting findings. This later study revealed that knowledge-deprivation, such as a problem, did not always correlate with increasing situational interest, especially if the student does not realize a lack of knowledge (Rotgans & Schmidt, 2014). Renninger and Hidi (2011) suggest that more information about triggering and sustaining interest still need to be investigated, along with how shifts between the phases occur.

STEM Interest

The theory of the development of phases of interest is evolving, just as is the shift in science instruction to STEM learning. In studying STEM interest, science, technology, engineering, and math content could be examined in separate silos (Drechsel et al., 2011). However, as STEM implies, by definition, an integrated approach to context might be better. A

theoretical approach for applying STEM instruction is applying a differentiated approach to interest by topic, context, or activity (Drechsel et al., 2011).

STEM Interest Development. Studies examining the development of interest in science and STEM sometimes include specified activity results reported by contextual properties of affective, cognitive, or the four-phase model. In the research on this differentiated model in an international study of physics, the context significantly influenced interest. An affective state defined the context, application to everyday life, basis for many vocations, challenges, and impact on society. It is important to note that the context of physics content was the most interesting to both genders in the study. (Häussler, 1987). Another study, exploring STEM self-efficacy through STEM interest development, examined a curriculum and group approach through project-based activity methods. This study indicated that STEM interest and the perception of STEM usefulness increased following activities design to solve a collaborative team problem (Brown et al., 2016).

STEM Learning in Informal Settings

In a similar approach, Barron (2006) investigated interest-driven learning and utilized pilot work to identify three case portraits in Bermuda and the United States. All three subjects were interested in science content and actively sought new information in multiple settings outside of their formal schooling. These results indicate the need for evaluating the interest of group members in an informal program. Program objectives need to align with the interest of its members as well as guide the content selection. Once appropriate content is decided upon, activities and experiences that align and are age-appropriate can be added. A study researching interest and out of school learning notes that informal programs are more sensory, participants

learn “through imitation and observation,” rely much less upon language, and function on a more personal level (Barron, 2006). Along the same line, it has been noted that an important outcome of informal science learning is the enhancement of science interest (Tang & Zhang, 2020).

Place-conscious STEM Pedagogy

This parallels the current approach of applying place-conscious pedagogy to STEM content to enhance STEM interest. STEM is the application of multiple disciplines simultaneously and harmoniously to solve problems in everyday and extraordinary situations. As indicated by *The National Science and Engineering Report*, several methods to increase STEM interest include “promoting personal relevance...and situating the investigation in socially and culturally appropriate contexts” (National Academies of Sciences, 2019, p. 281) Additionally, Flick and Lederman (2004) indicated future research needs to incorporate culture contexts, such rural applications, and inquiry methods to generate STEM interest. This would allow participants the view STEM within their community and how STEM applies to everyday occurrences and could generate STEM interest.

STEM Learning at Elementary Ages

Additionally, research indicates early intervention, specifically elementary experiences, can spark STEM interest (Master & Meltzoff, 2017). Previous research indicated that boys and girls around age ten already placed self-constraints on their science identity, suggesting STEM interventions before this age could more readily result in developing STEM interest. At this age of development, children can describe their emotions, are socially influenced, and are sensitive to context themselves (Renninger, 2009). As indicated by study results, early STEM interest for adult scientists was initiated at elementary school age, particularly for females. It was influenced

by role models in their own families (Maltese & Tai, 2010). Maltese and Tai (2010) recommended initiation of STEM interest early in education rather than focusing on student assessment. This can be difficult to achieve in formal educational classrooms with impending science state assessments but is more easily attained in an informal STEM program. A study focused on an experience and its effect on STEM interest in children ages eight to twelve indicated participants found the content interesting and exciting but asked for hands-on activities in conjunction with the scientist lectures (Walan & Gericke, 2019). These results indicate a need to investigate elementary interventions utilizing informal instructional methods.

Developing STEM Interest

To study elementary aged participants' interest, different methods have been applied to the four-phase model of interest development. Researchers conducted studies with elementary-aged children with two methods studying STEM interest development from situational to individual. One method approach was the repetition of problem-solving with incorporated knowledge gap guided discovery over four weeks. This resulted in a significant positive effect on individual interest from repeated triggered situational interest. The second study aimed to investigate the same content as a didactic problem treatment with a control group. Again, the treatment group had a significant increase in situation interest but this did not predict individual interest. A limiting factor in the second study indicated that both groups identified their learning gaps before instruction. A knowledge gap has been shown to trigger situation interest (Rotgans & Schmidt, 2017).

An additional study comparing STEM interest development and individual and situational interest interactions indicated that elementary students had correlations of individual

interest and situational interest before the problem content was presented and again before the participants started their research on the problem. This contradicts the four-phase development model and indicates that a student's starting level of situational interest influences their individual interest. This indicates that introducing a problem can help engage situational interest even if there is little individual interest in the content (Rotgans & Schmidt, 2018).

Developing Girls' STEM Interest

One emerging theme in the literature points to girls' lack of interest in STEM, which results in a less diverse STEM representation overall (Hill et al., 2010). In addition, a nationally-representative longitudinal study for elementary-age students focusing on math interest indicated girls are less interested in math from third to eighth grades but not at a significant level (Ganley & Lubienski, 2016). Some experts have suggested that if math content were purposefully intertwined with science, engineering, or technology, girls would have a useful purpose to be interested in math content (Cooper & Heaverlo, 2013).

Greenfield (1997) investigated gender differences in science attitude, scientist perceptions, science informal experiences, science teacher attention, and handling of science equipment in their study focused on science interest. She studied all age levels of participants: lower elementary, upper elementary, middle, and high school. Results showed an interactive effect on gender and grade level for scientific interest. Elementary school girls liked science more than boys, the attitude by both genders towards science declined in middle school, and only the boys' interest rose again in high school. Compared to younger students, older students held more negative perceptions of science career requirements such as intelligence and college training, workload, and male stereotyping (Greenfield, 1997).

It has been noted that girls' STEM interests can be changed through interventions such as informal experiences (Master & Meltzoff, 2017). In a study of gender and grade level differences in science, results indicated significant differences in boys' involvement in more physical science *informal* experiences than girls. The same study indicated no differences between genders for *informal* life science experiences (Greenfield, 1997). Likewise, in an international science interest study, results indicated equal gender interest in life sciences and higher male interest in the physical sciences (Drechsel et al., 2011).

Informal STEM Learning Research Needed

As pointed out by the following research studies, there is a gap in the literature of studies that focus on informal STEM programming at the elementary level. A meta-analysis of out-of-school STEM education programs, including after school, summer camps, and enrichment programs, from 2009-2015 indicated a positive effect on STEM interest. However, it should be noted that the findings for these informal program effects are not robust due to the unavailability of specific elementary informal program data. Of the 84 articles located, only 15 represented informal programs and the majority of which were geared towards middle school students. Study conclusions were that informal STEM programs should have an academic and social focus, including interactions with participants, homes, and communities. Most importantly, they concluded that further investigations at earlier grade levels should be carried out (Young et al., 2017).

Renninger et al. (2015) reviewed empirical studies which focused on the maintenance or triggering of STEM interest in children and concluded there was a need for studies conducted earlier in children's educational experiences. One identified obstacle for STEM interest

development was the lack of time spent on science content in the classroom, on average, students in the U.S. spent eight percent of their time studying STEM (Renninger et al., 2015). To bolster STEM interest, researchers suggested using an “inquiry approach...develop investigative skills through student participation in authentic and engaging activities” (Renninger et al., 2015, p. 21). Researchers have indicated a need to understand how to advance teaching and develop improved mentors to cultivate students' interest (Silvia, 2008).

Studies have also shown that children should have direct experiences with scientist role models to promote STEM interests and point to mentorship (Kekelis & Joyce, 2014; Mosatche et al., 2013). Equally important in developing STEM interest is moving from triggered situational interest towards maintained situational interest employing science content of personal value to the participant (Renninger et al., 2015). The 2019 *National Academies* report indicated more research was needed to address the following research question, “how does participation in scientific investigation and engineering design effect student interest in science and engineering?” (National Academies of Sciences, 2019, p. 281). Researchers could aim to respond to this question through a place-conscious pedagogical approach to an informal STEM program and examine its effects on STEM interest.

Methods Used to Study Student Interest

As presented by the National Science Foundation to inform the broadening participation context, case studies based on multiple methods are identified as a summative evaluation method to investigate interest in informal programs (Clewell & Fortenberry, 2009). Second, inter-group comparisons provide an internal check for maturation, participant age, and gender differences and verify each program element's STEM interest change (Allen et al., 2008). Third, Barron

(2006) indicates there are different pathways to interest development and researchers should investigate what sparks the interest. This study is researching different informal program instructional methods to examine which might be more influential in developing interest. Through the use of qualitative observations, direct records of participants can be documented. These records will then support qualitative focus group interviews and quantitative survey data. The simultaneous data collection of direct records of participants and group interviews and individual survey data will help identify when the participant STEM interest changes occur, and allow the study to identify how the examination of each program instructional method influences these changes.

Data Collection Through Observations

Using participant observational methods for detailing “intra-individual development” of STEM interest has been successfully implemented with elementary participants by Krapp and Prenzel (2011). Participant observations are useful when: face-to-face interactions with the researcher occurs, natural setting data collection is possible, and insights into behavioral nuances are desired, and allows the researcher to develop participant relationships. However, this method runs the risk of the observer effect (Bloomberg & Volpe, 2018) and care must be taken to limit introducing bias into the data collection and interpretation. Observational techniques have an advantage over self-reports, as there are instances where participants are unaware of their own triggered interest. Lastly, observational records provide more information about participants, their actions, and can be triangulated with other data sources (Renninger & Bachrach, 2015).

Field notes are an additional beneficial method to document direct participant observations by the researcher or other observers (Bloomberg & Volpe, 2018). In a post-hoc

analysis of an informal science camp, instructors were interested in how different activities triggered interest after reviewing their field notes. The notes were able to document conversations and behaviors immediately following a session of activity. These actions were possibly not captured by a video recording (Renninger & Bachrach, 2015). It has been noted that contexts have been captured with researcher field notes and provided the ability to detail elementary participant nuances and conversations for later analysis (Nolen, 2007). For example, to gather qualitative data, Walker et al. (2004) employed field notes to investigate group activities and individual student actions of 5th-grade participants. Field notes can provide rich details of the events that led to emerging and developing interest.

Research using observational methods and field notes can provide an analysis and report of rich details of participants' STEM interest development. Observational protocols based on previous research can outline actions and behaviors of participants during interest development. Researcher field notes can pinpoint details that may be eluded in the video data or validate details in their notes with participant interviews. Data gathered by observational methods provide tangible records that can then be explained through other data sources.

Data Collection Through Self-Report Surveys

In studying interest development, Renninger and Hidi (2011) discussed empirical self-report surveys, including the number of items and repeated measures. Studies reviewed had one or more items with varying degrees of Likert scales from four to seven over multiple times measures. It was noted that even one self-report survey item, coupled with other data sources, can provide details of interest development or its relation to other variables (Renninger & Hidi, 2011). It was also noted that self-report surveys used with different ages might lead to items

being interpreted differently. Younger participants may interpret interest as affective and valuable, whereas older participants may seek to deepen their knowledge (Renninger & Hidi, 2011).

Many empirical studies on interest employ self-report surveys (Lamb et al., 2011; Unfried et al., 2015). For example, an empirical research study was investigating the development and change of interest assessed participants with a five-point Likert scale survey. The purpose was to measure the intrinsic motivation of activity engagement regardless of setting. Furthermore, researchers desired to understand the interest in three dimensions: content, the context of the topic presentation, and activity related to a topic (Häussler, 1987). Similarly, interest measures were surveyed with a five-point Likert scale to determine intrinsic and extrinsic motivation and the relationship to performance in specific academic content areas (Schiefele & Csikszentmihalyi, 1994). In another example, an international study of science interest, researchers differentiated their four-point Likert scale survey questions by context and content, describing student interest (Drechsel et al., 2011). All of these studies were with high school-aged participants.

With younger participants, an investigation on the effects of an explicit teaching approach on STEM interest (Brown et al., 2016) employed a five-point Likert scale survey with 6th graders. There were 11 items on the survey, and the results indicated a significant increase in STEM interest for all participants. In a study investigating science interest in an informal environment of fourth through 8th-grade participants, a five-point Likert scale self-report survey with extensive inventory items to cover multiple content areas measured intrinsic and extrinsic

motivation towards science. The quantitative analysis was testing a hypothesis about motivation towards intrinsic motivation in science after different grouping methods (Holmes, 2011).

Another study of middle aged learners utilized a 21 item survey with a four point Likert scale to “gain an understanding of students perceptions, attitude, and confidence toward STEM fields” with a post-survey geared towards student enjoyment of individual camp sessions (Mohr-Schroeder et al., 2014, p. 295). In a longitudinal study on content interest, Dearing et al. (2012) employed a four-item self-report survey with a four-point Likert scale in third and fifth grades with good reliability. Similarly, grade levels, including a subset of elementary, were examined for science interest using a self-report survey with a five-point Likert scale. The Science Interest Survey (Lamb et al., 2011) was found to have high reliability (Greenfield, 1997). This is not an exhaustive list of self-survey data collected for interest measures but does illustrate that there is not a shortage of validated and reliable self-report surveys available.

After developing the four-phase model of interest development, another set of surveys was developed with more focused attention on situational and individual interest separately (Rotgans & Schmidt, 2011). The first use of the Situational Interest Measure (SIM) survey examines adult participants' interest changes with pre and post formal test measures. This four-item self-report survey was scored on a five-point Likert scale. The study investigated changes in interest during an active learning session. Participants answered the SIM survey after certain activities five times during one day. This tested a hypothesis of changing or stabilizing interest for the duration of their learning session (Rotgans & Schmidt, 2011). In two follow-up studies, the SIM was increased to six-items with middle school-aged (14 years old) participants and found highly reliable. This study investigated situational content interest regarding lack of

content knowledge (Rotgans & Schmidt, 2014). Following this study, an Individual Interest Questionnaire (IIQ) was developed and validated with high school students. This was to fill a gap on individual interest that follows situational interest in the four-phase model of interest development. This instrument was found valid for measuring interest from different content areas (Rotgans, 2015). Following this study, Rotgans and Schmidt (2017) utilized both instruments with elementary-aged students to measure situational and individual interest in science. The revised and updated Situational Interest Questionnaire (SIQ) consisted of six items with a five-point Likert scale with high reliability. The SIQ was administered four times over four weeks to investigate the interactions of situational interest with individual interest. This instrument has been validated with elementary students and, therefore, was selected for use in this proposed research study for measuring STEM interest (Rotgans & Schmidt, 2017, 2018).

Data Collection Through Semi-Structured Interviews and Focus Groups

Focus groups can be employed to ease participants' tension who may view the researcher as an outsider to the group. Focus groups allow participants to interact with each other to clarify complex interest development and verify other data findings (Bloomberg & Volpe, 2018). In a methodological review of focus groups with children, it was noted a researcher can "capture perspectives, original ideas, and insights" and these discernments can be limited in self-report methods (Kennedy et al., 2001, p. 184). Additionally, semi-structured interviews allow the researcher to carefully articulate interest development questions while leaving an opening to engage in follow-up questions as they evolve during an interview. This semi-structured interview with a focus group allows for the development of "context-rich personal accounts, perceptions, and perspectives" of STEM interest development (Bloomberg & Volpe, 2018, p. 388).

As noted in an empirical study investigating science interest, researchers employed interviews to triangulate their survey data to understand why the changes had occurred (Palmer et al., 2017). All the interview participants articulated that they experienced an increased interest in science and that it was not immediate but grew over time. The same study indicated that further research with younger participants might yield similar results more easily as younger participants might not have a negative predisposition towards science (Palmer et al., 2017).

Renninger and Bachrach (2015) and Renninger et al. (2015) employed and reviewed interview data as a validation for other data sources for interest triggers and science interest development. Similarly, Barron (2006) employed interviews as their primary source of data. He gathered rich details of each participant's STEM interest development outside of formal school environments. It has been additionally noted that there is a lack of studies using interviews with children, ages 8-12, specifically in an informal STEM context (Walan & Gericke, 2019). Walan and Gericke's (2019) study conducted focus group semi-structured interviews to stimulate discussion and provided additional details to their questionnaire results. Their recommendations were to include observational methods to further enhance their methodology (Walan & Gericke, 2019). As an additional support Krapp & Prenzel (2011) recommend, "As with all retrospective methods, it has to be taken into account that the interviewees normally will not be able to remember exactly the actual quality of their experience during the interest-related activity" (p.38). Pictures of and artifacts from each informal element could help participants remember how they felt while each lesson element occurred. This follows a similar photography technique and semi-structured interviews of Avery and Kassam (2011) and their study of local rural knowledge of STEM. They employed photo documentation and open-ended interviews to

investigate their understanding of STEM concepts. This supplemental interview data could provide rich details by participant's accounts of observational data and allow for validation of the participants' self-reported survey data.

Methodological Limitations

Although self-report surveys have been extensively used to study interest, there are limitations to its use. As noted by Clewell and Fortenberry (2009), administering self-report surveys in a pre- post- format may not indicate changes from the intervention. It is possible changes are sourced from an event outside the intervention. Additionally, observations are limited to a small number of participants and a unrandomized sample (Renninger & Bachrach, 2015). Additionally, limitations of semi-structured focus group interviews have been discussed. In research with elementary-aged children, respondents may not accurately recall information about an event (Clewell & Fortenberry, 2009). Focus groups also limit the amount of time spent, as well as, generalizations of results (Allen et al., 2008). Therefore, careful consideration needs to be used to triangulate data to account for the limitations and member checking is used to ensure children's verbal accounts are their own interpretation.

CHAPTER 3

METHODOLOGY

Introduction

The purpose of this study was to examine the effectiveness of different instructional methods on science, technology, engineering, and math (STEM) interest development for rural youth, ages eight to twelve, in an informal place-conscious STEM program. The following research questions guided the study.

For rural youth, ages eight to twelve, in an informal place-conscious STEM program:

1. What do their words and actions tell us about the effectiveness of hands-on activities to increase STEM interest?
 - a. How does this differ for boys and girls?
2. What do their words and actions tell us about the effectiveness of role models to increase STEM interest?
 - a. How does this differ for boys and girls?
3. What do their words and actions tell us about the effectiveness of culminating projects to increase STEM interest?
 - a. How does this differ for boys and girls?

To best answer the research questions, a case study design using multiple methods of data collection (Bloomberg & Volpe, 2018; Yin, 1994) was employed to gather, analyze and triangulate qualitative and quantitative data (Graue & Walsh, 1998). A case study is an ideal approach because it “aligns with interpretive constructivist philosophy” (Bloomberg & Volpe,

2018, p. 50; Merriam, 2009; Stake, 1995) and helps to document rural youth's perspectives on the effectiveness of three instructional methods to increase STEM interest in an informal place-conscious STEM education program (Creswell, 2007).

Self-report survey data provided an indicator of possible changes in STEM interest after each informal instructional method. Qualitative data collected through observations allowed the researcher to discover and explain some of the complexity inherent to youth STEM interest development and how it can be supported through specific instructional methods (Bloomberg & Volpe, 2018). Focus group interviews provided an opportunity for youth to describe if and how the instructional method was effective in supporting their STEM interest development.

Triangulation of the three data sources provided an opportunity to present “converging lines of inquiry” which corroborated evidence from multiple sources (Yin, 1994, p. 92). It also allowed the researcher to generate a rich, thick description of the effectiveness of instructional methods to support rural youth's STEM interest in the context of an informal place-conscious STEM program.

Research Context

This study was conducted in the northwestern United States. This state contains the largest number of rural school districts in the United States (Showalter et al., 2019). Additionally, this state has the highest percentage of rural schools and small rural districts (Showalter et al., 2017). Many districts contain only one school building for the K-12 student body which serves a large geographical area. The geographical locale for this study had a county population density of 2.1 individuals per square mile.

The National Center for Education Statistics (NCES) rural-remote classification was used in identifying schools for this study. This NCES definition states the classification criteria of each location will be over 25 miles from the next closest town (Greenough & Nelson, 2015). Following the principles of network sampling (Creswell, 1994), the researcher identified one school that was willing to participate in the study, and the superintendent provided recommendations for a neighboring school that would be appropriate to host an informal program and participate in the study.

This single case study was bounded by a geographical area that utilizes a local reservoir fed by an adjoining creek as a primary water source. The study was conducted in two school districts, each with one school building and both within 11 miles of each other. Each school contains between 35-50 students in their PK-6th grade population. The two districts are in a cooperative where they share basketball and volleyball teams and a band program. The upper-grade bands regularly travel to the other school for practices or travel together for games.

In each school, some grade levels are combined into one classroom to accommodate the small populations and maximize classroom efficiency. Each school in this study has combined classrooms for the 3rd and 4th grades and their 5th and 6th grades. Their class sizes range from three students to thirteen students.

The two communities are very similar in make-up. They each have a post office, volunteer fire department, church building, and at least one restaurant. Each town is composed of approximately one or two blocks along the main street. The area between the two sites is comprised mainly of ranches and farms. The drive between the two is on long winding country roads, parts paved and parts gravel, crossing a one-lane bridge over the river and split by rocky

mountainous outcroppings. It is typically dotted with white-tail and mule deer, antelope, elk, pheasants, ducks, and geese. The ranches and farms consist mainly of fields of hay and livestock, Angus cattle and horses. Besides farming and ranching, this community's primary industry consists of a few talc plants in the area. Both rural communities share a backdrop of scenic mountain skylines and a county border.

Currently, neither school has a comprehensive afterschool program. One location previously offered a study hall but not a structured program for its youth. The lack of afterschool programs at both locations is possibly hindered by geographical distances of youth homes from the school site. Limited funding and personnel also prevent offering a regular informal program.

An Informal Place-conscious STEM Program

In order to develop an informal place-conscious STEM program, it is crucial to understand the history and current STEM issues facing rural communities. A practical way to discover this information is to ask community members for their input and perspectives through semi-structured interviews and informal inquiry grounded in public-facing documents. These sources provide key insights into locally-relevant STEM topics that would be most appropriate to serve as the basis for curriculum development. Formal qualitative interviews with an extension specialist, a rural community member, and a state legislator identified several relevant topics related to crops, drought, and wildfires. Further exploration through informal community conversations with each site's superintendent revealed that water was a priority issue for the community. Thus, the topic selected as the focus for the curriculum developed for this study was farming and ranching water sources. The unit's design was developed in conjunction with an engineer and fellow scientists to incorporate each of their areas of expertise. The unit

incorporates STEM influences on transporting water for use in irrigation, such as pumps and water sources known to the area.

The water unit in this informal program was delivered through three lessons using three distinct informal instructional methods: hands-on activity, role model discussion, and a culminating project. The content was delivered every other week over a six-week timeline. An adult volunteer, who is also a pre-service science educator, facilitated each of the informal program lessons. Each lesson was scripted and piloted to ensure fidelity between the two sites. Each of the youth received a STEM journal and was prompted to record their reflections and thoughts during and at the conclusion of each lesson.

The hands-on lesson included the building and testing of a water pump. This instructional method was presented as an inquiry with very little instructional assistance. Youth were placed in groups of three, given an iPad with an instructional video, a bag of PVC pieces and PVC pipes, and two buckets of which one was filled with water. Youth were instructed to build a pump with the given materials by watching the video. Additionally, youth were instructed to move the water from one bucket to the other bucket with their constructed pump. The youth were able to test and calculate their pump's flow rate with water. This allowed the youth to simulate the effort required to move water from one location to another. Additionally, youth were asked to reflect on where they have seen pumps, or other means of moving water, in use in their community. These reflections in the form of writing or drawing were recorded in their STEM journals. The purpose of the hands-on activity was to simulate the engineering process and gain a deeper understanding of problem-solving. In alignment with the place-conscious pedagogy (Gruenewald, 2003a) of

“natural history”, this instructional method served to demonstrate the communities’ connections and issues with water sources.

The STEM role models recruited for this study were STEM career individuals whose expertise aligns with the curricular unit to assist in curriculum design and program implementation. All identified STEM role models were invited to participate in training to support their communication with elementary-aged students. Hour-long training sessions were based on Techbridge’s Role Models Matter Toolkit (<https://www.techbridgegirls.org/rolemodelsmatter/toolkit/>) to support role models’ ability to engage in relatable and child-friendly dialogue (Kekelis & Joyce, 2014). The researcher is a trained facilitator for Techbridge’s Role Models Matter Toolkit and guided the STEM role models through the training process. The individuals recruited for the program lesson were one male and one female, which balanced the gender representation. These local community members experienced in the STEM topic, irrigation, were invited to share their experiences. Local farmers and ranchers have first-hand local knowledge relevant to the topic of water and were able to share insights from their lived experiences connected to a previous rural community assessment and funds of knowledge specific to the community. This knowledge, shared in conjunction with STEM experts, can connect academic knowledge to local experience.

In the role model method, youth were placed in groups of two and given a prewritten question to guide the discussion with the role models. Accordingly, other impromptu questions naturally evolved in the discussion. The purpose of this session was to discuss the STEM relevance and connection to their local community, in alignment with the place-conscious pedagogy (Gruenewald, 2003a) of “cultural journalism”, this instructional method centered on

the role models and community members discussion to deepen the understanding and issues of community water sources.

In the third instructional method, youth were placed in groups of two. Youth were invited to take photographs relating to their interpretation of pumps and irrigation in their community. Some youth provided the researcher local community water pictures. Some youth gave directions on which local waters source pictures they wanted and the researcher provided these pictures. Each group was provided a laptop with access to Google Docs and a template for building a poster with suggested headings and a picture file. The headings were: name, school or town, introduction- what I knew before about water, pump building- what I learned, community role models- what I learned, what I think about water now, what I think others should know. Youth filled in their understandings of the headings and selected pictures to add to their poster. Posters were printed and given to the youth's school sites a week after the project was complete. Culminating projects incorporated their photographs of community STEM connections and personal reflections from the hands-on activity and the role model discussion. The purpose of this instructional method was to relate all of their reflections and experiences, as well as to provide an opportunity to share with their community. In alignment with place-conscious pedagogy (Gruenewald, 2003a) of "action research", this instructional method served as a platform for how youths' self-generated water data could help solve issues with local community water sources and connect to similar global water issues.

In order to control for instructional method presentation effects, the first site offered the three instructional methods in order of hands-on, role model, and a culminating project. The second site offered identical content while interchanging the first and second sessions, allowing

the youth to begin with a role model visit and then their hands-on activity. The final session was the culminating project. Therefore, each site experienced the same program instructional methods but reversing the order allowed for possible exploration of instructional presentation effects. Please see Appendix A for the full curriculum.

Participants

This study employed criterion sampling of rural youth, ages 8-12, who live in each community (Creswell & Clark, 2017). Each of the two rural schools offered the informal place-conscious STEM program for students in grades 3 through 6. Each of the two schools had a combined group of all boys and girls with approximately 13 participants per group. Institutional Review Board, parental consent, and verbal child assent were obtained prior to beginning the program. All invited participants engaged in the informal place-conscious STEM programs during the same six-week period, but on different days, allowing the researcher to collect comparable data from both sites.

Types of Data Collected

In keeping with findings and recommendations from previous research, this case study collected three types of data through the use of self-report surveys, non-participant observations, and focus group interviews. Self-report survey data served as an indicator of STEM interest level changes following interactions with each informal instructional method. Self-report surveys are a validated method for determining interest level changes (Rotgans & Schmidt, 2011).

A review of previous studies on the development of children's interest noted three shortcomings in the data collection (Renninger & Bachrach, 2015). First, young participants may

not always interpret these survey items as intended. Next, researchers sometimes only report positive affective items. Lastly, researchers do not always validate the findings with other types of data. Therefore, to address these shortcomings, the researcher collected data through non-participant observations in order to identify verbal and non-verbal indicators of STEM interest (Bloomberg & Volpe, 2018). The observational data were essential to provide details of complex behavior often not directly observed while facilitating informal programs (Bloomberg & Volpe, 2018).

Focus group interviews allowed youth to describe their experiences and answer questions to provide further details. The youth had the opportunity to build off one another's comments and provide insights and details possibly missed in non-participant observations. Additionally, focus group responses were used to validate observation data.

Observations

Core qualitative data were collected via researcher through observations of group activities. Using an observation protocol allowed the researcher to document indicators of youths' situational interest (Renninger & Bachrach, 2015) during each program meeting. Previous research studied differences amongst a variety of science activities that triggered interest during science workshops with middle school-aged participants post hoc. A preliminary literature review of interest variables was reduced to eight for interest to analyze the post hoc observational data. These interest variables note the participant's responses by way of "reflecting positive affect and/or other intense emotional response, and/or they continued to engage" (Renninger & Bachrach, 2015, p. 64) with an activity. Additionally, the study concluded that an observational protocol would include a list of interest triggers, the number of participants

involved with the type of interest, and the level of intensity for that type (Renninger & Bachrach, 2015). Renninger and Bachrach (2015) acknowledge that observational methods provide insight into the process that cannot be achieved through self-report surveys. Likewise, participants could be unaware of the triggering interest process (Renninger & Bachrach, 2015). Previous research has shown participants are sometimes unaware of their interest development (Renninger & Bachrach, 2015). These observations can be validated by participants during the focus groups. Additionally, purposeful sampling ensured one member from each group during instructional method activity was invited to the focus group. Observational notes described body language, gestures, non-verbal and verbal communication. These observations allowed for involvement with face-to-face interaction; they also alleviated additional survey/interview fatigue and allowed for insight into complex nuances of interest development (Bloomberg & Volpe, 2018).

Focus Groups

Next, the researcher conducted a focus group using semi-structured interviews (John & Susan, 1994) with youth from each community's informal place-conscious STEM program to gather insight into their perception of STEM interest changes. Focus group interviews allowed youth to reflect on their ongoing interactions with each program's instructional methods and any resulting STEM interest changes. Semi-structured questions were used to help participants focus or remember a particular event. Please see Appendix D for the interview protocol.

Focus groups with children have proven advantageous to create a safe environment, trigger responses from other participants' dialogue, facilitate sharing and discussion, and be successful with children as young as eight years old (Greene & Hogan, 2005). Furthermore, focus groups with children can facilitate involvement by encouraging peer involvement, reducing

self-consciousness with a peer audience, and modeling acceptance of children's accounts with their peers (Kennedy et al., 2001). In another study on children sharing information in groups, it was noted that children in groups were better able to communicate and make decisions than individual conversations with researchers (Gummerum et al., 2014). When children were asked to share information individually, details were left out compared to when they shared as part of a group.

This study sought to leverage detail-sharing by using the focus group format. Semi-structured questions utilized a hypothetical, third-person, or prop format (Graue & Walsh, 1998) and included questions such as, 'What would you tell another kid about your STEM program participation?' and stimuli such as providing completed pump as a stimulus for a question. The focus group established introductions to build rapport, ground rules such as hand-raising, and prioritized interest as the discussion topic (Kennedy et al., 2001). Furthermore, focus groups can help describe complex ideas, create transcripts and participant quotes, allow interaction between participants, clarify other data collected, and provide deep rich descriptions (Bloomberg & Volpe, 2018). The focus group protocol identified each youth by their name with a name placard, where each person answered a general warm-up question, clarifying there are no correct or incorrect answers and concluded with a researcher review and clarification for any misconstrued comments (Kennedy et al., 2001). Focus group interviews were video recorded and transcribed to capture dialogue as well as non-verbal communication.

Self-report Surveys

Finally, a survey instrument was used to collect self-report data from youth. The Situational Interest Measure (SIM) has been designed to assess students' focused attention and

affect with a short five-question instrument (Rotgans & Schmidt, 2011). The instrument is content-specific to ensure the measurement of relevant STEM interests. The original instrument used a five-point Likert scale; however, for this study, a four-point emoji Likert scale was employed to align with recommendations for working with elementary-age students (Drechsel et al., 2011; Harty & Beall, 1984). This modification is influenced by the format of the PISA (Program for International Student Assessment) interest four-point Likert scale (Drechsel et al., 2011) and the “Children’s Science Curiosity Scale” (Harty & Beall, 1984), which employed smiley faces to enhance interpretability. Additionally, research-based on secondary analysis of school-aged children’s response data sets from educational surveys (Hox & Borgers, 2001) found higher reliability with limited response choices. In that same context, Bell (2007) recommends surveys for children under age 11 use three or four responses and employ a visual image, such as a smiley face labeled scale, rather than numerical or partial labels.

Pilot Studies. The current study instrument was guided by the results of a 2019 pilot study instrument's findings which tested a four-point Likert scale utilizing emoji to assess STEM identity development in an informal STEM program. The instrument was analyzed using the Unfried et al. (2015) recommendations for confirmatory analysis. The three subscales were found reliable (science $\alpha = 0.89$, math $\alpha = 0.90$ and engineering = $\alpha 0.93$). A second pilot study in 2020 tested a similar instrument reducing study factors and question items focused on the context of the STEM activities. The instrument employed two practice questions to ensure the participants understood the intention of the survey’s smiley face Likert scale (Bell, 2007); ‘Is playing outside fun?’ and ‘How much fun is playing outside?’. (Appendix B for STEM Survey

Sample). This was followed by interest questions addressing the context of their STEM camp week, *Thingamajig Invention Convention*.

Pilot study findings indicated that participants were able to read the instrument, and a camp counselor confirmed that the participants did not need assistance reading during survey administration. This survey's original researcher utilized a reliability measure of Hancock's coefficient H as an alternative to Cronbach's alpha (Rotgans & Schmidt, 2011). Coefficient H is for maximal reliability of a scale and small sample research (McNeish, 2018). The revised instrument's reliability was analyzed using principal component analysis. The analysis with varimax rotation was conducted to assess how the variables clustered and determine factor loadings. This evidence suggests the validity of the instrument. This data was used to determine Hancock's coefficient ($H = 0.781$) for this 2020 pilot survey. The result was within the recommended cut-off of $H > .70$. Since the current research study anticipated small sample size, the same procedure for Hancock's coefficient was utilized. It should be additionally noted that the items were loaded into Qualtrics differently between the pilot studies of 2019 and 2020. The 2019 pilot layout was used for this study to help facilitate data uploading into the statistical software.

For this study, the pilot instrument from 2020 was employed, replacing the *Thingamajig* (summer camp 2020) specific content with informal STEM instructional methods context. The survey was administered before the program began as a pre-test measure and immediately followed each program element as a post measure. It was based on the four-point smiley face Likert scale used in both previous pilots. The survey was loaded into Qualtrics software so that participants could access it via Ipads without the researcher present. When the questions were

loaded onto Qualtrics, the survey questions were loaded with the following question settings; matrix table question type, four scale points, Likert type, single answer, and mobile-friendly. One item was reverse scored; “I feel bored with today’s STEM topic.” Participants' responses were secure and only accessed by permission from the researcher.

Data Collection Procedures

Data were collected at both locations over three informal STEM sessions for six weeks. Each informal program session lasted approximately 45 minutes. Before the first informal program session, youth were asked to complete the Situational Interest Survey (Rotgans & Schmidt, 2014) via an electronic platform, Qualtrics. This served as a pre-score for their interest level before the STEM topic of local water usage was explored through the initial instructional method. Additionally, following each instructional method, a post-survey was administered without the researcher present via an electronic platform.

During each session, the researcher recorded non-participant observation notes on the *STEM Interest Observation Tool*. This form was based on *Behavioral Observation of Students in Schools* (Volpe et al., 2005), and its protocol captured affective interest behaviors on-site. In Renninger and Bachrach’s (2015) post hoc analysis of observational video data, the researchers identified 16 triggers for interest-based on a literature review. Additionally, it has been noted by (Hidi & Renninger, 2006) that situational interest development can be observed through affective behaviors, such as participant actions, dialogue, and feelings during a learning experience. Non-participant observation data added details to actions or behaviors during each instructional method. Please see Appendix C for the *STEM Interest Observation Tool*. In the week between informal program sessions, a focus group interview was held at each location.

Focus groups were limited to 30-45 minutes, with four to six participants and video recorded. As noted in previous research, younger children ages six to ten years old can engage in dynamic discussion with a focus group of four to six participants and recommended 45 minutes for 6-8-year-olds (Kennedy et al., 2001). Participants were chosen based on interest factors noted or missing from the previous instructional method session. These individuals were invited to participate in the group interview at their school location. Each focus group was video recorded for the duration of the session. The focus group interview used semi-structured interview questions (Appendix D). The semi-structured questions helped participants elaborate on their intrinsic or extrinsic interest factors noted in the non-participant observational notes. The same procedures occurred at each location and for each instructional method session (Table 3.1).

Table 3-1. Program Timeline.

Sample 6- week session program implementation and data collection

Schedule	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Instructional Method	Hands-on activity		Role Model Discussion		Culminating Projects	
Data Collection	Pre and Post survey		Post-survey		Post-survey	
	Observational Notes	Focus Group	Observational Notes	Focus Group	Observational Notes	Focus Group

Variables

This study investigated research questions through quantitative analysis on each of three instructional methods. First, this study investigated three informal program instructional methods of hands-on activities, role model visits, and culminating projects as independent variables for STEM interest changes. There may be an interest level change or affective behavior difference

for each instructional method. Secondly, this study also investigated gender differences as an independent variable to determine if the informal STEM program instructional methods contributed to different interest levels or affective behavior differences for each gender. As this study specifically invited one female STEM professional and one male local community member as role models, there may be a significant STEM interest effect on either gender.

Data Analysis

Table 3-2 presents an overview of the connections between the major components of the study's design. Specifically, the table demonstrates alignment between the study's research questions, the quantitative and qualitative measures used for data collection, and the types of coding and analyses that will be employed to identify patterns in the data.

Table 3-2. Research Questions, Data Collection, and Analyses Alignment.

Research Questions	Quantitative Measures	Data Analysis	Qualitative Measures	Data Analysis
RQ1 What do their words and actions tell us about the effectiveness of hands-on activities to increase STEM interest?	Pre-& Post Interest Survey	Descriptive indicator of interest level change (positive, negative, neutral)	Non-Participant Observations	Observed indicators of activity interest behaviors Deductive Codes
			Focus Group Semi-Structured Interviews	Verbal indicators of activity and affective behaviors of interest Attribute Codes Deductive Codes In Vivo Quotes
RQ1a How does this differ for boys and girls?	Pre-& Post Interest Survey	Statistical analysis of gender difference Attribute codes	Non-Participant Observations	Observed indicators of activity interest behaviors gender differences Deductive Codes
			Focus Group Semi-Structured Interviews	Verbal indicators of activity and affective behaviors of interest Attribute Codes Deductive Codes In Vivo Quotes
RQ2 What do their words and actions tell us about the effectiveness of role models to increase STEM interest?	Pre-& Post Interest Survey	Descriptive indicator of change (positive, negative, neutral)	Non-Participant Observations	Observed indicators of activity interest behaviors

Table 3-2. Research Questions, Data Collection, and Analyses Alignment, continued.

Research Questions	Quantitative Measures	Data Analysis	Qualitative Measures	Data Analysis
			Focus Group Semi-Structured Interviews	Deductive Codes Verbal indicators of activity and affective behaviors of interest Attribute Codes Deductive Codes In Vivo Quotes
RQ2a How does this differ for boys and girls?	Pre-& Post Interest Survey	Statistical analysis of gender difference Attribute codes	Non-Participant Observations	Observed indicators of activity interest behaviors gender differences Deductive Codes
			Focus Group Semi-Structured Interview	Verbal indicators of activity and affective behaviors of interest Attribute Codes Deductive Codes In Vivo Quotes
RQ3 What do their words and actions tell us about the effectiveness of culminating projects to increase STEM interest?	Pre-& Post Interest Survey	Descriptive indicator of change (positive, negative, neutral)	Non-Participant Observations	Observed indicators of activity interest behaviors Deductive Codes
			Focus Group Semi-Structured Interviews	Verbal indicators of activity and affective behaviors of interest Attribute Codes Deductive Codes In Vivo Quotes
RQ3a How does this differ for boys and girls?	Pre-& Post Interest Survey	Statistical analysis of gender difference Attribute codes	Non-Participant Observations	Observed indicators of activity interest behaviors gender differences Deductive Codes
			Focus Group Semi-Structured Interviews	Verbal indicators of activity and affective behaviors of interest Attribute Codes Deductive Codes In Vivo Quotes

Observational Data.

Observational data and field notes were deductively coded with a priori codes. The a priori codes (Saldaña, 2015) were pre-determined to correspond to the theoretical framework of youth interest development (Renninger & Bachrach, 2015). The a priori codes were drawn from Renninger and Bachrach's (2015) interest study that identified "triggers for interest...and learner characteristics" (p.64). As suggested in the literature, deductive coding is useful for identifying patterns driven by research theories (Derry, 2007). Please see Table 3.3 for a partial sample of these codes. This analytical method of pattern-matching was described by Yin (1994) as a logical method to explain patterns of data based on theory and if codes are defined a priori. The a priori observational list served as deductive content codes of the participant observational data and reflective field notes (Appendix E).

Table 3-3. Sample A Priori Qualitative Codes

Code Name	Detail Description	Inclusion Criteria	Typical Exemplar
Autonomy	Focus on personal achievement, independence, and works alone	A participant is engaged in the activity alone.	Participants took pieces to another table to construct a pump without the group.
Challenge	An attempt to grasp a concept or reality sometimes viewed as contradictory to a participant's held belief	Relates to the STE topic or activity, should include an activity code	Participants are frustrated with putting materials together. Participant verbalizes their frustration, "I quit!"
Personal Relevance	Participant connects activity topic to their interests, aspirations, and life experiences	Relates activity to a community context or personal context.	"I have a water pump like that at my house."
Emotionality	Participants show feelings resulting from a physical or physiological response that influences thought and behavior	Participants express this through a change in facial expression, body language, or tone of voice.	"I got the water to come out!" shouts while jumping up and down.
Openness	A participant is willing to try new things	A participant is involved in an activity about the topic	The participant wants to be involved and states "Building is for not just for boys."

For this study, the interest activity type was tallied by level; high, medium, and low and scored. This approach followed Yin's (1994) description of "tabulating the frequency of different events" (p. 103) for analyzing case study evidence and avoiding bias. This allowed the researcher to compare descriptively major and minor interest activity levels. Additionally, each activity type had reflective researcher notes to further elaborate on the activity observed. These provided interesting action details to the activities observed.

Focus Group Semi-Structured Interviews.

Prior to focus group interviews, participants were matched with an identifier code. The following steps generated each participant's identifier code; each site was identified by either a W or H, gender by a B for boy, a G for a girl, or a P for prefer not to answer. A number 1-15 was placed at the end (Walan & Gericke, 2019). Gender was determined from the pre-survey demographic data.

All focus group interviews were recorded and transcribed. The data were deductively coded with a priori provisional codes. Additionally, the initial codes from observational data were validated if the participant joined the focus group. This allowed the researcher to utilize transcripts of the initial cycle a priori coding of the focus group interview data alongside the observational data. These coded segments were sequentially coded first for interest trigger activity and then learner characteristic behaviors. Through the data analysis of these interview transcripts, additional activity and characteristic codes were identified. These coded segments were then reviewed to identify in vivo quotes. This allowed the researcher to review transcripts multiple times via the transcription process, a priori activity coding, a priori characteristic

coding. This generated a list of in vivo quotes, participants' words to collaborate with participant actions.

Self-Report Survey

The data collected from the self-report STEM interest survey were analyzed using descriptive statistics such as frequency distributions. Previous studies found that the ordinal data was previously found to load on a single latent factor of situational interest (Rotgans & Schmidt, 2014). This study replicated this by principal component analysis and produced a summative value for each participant's survey. The summative data were analyzed with a Wilcoxon signed-rank test (Hoyle, 1999). This nonparametric test is used to compare the medians of two related samples, such as comparing pre-test and post-test scores, to determine if there has been a change in participants' interest levels. This quasi-experimental causal-comparative approach was used to determine if there was a difference in interest levels between each informal instructional method and between genders for each informal instructional method.

Focused Round of Analysis

Observational data, informed by focus group interview data, went through a focused round of coding. This coding round generated more detailed activity and characteristic codes for STEM and identified any emergent codes that evolved. Secondly, a round of in vivo quotes were reviewed from transcript data for participants communicating interest. All segments of data were indexed by informal instructional methods and participants. The attribute codes allowed for easier identification for gender comparison. This second cycle of coding happened wholly for each informal instructional method. These data codes were reviewed and themed. This helped

categories to emerge from the data. The second cycle of coding transitioned from each research question to a holistic review across the data set.

Second Cycle Coding. A data codes table was developed to transition from initial cycle coding into second cycle coding. This occurred for each informal instructional method to identify how STEM interest is exhibited and provided a succinct document to compare and contrast these results. This table outlined participant, site, researcher observation reflections, quotes, and primary codes developed during the initial cycle coding alongside the quantitative data. Additionally, analytic memos were recorded after the review of each set of data to keep a record of the researcher's thoughts on developing ideas about emerging codes and themes.

Second cycle coding is a preparation method to review data from another perspective before writing the analysis. Each informal element's complete data set received pattern coding to develop explanatory codes for data coded. Pattern coding is "appropriate for:...the search for ...causes and explanations in the data...[and] laying the groundwork for cross-case analysis by generating common themes" (Saldaña, 2015, p. 236). This research study is based on Renninger and Bachrach's (2015) findings for situational interest in observational data and should be examined for differences and similarities in their results. Finally, informal instructional method interest data of individuals and groups will be cross-case analyzed by gender. This was accomplished through concept mapping each instructional method by major codes and cross-case analysis across all the instructional methods to examine similarities and differences. This final phase of coding will help identify patterns that have developed and elaborate on previous research findings of STEM interest development from the application of an informal place-conscious STEM program.

It is suggested that after all coding is complete and themes emerge from the data, post-coding strategies can be applied (Saldaña, 2015). Quotes should be used for representation to focus on which details are essential to convey in writing the next chapters. Additionally, to identify key findings, significant codes or themes should be identified. These should stand out to the researcher and be reflected upon before structuring the analysis. These two methods should help further identify which data is most representative in relaying STEM interest changes for participants while reflecting on what overarching STEM interest themes have evolved from developing an informal place-conscious STEM program.

Reliability/ Validity/ Trustworthiness

Reliability is achieved through the use of a priori coding. The use of codes developed by another researcher may help establish their study's reliability, especially when using focus group interview data (Saldaña, 2015). The self-report survey's reliability will be determined by Hancock's coefficient as it is recommended for small sample studies (McNeish, 2018).

To achieve the trustworthiness of data, the researcher will keep analytic memos after each coding cycle to reflect on codes developed or applied during that cycle. Additionally, interpretations of transcripts will be checked with participants to verify meaning. Trustworthiness is further established through multiple data sources, which can verify a code's meaning through a participant's actions. Furthermore, the study has purposefully outlined the coding plan to establish the trustworthiness of the analytical methodology.

Construct validity is supported through the collection of multiple types of evidence, which can help to establish the connection between the evidence (Yin, 1994). For example, the validity of the observation data and self-report survey data is supported through data from the

focus group interviews. Participants are able to identify their thoughts and feelings through the use of focus group interviews. Survey interest data was subject to experimental validity. Gender differences or site locations should not violate internal validity. There could be a slight threat to the informal instructional method order's internal validity due to differences in the discussion at each location. Participants asked and generated different questions and reactions to content due to the contextual differences of their rural communities. The results' external validity was not wholly generalizable to other rural communities as each has a different context of relevance to their area. Additionally, previous research has noted individuals have different interest behaviors day to day (Renninger & Bachrach, 2015). The internal validity of the survey is not affected, as each survey is modified to the content of the informal instructional method being tested. Since there was a repeated measure of the survey throughout the program, internal validity should not be violated.

Conclusion

This case study design with triangulated multiple methods with three distinct instructional methods was used to identify STEM interest changes and explain how STEM interest changes in rural youth, ages eight to twelve, joining an informal place-conscious STEM program. These methods provided a detailed and rich explanation of how each informal program instructional method affects STEM interest development while comparing genders and instructional method sequencing.

CHAPTER 4

RESULTS

In rural settings, cultural and social influences that are uniquely different from other areas could inform or shape the development of students' science, technology, engineering and math (STEM) interest. However, previous research focusing on place-conscious designs in rural locations has not explored how to increase students' interest in STEM. Thus, this study was designed to examine the effects of three informal instructional methods (hands-on, role model, and culminating projects) in a place-conscious curriculum on STEM interest. Participants included youth in grades 3rd through 5th attending two local schools in one community. The following research questions guided this study. For rural youth, ages eight to twelve, in an informal place-conscious STEM program:

1. What do their words and actions tell us about the effectiveness of hands-on activities to increase STEM interest?
 - a. How does this differ for boys and girls?
2. What do their words and actions tell us about the effectiveness of role models to increase STEM interest?
 - a. How does this differ for boys and girls?
3. What do their words and actions tell us about the effectiveness of culminating projects to increase STEM interest?
 - a. How does this differ for boys and girls?

This chapter reports the results of the study in four sections. The first section provides an overview of the types of data collected and the study's approach to analysis of both the qualitative and quantitative data. The second section reports what rural youth's words and actions indicate about the effectiveness of hands-on activities to increase STEM interest. The third section reports what rural youth's words and actions indicate about the effectiveness of role models to increase STEM interest. The fourth section reports what rural youth's words and actions indicate about the effectiveness of culminating projects to increase STEM interest.

Overview of Data Analysis

The data analyzed in this study were drawn from self-report surveys, observations, and focus group interview data. The self-report survey data were analyzed using SPSS software to determine descriptive data frequencies and non-parametric statistics. Observation data and focus group data were analyzed using NVIVO software. Interest codes were determined a priori and loaded as nodes into the software for both data sets. Each participant was identified with attribute codes to anonymize them except for location, gender, and grade. The video for each focus group interview was transcribed and coded a priori using 16 interest codes (Renninger & Bachrach, 2015). Each transcript was reviewed multiple times to ensure accuracy and revealed two additional emergent interest codes.

Additionally, the observation protocol was developed based on the interest activity research conducted by Renninger and Bachrach (2015) who suggested analyzing observation data by activity level. Therefore, interest activity codes were generated to code observations with a value reflecting high, medium, or low level of activity. This produced a total score for each interest activity code. These observations also contained researcher reflection notes headed by

activity interest codes for each session. Please refer to Appendix C for a copy of the observation form used.

Frequencies were generated for the observation and focus group interview codes. The frequencies were used for pattern evaluation as a method to represent the impact of each instructional method on STEM interest. Qualitative and quantitative representations were used to provide similar and different views of the same data (Pagano & Dolan, 2014). As noted by Sandelowski et al. (2009), quantization of data to evaluate for treatment or variable differences, in this case, instructional method or gender, has been found to give researchers the ability to “discern and to show regularities” in qualitative data (p.3). Therefore, data were organized into two categories – 1) physical interest indicators and 2) emotional interest indicators. The data in each category were then partitioned into four naturally occurring clusters -- labeled many, some, few, and very few – to provide a different representation of the frequency of participants’ responses or actions about STEM interest. This process of partitioning was conducted relative to the set of participants’ responses or actions for each method. Given the different number of total responses for each instructional method, the qualitative labels represent a different percentage range for each method. All responses that fell into the “many” cluster were determined to be meaningful indicators of STEM interest.

Thus, the data from focus group interviews and observations, along with data generated from the self-report surveys, generated themes that spoke to the impact of each instructional method. Participants’ quotes provide additional contextual details to tell a rich, detailed story of how interest developed during each instructional method.

STEM Interest Survey Pre-Test Analysis

A principal component analysis (PCA) was conducted on the six-question self-report survey that measured STEM interest for 26 youth before they participated in the first instructional method. PCA is a technique for reducing the dimensionality of a dataset and increasing its interpretability. Assumptions of the PCA approach include: multiple variables that are continuous or ordinal, linear relationship between all variables, no outliers, and large sample size defined as five to ten cases per variable (Laerd Statistics, 2015).

The STEM Interest survey data were reduced using PCA to generate one data score per survey. Next, the PCA data score was used in a Wilcoxon-Signed rank test to compare results for each participant from their pre- and post- survey scores for each instructional method. A Wilcoxon-Signed rank test was utilized due to the non-parametric properties of data sets. The post-test results for each method are reported by PCA and Wilcoxon-Signed rank test in each of the following sections.

Inspection of the correlation matrix showed that five variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.673 with individual KMO measures all greater than 0.6. This finding earns the overall measure a classification of 'mediocre' to 'meritorious' according to Kaiser (1974). Bartlett's Test of Sphericity was statistically significant ($p < .001$), indicating that the data were likely factorizable.

PCA revealed five components that had eigenvalues greater than one and which explained 72.2%, 10.8%, 9.6%, 5.3%, and 1.9% of the total variance, respectively. Visual inspection of the scree plot, Figure 4-1, indicated that one component should be retained (Cattell,

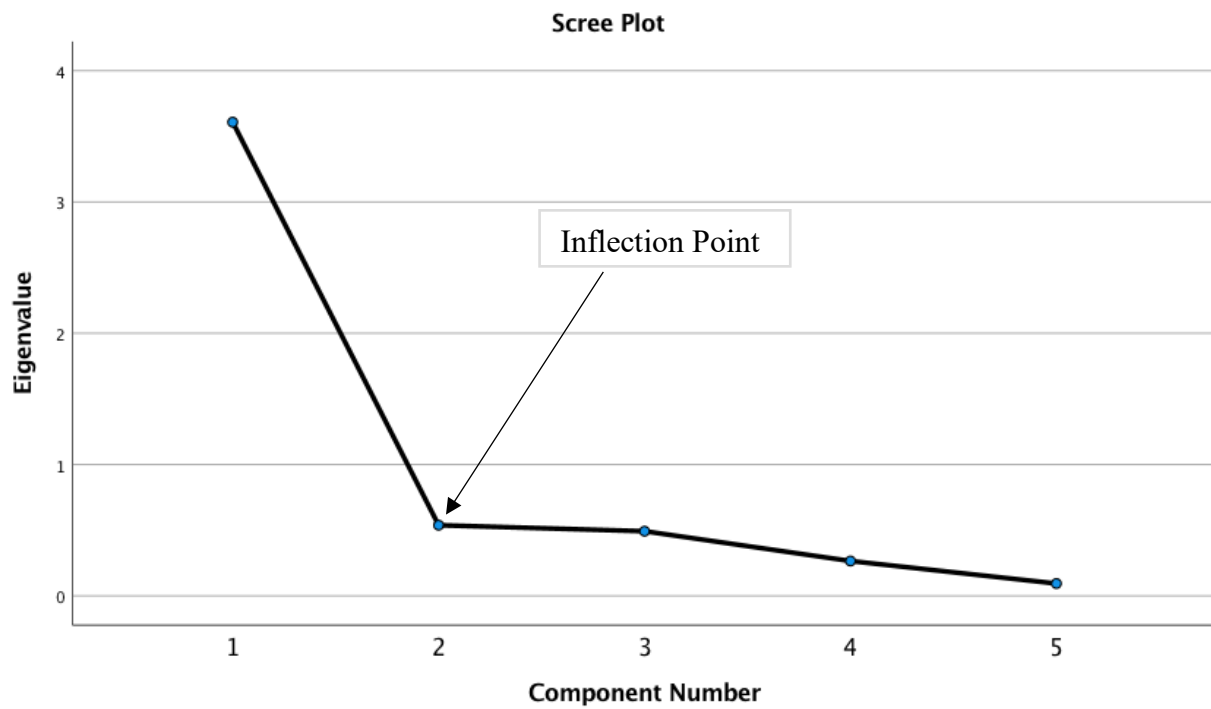
1966). In addition, a one-component solution met the interpretability criterion. As such, one component was retained.

The one-component solution explained 100% of the total variance. A varimax orthogonal rotation was employed to aid interpretability. The rotated solution exhibited 'simple structure' (Thurstone, 1947). The interpretation of the data was consistent with the previous interest attributes the survey was designed to measure with strong loadings of five of six interest items on Component 1. The sixth item was reverse scored, could have led to interpretability issues, and therefore was dropped. Component loadings and communalities of the rotated solution are presented in Table 4-1.

Table 4-1. Rotated Structure Matrix for PCA with Varimax Rotation of a One Component Survey

Items	Rotated Component Coefficients	
	Component 1	Communalities
PRQ2	0.897	0.804
PRQ3	0.865	0.748
PRQ1	0.831	0.691
PRQ5	0.829	0.688
PRQ4	0.823	0.677

Figure 4-1. Pre-Survey Data Scree Plot to determine the number of components to retain.



Effectiveness of Hands-On Activities to Increase STEM Interest

Data from observations, focus group interviews, and pre/post surveys were analyzed to understand the effectiveness of hands-on activities to increase rural youth STEM interest. The findings suggest that the hands-on activity impacted STEM interest through challenge, group work, hands-on activity, and emotionality. The theme of collaboration brought participants together for this instructional method. Youth interest was increased by the enjoyment of the challenge and the process of working together to find a solution.

Findings from Observation Data Regarding Hands-On Activities and STEM Interest

Observation data were organized using activity codes and analyzed descriptively by frequency and percentage for the hands-on instructional method. Frequency was determined by identifying the number of instances for each individual interest variable (See Appendix E for a full definition of each variable). Percentages were calculated for each individual interest variable type. Please see Table 4-2 for frequencies, percentages, and qualitative categories. For the hands-on instructional method, the following interest variables which had the highest frequencies were group work and hands-on activity.

Table 4-2. Table of frequencies and percentages of variables coded for observation of participant.

Instructional Method Hands-On			
Interest Variable	n	%	Qualitative Category
Autonomy- Independence	5	2.26%	Few
Challenge- Belief Conflict	30	13.57%	Some
Computer/ Technology	30	13.57%	Some
Group Work- Interactive Effort	48	21.72%	Many
Hands-on Activity- Physical Participation	55	24.89%	Many
Instructional Conversation- Meaning Clarification	33	14.93%	Some
Novelty- New and Unusual	1	.45%	Very Few
Personal Relevance- Self-Connection	19	8.60%	Few
Activity	221	100%	
Codes (N)			

Findings from Focus Group Interviews Regarding Hands-On Activities and STEM Interest

Data from the focus groups were organized using activity and characteristic codes and analyzed descriptively by frequency and percentage for the hands-on instructional method.

Frequency was determined by identifying the number of instances for each individual interest

variable. Percentage were calculated per each individual variable type, activity or characteristic. The researcher examined the data for logical frequency patterns to determine the most common codes. Please see Table 4-3 for frequencies, percentages, and qualitative categories. For the hands-on instructional method, the interest variables that had the highest frequencies were: challenge, group work, hands-on activity, and emotionality.

Table 4-3. Table of frequencies and percentages of variables coded during focus group from transcripts.

Instructional Method			
Hands-on			
Interest Variable	n	%	Category
Autonomy- Independence	2	1.90%	Few
Challenge- Belief Conflict	26	24.76%	Many
Computer/ Technology	2	1.90%	Few
Group Work- Interactive Effort	26	24.76%	Many
Hands-on Activity- Physical Participation	21	20.00%	Many
Instructional Conversation- Meaning Clarification	9	8.57%	Few
Novelty- New and Unusual	14	13.33%	Some
Personal Relevance- Self Connection	5	4.76%	Few
Activity Codes (N)	105	100%	
Activity Level- Engagement Level	24	18.32%	Some
Awareness- Insight	25	19.08%	Some
Emotionality- Feeling	38	29.01%	Many
Independence- Individual Effort	15	11.45%	Some
Mood- Affective State	0	0.00%	None
Openness- Willing	8	6.11%	Few
Reactivity- Behavior Change	0	0.00%	None
Sociability- Collective Relation	21	16.03%	Some
Character Codes (N)	131	100 %	

Findings from Self- Report Surveys Regarding Hands-On Activities and STEM Interest

A principal component analysis (PCA) was run on a six-question survey that measured STEM interest on 27 participants in the hands-on instructional method. The suitability of PCA was assessed prior to analysis. Inspection of the correlation matrix showed that five variables had at least one correlation coefficient greater than 0.3. The individual Kaiser-Meyer-Olkin (KMO) measure was 0.824, with individual KMO measures all greater than .7 classifications of 'middling' to 'meritorious' according to Kaiser (1974). Bartlett's Test of Sphericity was statistically significant for all measures ($p < .001$), indicating that the data were likely factorizable.

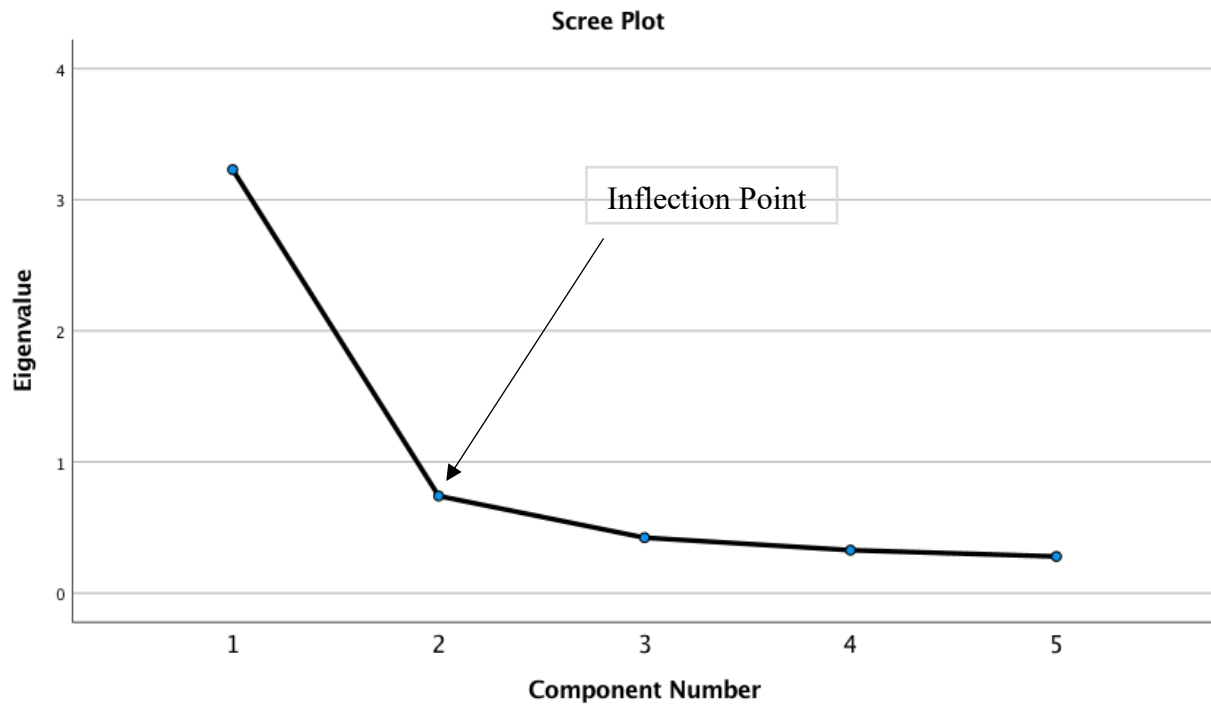
The hands-on interest survey PCA revealed five components with eigenvalues greater than one and explained 64.6 %, 14.8 %, 8.5 %, 6.5 %, and 5.6 % of the total variance, respectively. Visual inspection of the scree plot, Figure 4-2, indicated that one component should be retained (Cattell, 1966). In addition, a one-component solution met the interpretability criterion. As such, one component was retained.

Each of the one-component solutions explained 100% of the total variance. Subsequently, a Varimax orthogonal rotation was employed to aid interpretability, and the rotated solution exhibited a 'simple structure' (Thurstone, 1947). The interpretation of the data was consistent with the prior interest attributes the survey was designed to measure with strong loadings of five of six interest items on Component 1. The sixth item was reverse-scored, which could have led to difficulties for the participants' understanding, and therefore was dropped. Component loadings and communalities of the rotated solution are presented in Table 4-4.

Table 4-4. Rotated Structure Matrix for PCA with Varimax Rotation of a One Component Survey.

Items	Rotated Component Coefficients	
	Component 1	Communalities
PBQ3	0.882	0.777
PBQ5	0.829	0.688
PBQ1	0.826	0.682
PBQ4	0.778	0.606
PBQ2	0.691	0.477

Figure 4-2. Hands-on Survey Data Scree Plot to determine the number of components to retain.



Self-Report Surveys Wilcoxon-Signed Rank Test

A Wilcoxon signed-rank test was conducted to determine the effect of each instructional method on STEM interest. The difference scores were approximately symmetrically distributed, as assessed by a histogram with superimposed normal curve.

Of the 20 participants who completed the post-activity survey, the hands-on activities elicited a decrease in STEM interest in nine participants post-intervention, whereas 11 participants' STEM interest increased post-intervention. There was a median increase in STEM interest ($Mdn = 0.0620$) from pre-intervention ($Mdn = 0.265$) to post-intervention ($Mdn = 0.147$), but this difference was not statistically significant, $z = 0.373$, $p = 0.709$.

Gender Differences for Interest Following Hands-On Activities

Focus Group

Data from the focus groups were organized using activity and characteristic codes and analyzed descriptively to determine the mean frequencies for all interest codes. The codes were then analyzed for differences between genders and ranked (Table 4-5). For hands-on activities, boys displayed a higher variation in mean interest scores in activity level, whereas girls displayed a higher variation in mean interest scores in personal relevance and awareness.

Table 4-5. Calculations of average scores per each gender participating in focus groups for Hands-On.

Interest Variable	Instructional Method Hands-on			
	Boys	Rank	Girls	Rank
Autonomy- Independence	0.5	6/7	0.667	7
Challenge- Belief Conflict	2.75	1	3.33	1/2
Computer/ Technology	0.5	6/7	0.166	8
Group Work- Interactive Work	1.75	2/3	3.33	1/2
Hands-on Activity- Physical Participation	1.75	2/3	3.166	3
Instructional Conversation- Meaning Clarification	1	4/5	1.5	5
Novelty- New and Unusual	1	4/5	2.5	4
Personal Relevance- Self Connection	0	8	1.33	6 ↑
Activity Level- Engagement Level	3	1 ↑	2.666	3/4
Awareness- Insight	1	4	3.666	2 ↑
Emotionality- Feeling	2.25	2	6.333	1
Independence- Individual Effort	0.75	5	2.166	5
Mood- Affective State	0	7/8	0	7/8
Openness- Willing	0.5	6	0.833	6
Reactivity- Behavior Change	0	7/8	0	7/8
Sociability- Collective Relation	1.25	3	2.66	3/4

Self- Report Survey Data

After sorting data by gender for each instructional method, assumptions could not be met for PCA analysis. Therefore, a different non-parametric analysis was pursued to evaluate differences in gender by individual survey questions.

A Kruskal-Wallis test was conducted to determine differences in STEM interest scores between boys and girls. Distributions of the STEM interest scores for each question were similar for all groups, as assessed by visual inspection of the box plot. Median STEM interest survey scores for the hands-on instructional method were not significantly different. Please see Table 4-6 for findings for each survey question.

Table 4-6. Kruskal-Wallis Results for Hands-On.

Kruskal-Wallis H Test Results		
Survey Question	Hypothesis Test Summary	Decision
Q1	$X^2(1) = .007, p = .931$	Retain the null
Q2	$X^2(1) = .003, p = .956$	Retain the null
Q3	$X^2(1) = .701, p = .403$	Retain the null
Q4	$X^2(1) = .431, p = .511$	Retain the null
Q5	$X^2(1) = .104, p = .709$	Retain the null

Summary of the Findings for Effectiveness of Hands-On Activities on STEM Interest

Hands-on activities increased STEM interest through opportunities for collaboration. The youth were observed to actively work together to build a pump with little direct instruction. They

were very focused on the hands-on build of the pump and observed to put together and take apart the pump many times. Many participants did this until the pump could move water to the second bucket. The youth noted that the activity was challenging and was only successful if all group members could work together. They noted their previous experiences of building assisted them during the hands-on STEM activity. WG4 commented on her group building issues; “One of the tips that my dad always told me when I was helping him work on cars is every time, righty tighty lefty loosey, because they [group partners] were trying to figure out how to twist it on the right way.” Some youth recalled previous building stories of their family members that connected to positive feelings about their building success.

STEM interest was expressed in multiple ways by participants. Participants were challenged by the pump building and left to figure out the build with limited resources. Participants were skeptical of a bag of PVC parts and PVC pipes would actually become a pump. As stated by WB5, “I never knew you had to have all those parts to build one.” Participants expressed interest in working in groups stating conflicting opinions about whether to work alone or with others. Participants were interested in the act of building with their hands. Participants conveyed emotions of happiness, surprise, pride, excitement, and anger in conjunction with building the pump and working in their groups. They also discovered some of the physics involved in moving the water. HG5 stated, “I didn’t know that using so much force could make like water go into another bucket.” Participants expressed interest in learning from mistakes, similar to a challenge or growth mindset (Dweck, 2008). These emotions and challenge are expressed by HB4, “Like sometimes we get things wrong and then it’s like, oh, I got it right, you kind of feel like YAY!” STEM interest was generated by collaboratively working together

through the informal method of hands-on and the inquiry pedagogy while emphasized by the challenge and emotions for the youth.

Gender differences were noted regarding the increase of STEM interest. Girls identified with previous knowledge or experiences, showing more interest in personal relevance and awareness. Girl participants expressed their interest of knowledge for use as adults. As noted by WG3, “the more you know, it's the more of growing up. Like when something happens, you know what to do.” Boys were more interested in the activity level through cognitive and physical involvement. This was observed when two boys were unable to get the piston to work properly. They started using their mouths to siphon water through the valve from one bucket to another. Boys and girls experienced STEM interest differently in this hands-on instructional method.

Effectiveness of Role Models to Increase STEM Interest

Data from observations, focus group interviews, and pre/post surveys were analyzed to understand the effectiveness of role models to increase rural youth STEM interest. The findings suggest that the role model activity impacts STEM interest through personal relevance, novelty, and emotionality. The theme of discovery increased STEM interest following this instructional method. Youth interest was increased by the novel connections to their community and being able to interact with the role models.

Findings from Analysis of Observation Data Regarding Role Models and STEM Interest

Observation data were organized using activity codes and analyzed descriptively by frequency and percentage for the role model instructional method. Frequency was determined by identifying the number of instances for each individual interest variable. Percentages were

calculated for each individual variable type. Please see Table 4-7 for frequencies, percentages, and qualitative categories. For the role model instructional method, the interest variable which had the highest frequency was personal relevance.

Table 4-7. Table of frequencies and percentages of variables coded for observation of participant.

Instructional Method Role Model			
Interest Variable	n	%	Qualitative Category
Autonomy- Independence	35	16.75%	Some
Challenge- Belief Conflict	17	8.13%	Few
Computer/ Technology	16	7.66%	Few
Group Work- Interactive Work	11	5.26%	Few
Hands-on Activity-			Very Few
Physical Participation	1	0.48%	
Instructional Conversation-			Some
Meaning Clarification	22	10.53%	
Novelty- New and Unusual	30	14.35%	Some
Personal Relevance-			Many
Self Connection	77	36.84%	
Activity Codes (N)	209	100%	

Findings from Analysis of Focus Group Interviews Regarding Role Models and STEM Interest

Data from the focus groups were organized using activity and characteristic codes and analyzed descriptively by frequency and percentage for the role model instructional method. Frequency was determined by identifying the number of instances for each individual interest variable. Percentages were calculated for each individual variable type, activity or characteristic. The researcher examined the data for logical frequency patterns to determine the most common

codes. Please see Table 4-8 for frequencies, percentages, and qualitative categories. For the role model instructional method, the interest variables that had the highest frequencies were: novelty, activity level, and emotionality.

Table 4-8. Table of frequencies and percentages of variables coded during focus group participants.

Instructional Method Role Model			
Interest Variable	n	%	Qualitative Category
Autonomy-Independence	7	10.77%	Some
Challenge-Belief Conflict	7	10.77%	Some
Computer/ Technology	2	3.08%	Few
Group Work-Interactive Work	5	7.69%	Few
Hands-on Activity-Physical Participation	5	7.69%	Few
Instructional Conversation-Meaning Clarification	9	13.85%	Some
Novelty-New and Unusual	21	32.31%	Many
Personal Relevance-Self Connection	9	13.85%	Some
Activity Codes (N)	65	100%	

Table 4.8. Table of frequencies and percentages of variables coded during focus group participants, continued.

Instructional Method Role Model			
Interest Variable	n	%	Qualitative Category
Activity Level- Engagement Level	26	40.00%	Many
Awareness- Insight	7	10.77%	Some
Emotionality- Feeling	24	36.92%	Many
Independence- Individual Effort	3	4.62%	Few
Mood- Affective State	0	0.00%	None
Openness- Willing	1	1.54%	Very Few
Reactivity- Behavior Change	0	0.00%	None
Sociability- Collective Relation	4	6.15%	Few
Character Codes (N)	65	100%	

Findings from Analysis of Self-Report Survey
Regarding Role Models and STEM Interest

A principal component analysis (PCA) was run on a six-question survey that measured STEM interest on 23 youth that joined in the role model instructional method. The suitability of PCA was evaluated prior to analysis. Inspection of the correlation matrix showed that five variables had at least one correlation coefficient greater than 0.3. The individual Kaiser-Meyer-Olkin (KMO) measure was .709, with individual KMO measures all greater than 0.6, classifications of 'mediocre' to 'middling' according to Kaiser (1974). Bartlett's Test of Sphericity was statistically significant for all measures ($p < .001$), signifying that the data were likely factorizable.

PCA revealed five components with eigenvalues greater than one and explained 71.4%, 15.8%, 7.7%, 4.3%, and 0.76% of the total variance, respectively. Visual inspection of the scree

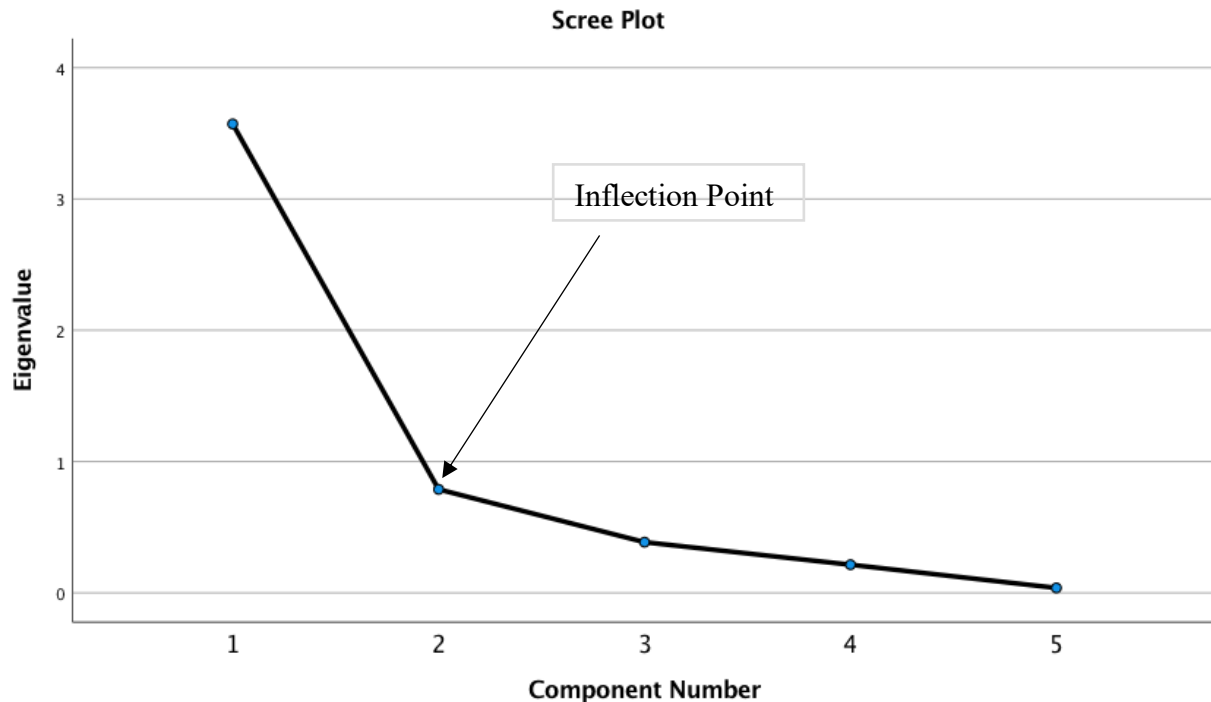
plot, Figure 4-3, showed that one component should be retained (Cattell, 1966). In addition, a one-component solution met the interpretability criterion. As such, one component was retained.

The one-component solutions explained 100% of the total variance. A varimax orthogonal rotation was used to aid interpretability. The rotated solution exhibited a 'simple structure' (Thurstone, 1947). The analysis of the data was consistent with the prior interest attributes the survey was designed to measure with strong loadings of five of six interest items on Component 1. The sixth item was reverse-scored, which could have led to difficulties for the participants' comprehension and therefore was dropped. Component loadings and communalities of the rotated solution are presented in Table 4-9.

Table 4-9. Rotated Structure Matrix for PCA with Varimax Rotation of a One Component Survey.

Items	Rotated Component Coefficients	
	Component 1	Communalities
RMQ5	0.945	0.892
RMQ1	0.929	0.862
RMQ3	0.911	0.830
RMQ4	0.784	0.615
RMQ2	0.610	0.372

Figure 4-3. Pre-Survey Data Scree Plot to determine the number of components to retain.



Self-Report Survey Wilcoxon-Signed Rank Test

A Wilcoxon signed-rank test was conducted to determine the effect of the role model instructional method on STEM interest. Twenty-seven participants were invited to the study to participate in an informal place-conscious program with three distinct instructional methods. STEM interest was measure pre-program and immediately following each instructional method. The difference scores were approximately symmetrically distributed, as assessed by a histogram with superimposed normal curve.

Of the 19 participants who completed the post-activity survey, the role models elicited a decrease in STEM interest in nine participants post-intervention, whereas ten participants' STEM interest increased post-intervention. There was a median decrease in STEM interest

(Mdn= -.0709) from pre-intervention (Mdn = 0.265) to post-intervention (Mdn = 0.230), but this difference was not statistically significant, $z = 0.080$, $p = 0.936$.

Gender Difference in STEM Interest Following Role Models

Focus Group

Data from the focus groups were organized using activity and characteristic codes and analyzed descriptively to determine the mean frequencies for all interest codes. The codes were then analyzed for differences between genders and ranked. Please see Table 4-10 for mean and ranking data. For role model activities, boys displayed a higher variation in mean interest scores in group work and sociability, whereas girls displayed a higher variation in mean interest scores in personal relevance. The girls made connections to their homes where they could apply their new found knowledge. HG3 comments on her own interest, “What was interesting to me is they tell us how to put in our pump “. This parallels to the boys sharing their new information with others. This was noted in observations where boys were sharing information with their peers and the role models during the discussion.

Table 4-10. Calculations of average scores per each gender participating in focus groups for role models.

Interest Variable	Instructional Method		Role Model	
	Boy	Rank	Girl	Rank
Autonomy- Independence	0.8	6/7	0.666	6/7
Challenge- Belief Conflict	1.8	2	1.5	2/3
Computer/ Technology	0.2	8	0.333	8
Group Work- Interactive Work	1.4	3 ↑	0.833	5
Hands-on Activity- Physical Participation	1	4/5	0.666	6/7

Table 4-10. Calculations of average scores per each gender participating in focus groups for role models, continued.

Interest Variable	Instructional Method Role Model			
	Boy	Rank	Girl	Rank
Instructional Conversation-Meaning Clarification	1	4/5	1.5	2/3
Novelty-New and Unusual Personal	2.2	1	2.5	1
Relevance-Self Connection	0.8	6/7	1.166	4↑
Activity Level-Engagement Level	2.6	1	3	2
Awareness- Insight	0.8	4	1.166	3
Emotionality- Feeling	2.2	2	3.5	1
Independence- Individual Effort	0.6	5/6	0.83	4
Mood- Affective State	0	7/8	0	6/7/8
Openness- Willing	0.6	5/6	0	6/7/8
Reactivity- Behavior Change	0	7/8	0	6/7/8
Sociability- Collective Relation	1	3 ↑	0.66	5

Survey Data

After sorting data by gender for each instructional method, assumptions could not be met for PCA analysis therefore, a Wilcoxon-Signed Rank test was not utilized. A Kruskal-Wallis test was conducted to decide if there were differences in STEM interest scores between boys, girls, and prefer not to answer. Distributions of the STEM interest scores for each question were comparable for all groups, as assessed by visual inspection of the box plot. Median STEM interest survey scores for role model instructional method were not significantly different. Please see table below for findings for each survey question.

Table 4-11. Kruskal -Wallis Results for Role Model

Kruskal-Wallis H Test Results		
Survey Question	Hypothesis Test Summary	Decision
Q1	$X^2(2) = .742, p = .690$	Retain the null
Q2	$X^2(2) = 3.186, p = .203$	Retain the null
Q3	$X^2(2) = .710, p = .701$	Retain the null
Q4	$X^2(2) = 2.071, p = .355$	Retain the null
Q5	$X^2(2) = .751, p = .687$	Retain the null

Summary of Findings Regarding Role Models and STEM Interest

The main finding for increasing STEM interest during the role model instructional method was discovering new community knowledge. Participants were particularly interested in the discussions about local activities related to water, including drilling wells and examples of ranching/farming pumps. Additionally, participants were interested in writing their thoughts about the discussion. Especially the younger participants, who enjoyed writing in their science notebooks, as expressed by WG4, “I like when we get to do writing projects, you know what that means in general, and you have and try to figure it out; by ourselves most.”

Youth appeared to be cognitively engaged at a higher activity level when gaining understanding of concepts explained by the community role models. Participants express mostly positive emotions about the ability to write during the role model activity although one described themselves as “*happy with a sprinkle of bored*” (HB3) when needing to sit and listen. The

novelty of the information was of interest to the participants as noted by their comments and questions about drilling under the ground to reach water. Many participants were able to connect the information to their home and community experiences, and sometimes to future events like starting their own family farm, which is also an indicator of interest. Participants were interested in learning new information and its relevance to their community, especially concerning ranch animals and people. HB4 states this as, “Yes, it's clean for animals now, OK, but it's not it's not cool for people. Well, it was farther down, people want that water farther down.” Participants were aware of personal relevance of their education and future needs of STEM knowledge. WB4 explains, “Maybe it can help them find a job, but they hope it can help them understand more so that if they know about it, they have a good chance at the job.” Youth were interested in knowing more and being actively engaged in constructing understanding of the STEM water information for themselves.

Gender differences were noted during the role model activity as boys displayed a higher variation in their mean scores for interest in group work and sociability, whereas girls displayed a higher variation in their mean scores for interest in personal relevance, HG3 commented on her own interest, “What was interesting to me is they tell us how to put in our pump”. She had indicated that her family was moving to a ranch, and she would be able to apply her STEM knowledge in her new family context. This is contrasted with the boys sharing their new information with others. An example of STEM interest was a boy talking to his mother about finding water, and they both started digging. They wondered how far they would need to dig to find water. Additionally, boys shared stories with the group of lakes in the local mountains and types of irrigation, such as center-pivots.

Effectiveness of Culminating Projects to Increase STEM Interest

Data from observations, focus group interviews, and pre/post surveys were analyzed to understand the effectiveness of culminating projects to increase rural youth STEM interest. The findings suggest that the culminating project activity impacts STEM interest through personal relevance, autonomy, computer/technology, and group work. The interest characteristic codes were autonomy, activity level, awareness, and emotionality. The theme of actively presenting to their community was positively affecting STEM interest for the youth.

Findings from Analysis of Observation Data Regarding Culminating Projects and STEM Interest

Observation data were organized using activity codes and analyzed descriptively by frequency and percentage for the culminating project instructional method. Frequency was determined by identifying the number of instances for each individual interest variable. Percentages were calculated for the individual variable type. Please see Table 4-12 for frequencies, percentages, and qualitative categories. For the culminating project instructional method, the interest variable which had the highest frequencies was computer/technology, and group work. These two variables were also identified in focus group interview data.

Table 4-12. Table of frequencies and percentages of variables coded for observation of participant.

Instructional Method Culminating Project			
Interest Variable	n	%	Qualitative Category
Autonomy- Independence	6	7.69%	Some
Challenge- Belief Conflict	3	3.85%	Few
Computer/ Technology	29	37.18%	Many
Group Work- Interactive Work	15	19.23%	Many
Hands-on Activity-			Some
Physical Participation	8	10.26%	
Instructional Conversation-			Some
Meaning Clarification	9	11.54%	
Novelty- New and Unusual	2	2.56%	Few
Personal Relevance-			Some
Self Connection	6	7.69%	
Activity Codes (N)	78	100%	

Findings from Focus Group Interviews Regrading Culminating Project and STEM Interest

Data from the focus groups were organized using activity and characteristic codes and analyzed descriptively by frequency and percentage for the culminating project instructional method. Frequency was determined identifying the number of instances for each individual interest variable. Percentages were calculated for each individual variable type, activity or characteristic. The researcher examined the data for logical frequency patterns to determine the most common codes. Please see Table 4-13 for frequencies, percentages, and qualitative categories. For the culminating project instructional method, the following interest variables that had the highest frequencies were: personal relevance, autonomy, activity level, awareness, and

emotionality. Additionally, computer/ technology and group work were also identified in the observational data.

Table 4-13. Table of frequencies and percentages of variables coded during focus group participants.

Interest Variable	Instructional Method Culminating Project		Qualitative Category
	n	%	
Autonomy- Independence	12	18.18%	Many
Challenge- Belief Conflict	8	12.12%	Some
Computer/ Technology	7	10.61%	Some
Group Work- Interactive Work	9	13.64%	Some
Hands-on Activity- Physical Participation	5	7.58%	Few
Instructional Conversation- Meaning Clarification	8	12.12%	Some
Novelty- New and Unusual	2	3.03%	Few
Personal Relevance- Self Connection	15	22.73%	Many

Table 4-13. Table of frequencies and percentages of variables coded during focus group participants, continued.

Interest Variable	Instructional Method Culminating Project		Qualitative Category
	n	%	
Activity Codes (N)	66	100%	
Activity Level- engagement level	23	20.91%	Many
Awareness- Insight	22	20.00%	Many
Emotionality- Feeling	26	23.64%	Many
Independence- Individual Effort	9	8.18%	Few
Mood- Affective State	0	0.00%	None
Openness- Willing	16	14.55%	Some
Reactivity- Behavior Change	0	0.00%	None
Sociability- Collective Relation	14	12.73%	Some
Character Codes (N)	110	100%	

Findings from Self-Report Survey Regarding Culminating Projects and STEM Interest

A principal component analysis (PCA) was run on a six-question survey measuring STEM interest on 27 youth who participated in the instructional method. The appropriateness of PCA was assessed prior to analysis. Examination of the correlation matrix showed that five variables had at least one correlation coefficient greater than 0.3. The individual Kaiser-Meyer-Olkin (KMO) measure was 0.765 with separate KMO measures all greater than .7, classifications of 'middling' to 'meritorious' according to Kaiser (1974). Bartlett's Test of Sphericity was

statistically significant for all measures ($p < .001$), indicating that the data were likely factorizable.

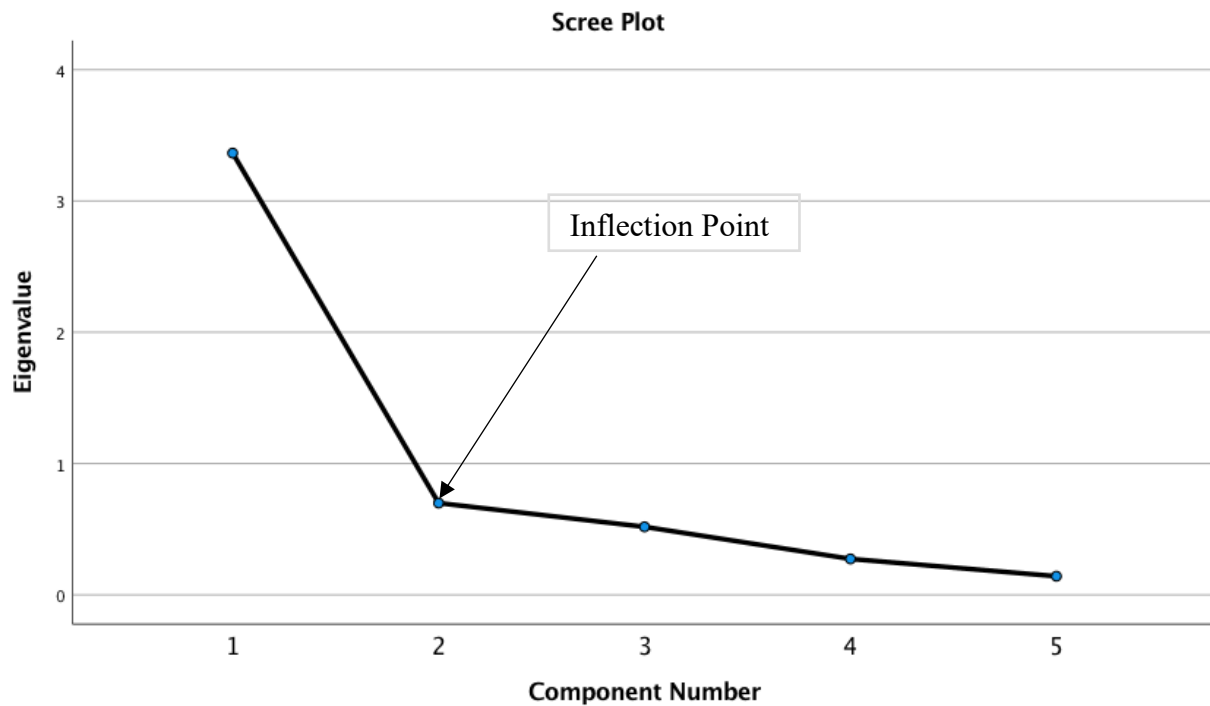
The PCA revealed five components with eigenvalues greater than one and described 67.3%, 14.0%, 10.4%, 5.5%, and 2.8% of the total variance, respectively. Visual inspection of the scree plot, Figure 4-4, indicated that one component should be kept (Cattell, 1966). In addition, a one-component solution met the interpretability criterion. As such, one component was retained.

Each of the one-component solutions explained 100% of the total variance. Therefore, a Varimax orthogonal rotation was employed to aid interpretability, and the rotated solution displayed a 'simple structure' (Thurstone, 1947). The interpretation of the data was comparable with the previous interest attributes the survey was designed to measure with strong loadings of five of six interest items on Component 1. The sixth item was reverse-scored, which could have led to problems for the participants' understanding and therefore was dropped. Component loadings and communalities of the rotated solution are presented in Table 4-14.

Table 4-14. Rotated Structure Matrix for PCA with Varimax Rotation of a One Component Survey.

Items	Rotated Component Coefficients	
	Component 1	Communalities
P3Q3	0.891	0.794
P3Q2	0.875	0.766
P3Q1	0.833	0.694
P3Q5	0.755	0.570
P3Q4	0.736	0.541

Figure 4-4. Pre-Survey Data Scree Plot to determine the number of components to retain.



Self-Report Survey Wilcoxon-Signed Rank Test

A Wilcoxon signed-rank test was conducted to determine the effect of each instructional method on STEM interest. Twenty-seven participants were invited to the study to participate in an informal place-conscious program with three distinct instructional methods. STEM interest was measure pre-program and immediately following each instructional method. The difference scores were approximately symmetrically distributed, as assessed by a histogram with superimposed normal curve.

Of the 27 participants who completed the post-activity survey, the culminating projects elicited a decrease in STEM interest in eight participants post-intervention, whereas nine participants' STEM interest increased post-intervention. There was a median increase in STEM interest ($Mdn = 0.0762$) from pre-intervention ($Mdn = 0.265$) to post-intervention ($Mdn = 0.0291$), but this difference was not statistically significant, $z = -0.403$, $p = 0.687$.

Gender Difference in STEM Interest Following Culminating Projects

Focus Group

Data from the focus groups were organized using activity and characteristic codes and analyzed descriptively to determine the mean frequencies for all interest codes. The codes were then analyzed for differences between genders and ranked. For the focus group data interest codes, boys displayed a higher mean interest code in group work, whereas girls displayed a higher mean interest code for personal relevance. The rank differences in gender were most notable here as compared to previous instructional methods. Rankings were separated by four to five positions instead of two. See Table 4-15, for the means and rankings by gender.

Table 4-15. Calculations of mean for each gender participating in focus groups for each instructional method.

Interest Variable	Instructional Method Culminating Project			
	Boy	Rank	Girl	Rank
Autonomy- Independence	1.2	4	2.2	2/3/4
Challenge- Belief Conflict	2	2	2.2	2/3/4
Computer/ Technology	0.8	8	1	8
Group Work- Interactive Work	2.2	1 ↑	1.8	6/7
Hands-on Activity- Physical Participation	1	5/6/7	1.8	6/7
Instructional Conversation- Meaning Clarification	1.4	3	2.2	2/3/4
Novelty- New and Unusual	1	5/6/7	2	5
Personal Relevance- Self Connection	1	5/6/7	2.8	1 ↑
Activity Level- engagement level	3.8	1	5.2	2
Awareness- Insight	2	3	3.8	3
Emotionality- Feeling	3.2	2	7.6	1
Independence- Individual Effort	0.8	5/6	1.8	6
Mood- Affective State	0	7/8	0	7/8
Openness- Willing	0.8	5/6	2.6	4
Reactivity- Behavior Change	0	7/8	0	7/8
Sociability- Collective Relation	1.8	4	2.2	5

Survey Data

After sorting data by gender for each instructional method, assumptions could not be met for PCA analysis consequently, a Wilcoxon-signed rank test was not utilized. A Kruskal-Wallis test was conducted to establish differences in STEM interest scores between boys and girls.

Distributions of the STEM interest scores for each question were alike for all groups, as assessed by visual inspection of the box plot. Median STEM interest survey scores for culminating project instructional method were not significantly different. Please see table below for findings for each survey question.

Table 4-16. Kruskal -Wallis Results for Culminating Project.

Kruskal-Wallis H Test Results		
Survey Question	Hypothesis Test Summary	Decision
Q1	$X^2(1) = 2.228, p = .135$	Retain the null
Q2	$X^2(1) = .017, p = .897$	Retain the null
Q3	$X^2(1) = .003, p = .957$	Retain the null
Q4	$X^2(1) = 2.452, p = .117$	Retain the null
Q5	$X^2(1) = .208, p = .648$	Retain the null

Summary of Findings Regarding Culminating Projects and STEM Interest

The main finding for the culminating project is represented as active research, a component of the place-conscious theoretical curriculum framework. The youth were interested

in presenting the posters they created with their community. This STEM interest effect was the desire to actively work preparing and presenting the newly acquired knowledge. This included a desire for sharing that STEM knowledge with others in their community. As stated by HG5, “Because knowing that a lot of people are going to see it and you're going to see how much kids can really do.” An additional interest finding during this third instructional method was how it correlates to the first two instructional methods. Meaningful interest codes were repeated from the hands-on and the role model sessions. This aligns developing STEM interest with instructional methods. Hands-on and culminating project shared majority interest development through group work, whereas the role model and culminating project shared majority interest development through personal relevance.

This finding is supported by the youth expression of many emotions including happiness, pride, and excitement about designing posters and presenting them to their community. The youth showed physical and verbal signs of enjoyment during and after the making of their posters. Several individuals expressed being proud of creating a poster and presenting to adults. HB6 *“knowing that like the whole, like a lot of people could see it.”* There were mixed opinions of working alone or working in a group. Participants were interested in the autonomy of presenting their culminating project to an audience but equally interested in working with a group to develop the posters. Participants appear to have deep knowledge of their partners since they have attended school together. Some are aware of difficulties with certain individuals and some note strengths and comfortability in individuals. WB4 explains, “Not fun because of my partner, he is tired in the afternoon”, which is contrasted by WG4, “I’m glad because of my partner, because I’ve known him since I was in this school...I really enjoy it and relax a little bit.

So, I have fun.” Participants were interested in working with computers and learning new technology skills. Participants were interested because of the higher cognitive and physical engagement of creating a digital poster. Participants were able to draw from their past STEM experiences. They used their STEM experiences to fill their poster content, indicating an interest variable of awareness. Youth also noted their interest to their own aspirations, as stated by WG3, “it made it more interesting to make stories, made me want to be an author one day.” Participants are interested in trying new things, openness. HG4 states, “I stepped out of my box and I feel that I didn't feel I was nervous or not nervous to try something new again, to try new things.” Interest development was more varied and demonstrates how interest development is compounded by the culminating project.

Boys were more interested working together on the project and girls were more interested in how it connected to their personal context. Girl participants showed more personal relevance reflecting on the culminating posters. Girls were observed to share pictures from their ranch or community. One aspect making it personally relevant to girls is stated by WG3, “what I like about it was the pictures, how you like to map out the bottom of what you found interesting or what you did in the picture.” Boy participants were more interested in the group work. HB3, “We've known each other for a few years, so yeah, I know what I do feel like it was comfortable because you had previously known.” This differentiation in STEM interest development was noteworthy as it was both displayed in an intrinsic context. This difference was especially prominent in the focus group data.

Conclusion

The results and findings of the analysis on the effects of STEM interest by an informal place-conscious curriculum were positive and informative. Each instructional method showed an effect on STEM interest from the observational and focus group interview analysis. The analysis of the self-report survey was unable to show any significant statistical findings. Additionally, there were notable gender differences on STEM interest effect for all three instructional methods.

The application of informal instructional methods on a place-conscious curriculum indicated STEM interest can be affected in different and similar ways throughout this project. Interest developed similarly through emotions across all three instructional methods. During the hands-on instructional method based on the natural history component of place-conscious design, STEM interest developed from group work, hands-on, and challenge. During the role model instructional method based on the cultural journalism of place-conscious design, STEM interest developed from personal relevance and novelty. During the culminating project instructional method based on action research of place-conscious design, STEM interest developed from similar previous sources of group work and personal relevance and differently through autonomy and computer/technology. Please see Table 4-17 for STEM interest indicators found meaningful during the overall study. Finally, these STEM interest findings indicate that an informal place-conscious curriculum can cultivate short term situational interest. Future research will be able to explore if and how this situational interest can be further developed into longer lasting individual interest for the same individuals.

Furthermore, the examination of gender differences revealed girls expressed STEM interest more by personal relevance and boys expressed more STEM interest in group work.

Girls expressed mixed feelings about group work but noted that they didn't like it when boys took over. WG4 explains, "I learned that sometimes people just want to take over...I was sitting down on the bench because everybody else is doing everything and they really weren't letting me do anything. When I tried to help one of my partners yelled at me and no that wasn't very fun."

Girls were more interested in tying the knowledge to their personal context of interests, aspirations, and experiences. Boys were more interested in working in groups during sessions. It was noted that most boys worked well together and expressed emotions of happiness about having someone to work with them. The boys enjoyed having groups during activities to generate more ideas and solutions. Please see Table 14-18 for STEM interest indicators by gender. The STEM interest development geared toward different genders should note these findings in informal curriculum development and future interest studies.

Table 4-17. STEM Interest Indicators.

Informal Instructional Method	Place-Conscious Pedagogy	Main Finding	STEM Activity Interest Indicators	STEM Characteristic Interest Indicators
Hands-On	Natural History	Collaboration	Challenge <i>Group Work</i> Hands-On	Emotionality <i>Awareness</i>
Role Model	Cultural Journalism	New Community Knowledge	Novelty <i>Personal Relevance</i>	Emotionality <i>Activity Level</i>
Culminating Project	Action Research	Action Research	<i>Group Work</i> Autonomy Computer/Technology <i>Personal Relevance</i>	Emotionality <i>Activity Level</i> <i>Awareness</i>

Italicized* indicators show overlap in two instructional methods and **bold indicators show repetitions in all instructional methods.

Table 4-18. Gender Comparison STEM Interest Indicators.

Informal Instructional Method	Place-Conscious Pedagogy	Main Finding		STEM Activity Interest Indicator		STEM Characteristic Interest Indicator	
		Boy	Girl	Boy	Girl	Boy	Girl
Hands-On	Natural History	actively working together.	awareness to personal experiences		Personal Relevance	Activity Level	Awareness
Role Model	Cultural Journalism			Group Work	Personal Relevance	Sociability	
Culminating Project	Action Research			Group Work	Personal Relevance		

***Bold** indicators show overlap in multiple instructional methods.

CHAPTER 5

DISCUSSION

Introduction

This study was designed to investigate rural cultural and social influences that are uniquely different from other areas that could inform or shape the development of students' science, technology, engineering and math (STEM) interest. However, previous research focusing on place-conscious designs in rural locations has not explored how to increase students' interest in STEM. Specifically, this study investigated the effects of three informal instructional methods (hands-on, role model, and culminating projects) in a place-conscious curriculum on STEM interest. Participants included youth in grades 3rd through 5th attending two local schools in one community. The following research questions guided this study. For rural youth, ages eight to twelve, in an informal place-conscious STEM program:

1. What do their words and actions tell us about the effectiveness of hands-on activities to increase STEM interest?
 - a. How does this differ for boys and girls?
2. What do their words and actions tell us about the effectiveness of role models to increase STEM interest?
 - a. How does this differ for boys and girls?
3. What do their words and actions tell us about the effectiveness of culminating projects to increase STEM interest?
 - a. How does this differ for boys and girls?

This chapter presents a summary and interpretation of the results of the investigation and provides an evaluation of the approach used to collect and analyze the data. Finally, this chapter describes the study's contributions to the literature, its implications for professional practice and possible avenues for further study.

Summary of the Study

This case study was bounded by a rural community composed of two rural towns classified as rural fringe by the National Center for Educational Statistics (NCES) connected by a 16 mile stretch of road. The physical tie between both communities is a shared water source of creeks and a reservoir. This water topic served as the foundational STEM topic for rural youth exploration. Between the two towns is an extensive farming/ranching community. Ranching families in this rural community represent multiple generations and have personal contact with both schools. These families have served as athletic coaching volunteers and educators. The youth participants were in 3rd – 6th grades and participate in a co-op between both schools for athletics and extra-curriculars due to their small school population size. The size of the participant group at the two school sites varied between 10 to 17 participants for each instructional method and the data were analyzed as a single case of a total size (N) of 19 to 27 participants. Each instructional method was delivered in the school cafeteria or, if possible, in one classroom. The entire program occurred during the COVID pandemic and thus, the researcher and facilitator wore face masks and followed university protocols. Participants followed their respective school protocols.

The study was designed to examine the efficacy of three informal instructional methods to increase STEM interest for rural youth. The pump lesson allowed the youth, working in

groups of three, to assemble a working pump from pre-cut PVC pieces. The role models, a local cattle rancher and a local water technician (tests for drinking water contaminants) introduced themselves in a way to make connections with the youth and answered pre-scripted community water questions. The culminating project involved a visual representation created by the youth of their local community photos and STEM knowledge.

To determine the efficacy of each instructional method, data were collected throughout the time period each instructional method occurred. During each instructional method, observations were documented by the researcher. Self-report survey data were collected once before all instructional methods and immediately following each instructional method. The week between instructional methods, a focus group with semi-structured interview questions were videotaped by the researcher. This data collection allowed the researcher to examine the words and actions of youth following the three instructional methods.

Summary and Interpretation of the Findings

Main Findings

The evidence collected in this study suggest that the three instructional strategies worked to increase STEM interest through collaborative work, new knowledge, and action research. The data analysis revealed that youth were interested in the STEM topic throughout the hands-on project because it allowed them to work together and draw upon their previous STEM experiences. The participants expressed positive feelings towards being challenged during the pump building lesson, enjoyed working in groups, and shared reflections of other similar hands-on experiences. Second, the evidence revealed that the youth were interested in the STEM topic during the role model session because they acquired new knowledge that was connected to their

rural community. The youth actively asked questions and wrote notes during the role model session. They expressed positive feelings of interest when asked about the role model session because they enjoyed writing and participating in the discussion. Finally, the evidence suggests that the youth were interested in the STEM topic during the culminating project because it allowed them to actively work together integrating their individual experiences with the STEM topic into a project that could be shared. Again, they expressed positive feelings of interest while being actively involved in composing their findings. The first two instructional methods, based on hands-on and role model activities, generated interest in different ways, and these were repeated in the culminating project method. This significant finding shows that interest was formed during the first two experiences and culminated in the third instructional method. The STEM interest continued to develop throughout this informal place-conscious program. STEM interest was developed in multiple manners, as well as, repeated manners. STEM interest development at an age of upper elementary could help sustain STEM interest during subsequent schooling grades where STEM interest has been indicated to drop (Sadler et al., 2012). These findings indicate STEM interest can be generated through informal instructional methods that are grounded in a place-conscious framework for rural youth.

Gender Differences

The study was also designed to investigate if there were differences in interest development between genders. The cross-case examination for gender was explored for each instructional method and gender differences were noted for all three instructional methods. Both genders showed similar interest based on challenge during all the instructional methods. Each instructional method challenged their ideas of water in their community. However, the girls

showed interest intrinsically as illustrated by the evidence connecting interest development to awareness and personal relevance. An example of this is when HG5 shares her thoughts on pump building, “Oh, and that it might have interested you, you can build something else and get a new idea about something else, or wanting to build it again, even for your house.” Conversely, boys displayed interest extrinsically; their interest development was more connected to group work, activity level, and sociability. One boy noted this in the focus group, HB6 states “Yeah. I would like to be in a group because somebody else might have a better idea. So, you guys can talk to each other as you go.” Gender difference findings could be suggesting boys were more physical in their interest development than girls who were more reflective in their interest development. The significance in these gender differences is analogous to the differences found in STEM paths. Women tend to choose STEM paths that give them personal fulfillment (VanLeuvan, 2004). This is important to note for developing STEM interest in girls as their interest was established by a personal context to their community. This could indicate girls would like to be personally connected to their STEM learning experiences, whereas boys would like to be more physically active in their STEM learning experiences. The significance is found in the alignment of gender-focused interest development. These findings indicate that the girls' interest is aligned with the place-conscious basis of the informal STEM program, whereas the boys' interest development is more closely aligned with the informal instructional methods. By that configuration, the program's conceptual framework supported the development of STEM interest for both groups.

Ancillary Results

Group Work

Participants offered mixed reactions to working in groups. This focus group dialogue was more readily discussed by girls. Some examples are, “But the problem was I was the one of those that looks the most or whatever and not really tell people what to do” or “not excited. And that was because the partners.” Some girls indicated they liked working in groups but were not always comfortable with their partner. However, some also indicated being very comfortable with their partners. This could be a reflection of the rural context where the participants are members of a small school community. Multi-grade classrooms and school member consistency throughout their school lifecycle could also contribute to this effect. All youth were very open about which gender they preferred to work with and complementary of each other as well.

Gender

The girl participants expressed how they did not like group work when their voice or participation was not heard or valued. This can be noted in their words; “No takeovers” (HG5) or “[there] is always the one person that puts himself in charge” (HG6). Additionally, I observed and noted a groups actions during the hands-on activity. My observation and notes did not align with WG4’s comment of an event. I observed an adult reprimand her for taking over the group dynamics. WG4 remembered the boys in her group took over the project and this upset her. She commented, “I learned that sometimes people just want to take over.” I found this contradiction in observation and focus group interview striking and wondered if I had missed an event during the observation. She may have felt the scolding belittled her involvement in the hands-on activity and in turn she felt undervalued by her group. The opinions expressed by the girls gave witness to their dissatisfaction of their input not being heard.

Limitations of the Findings

The design of this study was grounded in qualitative interview pilot research with individual participants living in various rural communities across the state. Given that there are both similarities and differences amongst rural regions and communities, the findings from this study are best applied to the participants from this small close-knit rural community. For example, the community represented in this study is composed of multi-generational members that may help establish familiarity and comfort levels for student group work and with community role models. Furthermore, it is possible that the small number of participants limit the interpretability of the self-report survey results and contributed to the lack of evidence for the interest indicators mood and reactivity. Finally, the school sites were still under COVID-19 restricted access, and this may have limited participants' comfort with the research team as well as the participants' access throughout the project. Thus, the findings from this study could be relevant to other rural schools and communities, but they would need to be applied using a place-attentive lens (White & Downey, 2021)

Contributions to the Literature

Alignment with Previous Theory and Research

Key Connections Between STEM Interest and Informal, Place-Conscious Programs.

Previous research has outlined five characteristics of students' interest development that were also identified in this study (Renninger & Hidi, 2011). First, interest is specific to an object or content (Renninger & Hidi, 2011). In this current study, the culminating project demonstrates that the youth were interested in water as an environmental factor critical to their community.

Furthermore, this illustrates the importance of place-conscious curriculum (Greenwood, 2013) as a significant factor to generating STEM interest. Second, interest relates a person to their environment and this interaction sustains this interest (Renninger & Hidi, 2011). In the current study, the informal STEM program took place over a six week period allowing youth time to reflect and notice water and pumps in their community. Youth revisited community water sources and engineering practices allowing them to interact with the content and build their interest (National Research Council, 2009).

Third, interest is displayed and observed in both cognitive and affective ways (Renninger & Hidi, 2011). In the current study, an overarching emotional interest indicator was noted during all of the instructional methods while different cognitive components were evident in each instructional method. Youth were able to engage using their knowledge in each instructional method while also noting their interest feelings. Fourth, previous research suggests that youth are not always aware of their interest (Renninger & Hidi, 2011). This was supported in the current study, as even when youth were frustrated during an instructional method, they still indicated interest through their actions and words. This could be seen in the hands-on instructional method where youth were challenged to build a pump but displayed positive emotions when they moved water from one bucket to another. Informal learning is designed to give youth the ability to inquire and enjoy (National Research Council, 2009) while being personally relevant (Greenwood, 2013). Finally, interest has a physiological/ neurological difference when a person is interested in content (Renninger & Hidi, 2011). This was most evident during the culminating projects component of the program when youth were drawing on previous experiences and knowledge they had acquired during earlier instructional methods. Overall, their sustained

interest in community water was facilitated by the place-conscious pedagogy and informal design (Greenwood, 2013). The informal approach does not have formal requirements or assessments to be met (National Research Council, 2009). Albeit, youth expressed their desire to share their knowledge even though there was no requirement to do so. These study findings align with the five characteristics of interest development. This indicates an informal place-conscious STEM program can develop interest in rural youth.

Four Phases of Interest Development. The stages of interest development (Hidi & Renninger, 2006) were also observed throughout the program. For instance, triggered situational interest was demonstrated by participants through positive and negative feelings in the hands-on activity and maintained situational interest was exhibited through the reengagement with content after hands-on and role model instructional methods. As an example, youth commented that they were better able to recognize pumps in their community. Additionally, youth grounded their understanding of water in their community and its importance to the farming or ranching context. Some youth progressed to the third and fourth phases of emerging individual interest and well-developed individual interest. An illustration of emerging individual interest was the action of one participant digging a hole to find the water. The youth engaged in this activity on their own. The youth was interested because of the novelty of water underground and showed independence by acting on his own to find a water source. They described their actions in this way-- “I actually tried to dig down... well, when I was digging, I hit a lot of rocks...and that’s what forced me to stop” (WB4). Finally, an exemplar of well-developed individual interest was seen during the culminating project. The youth desired to present their knowledge to their rural community. Several youths had positive emotions of pride concerning their project. They commented about

their desire to share their knowledge with the community. This evidence supports the four-phase development of interest and provides empirical findings supporting this model for STEM interest development in a period of six weeks. This is of significance to note, as previous quantitative research (Rotgans & Schmidt, 2017) indicates individual interest would develop over much more extended periods, up to several months, whereas this study discovered qualitative indicators of individual interest development within two weeks. Perhaps, quantitative surveys alone are not sensitive enough to gather details that are found in qualitative methods.

Extending Previous Theory and Research

Upper Elementary Aged Youth. This project specifically investigated interest development in upper elementary aged youth, ages 8-12. This appears to be one of the first research studies investigating this age group through qualitative methods. Previous research has not focused on this age group due to concerns about younger participants ability to describe their own feelings on interest. However, evidence from this study suggest that youth are very capable of describing their feelings on interest and describing encounters that made them feel interested. Youth were very engaged and comfortable in sharing their thoughts and ideas on what interested them despite the lack of statistical significance in the survey analysis. Furthermore, the evidence indicates that the focus groups used in this study are an effective and dynamic method for collecting STEM interest data for upper elementary youth. Holding a focus group with five participants was found to be ideal in terms of participant interaction and also revealed the majority of details for interest development. Given that this age group has been understudied in previous research, further studies in this vein are recommended.

Gender Differences. Although gender differences in STEM interest have been examined in previous studies, little research has explored gender differences in interest development for youth ages 8-12. The differences noted in this study provide a more nuanced understanding of how interest factors can be different between the genders. For example, previous research has suggested that girls needed to be acknowledged in order to value STEM (Calabrese et al., 2013). Furthermore, in this study, the findings suggest that while boys were more interested in group work and socialization, girls tended to note problems in group dynamics. Similar to previous empirical evidence with adults working in co-ed groups, it was noted that men would direct group effort and monopolize conversations (Edelsky, 1981). Additionally, girls noted that interest contained more of a personal connection. This interest factor of personal awareness ties closely with self-efficacy (Brown et al., 2016). This could indicate a linkage of interest and self-efficacy development at this age or earlier and support the development of STEM career paths as noted by Social Cognitive Career Theory (Lent et al., 1994) which ties interest, self-efficacy, and career choice.

New Interest Variable -- Competition. The youth expressed that having a contest was a way to build their interest. From their perspective, a contest would be different from a challenge; they viewed a challenge as an intrinsic factor, whereas, they saw competition as an external factor. The following participant statement illustrates this concept; “every once in a while, we should like make teams, do stuff against each other” (WG4). This was noted across cases and discussed in multiple focus group sessions by boys and girls. This variable does not appear to align with previous findings regarding individual interest development but it does appear to support situational interest development (Hidi & Renninger, 2006). Competition and situational

interest are supported by an individual's need for encouragement from others, such as when groups compete (Hidi & Renninger, 2006).

Contributions to Professional Practice

Alignment with Previous Theory and Research

The professional practice of teaching has many pedagogical approaches that help assist with student interest including competitions and differentiation. The following section addresses participants' comments to share with teachers about increasing interest in instruction.

Competition to Increase Interest. The interest variable of competition also ties with professional practice, as the participants indicated interest would be generated through a competition. Teachers have often tried having friendly competitions in the classroom. Although, its implementation has sometimes proven problematic. For example, some youth have expressed threatened feelings of underperforming in some cases of competition, however it has been shown to build motivation as well (Cecchini et al., 2001). Competition has also been shown to have benefits including; improving collaboration, facilitating growth-mindset, and developing critical thinking (Gokhale, 1995).

Teaching Informed by Youth. The evidence from this study revealed that the participants were able to articulate their desire for differentiation (Tomlinson & McTighe, 2006) in instruction for their and their classmates' cognitive levels, as well as, preferred approaches to learning. Youth can be very informative about what interests them in a lesson (Renninger et al., 2015). One formal education goal is assessment for knowledge. One way to achieve this

cognitive goal is to support students continued interested in the content. Student centered instruction and place-conscious design are two factors that can help to achieve this goal of increasing content interest by differentiated instruction.

Extending Previous Theory and Research

Younger Students Seeking STEM. During a focus group discussion, two third grade youth spoke of actively seeking hands-on activities and increased activity levels. This was supported by an older youth indicating a need of younger grade-level participation. This is articulated by a 4th grader reflecting on what happens in the 3rd grade classroom during science lessons:

Kids don't learn about that until they get to our grade [4th]. They learn about math and reading and stuff. Usually they do things they have learned so much about...I was bored. I actually wanted to do the exact same thing, if you would like to learn, so they can try to dig a hole like WB4 did, instead of reading a book, because I thought I would rather do actual science experiments and stuff. (WG4)

This example extends previous empirical work with teachers implementing inquiry experiments in the elementary classroom (Hansen & Buczynski, 2013). Previous research indicated that teachers were less likely to extend science experiments to students if they felt the equipment was inadequate (Hansen & Buczynski, 2013). Additionally, it has been shown that some teachers are uncomfortable with STEM content and therefore reluctant to approach STEM activities in the classroom (Falk & Dierking, 2010). This example of the need for hands-on activities is shifted to the viewpoint of the student. This illustrates frustration from the younger students and the lack of hands-on science in the classroom. In order to create interest for students, teachers need to give all grade levels appropriate genuine STEM opportunities. As shown in previous research in

initiating STEM interests (Master et al., 2017), early elementary experiences can facilitate STEM interest that could be sustained beyond the elementary grades.

Recommendations for Future Research

Future research regarding the development of rural youth's STEM interest would do well to expound on several questions raised by this study particularly regarding key aspects of informal place-conscious curriculum. Areas of concern with session delivery could indicate further exploration is needed regarding research timing in rural and elementary settings. This was mostly noted as optimal timing during a school day including interfering with recess. Additionally, ample time should be spent building community partnerships as these are critical in the delivery of a program such as this. Extensions and timing during projects similar to this should be planned for and developed. Additionally, longitudinal data for this type of work is recommended with subsequent informal place-conscious program opportunities to explore continuing STEM interest development.

Furthering Interest Development with Place-Conscious Design

Culminating project presentations could be studied in deeper detail in the future. This could be achieved through a qualitative or quantitative approach. Of real research interest is an investigation of how youth respond to community members during interactions with culminating posters presentations. Additionally, research examining how youth present their ideas about water to their community would also be of value. This could lead to increased interest if youth actively seek more information from the community members and attempt to further their current understandings of water sources. Youth may attempt to gain a richer understanding of STEM

impacts on their current and future lives as adults in this community. This would provide insight into individual interest development. Specifically noted by Renninger (2009) individuals need to “feel their idea[s] ...are understood ...[and need] feedback” which addresses emerging individual interest, while also noting individuals want “to balance their personal standards with more widely accepted standards...[and] constructive feedback” (p. 108). A study examining the interactions of youth and their poster presentations could further enlighten researchers on how interest could be further developed with this instructional method.

Instrument Development with Youth

As noted in this study, observing and talking directly with youth about their interest development gave more profound insights into their thoughts and actions. The validated self-report survey produced nonsignificant results. There is work needed to ensure unambiguity in working with small groups of participants. Additionally, the interest observation form developed for this project could be advanced with behavior analysis insights with youth in this age frame. These two instruments could be strengthened to better support findings of direct communication with youth. As indicated in previous research that investigated the interest of participants post hoc (Renninger & Bachrach, 2015), improved instruments would also assist future studies that may not have the accessibility for direct contact with the participants.

Informal Programing in Rural Communities

This project was delivered at the two rural school locations during the school day. This was to eliminate transportation issues faced in rural communities and to maximize participation within an already small group. This requires extra coordination with school teachers,

administration, and staff. As an outsider examining their students' reactions to a curriculum, researchers need to develop a relationship with many individuals at each school site teachers in multiple classrooms, principals, secretaries, and other school staff. This took some time to gain trust and to integrate into their schedules and availability. Issues did arise around COVID-19 cleaning requirements, group size limitations, and missing youth due to athletic competitions.

Relationship Building

Along a similar vein, recruitment of community role models and coordination of their attendance also requires community relationships. Originally, STEM university role models were invited. Due to the time constraints, they were unable to attend. Recruitment of community role models was complex due to commitments to rural ranching and farming activities. Utilizing networking within the school community enlisted the two community role models for this study.

Future recommendations include project extensions of community presentations to examine individual STEM interest development and longitudinal follow-up research to explore situational STEM interest development. Additionally, directions for future work include thoughtful timing of the project within the school day, as well as, community relationship building to assist with recruitment of role models for cultural journalism with place-conscious pedagogy. This research could provide a foundation upon future work to extend these findings and develop deeper pedagogical methodologies for informal and place-conscious designs.

Conclusion

This research study examining STEM interest development through an informal place-conscious STEM program for rural youth demonstrates how three different instructional methods

can facilitate STEM interest for upper elementary aged youth and offers some insights for differentiating instruction for gender. Specifically, boys were interested when they were actively interacting and girls were interested through their awareness and personal relevance to the STEM content. These findings also indicate a desire expressed by younger participants to be actively involved with STEM lessons and not passively watching.

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APPENDICES

APPENDIX A

INFORMAL PLACE-CONSCIOUS STEM LESSONS

Grade/ Grade Band:3-5		Topic: Engineering Design	Lesson # 1 in a series of 3 lessons
Brief Lesson Description: Students will build and test PVC hand pumps to explore a specific aspect of engineering design: planning and carrying out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.			
Performance Expectation(s): 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.			
Specific Learning Outcomes: Students will be able to carry out the investigation, collecting and recording data according to the developed plan.			
Essential Question: <i>How does a water pump work and what changes can be made to improve it?</i>			Big Idea: How does water get into our homes and farms? Is it difficult to move water from one place to another? How easy is it to find water underground?
Science & Engineering Practices: Planning and Carrying Out Investigations <i>Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.</i> <i>Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.</i>	Disciplinary Core Ideas: <u>ETS1.B: Developing Possible Solutions</u> <i>Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.</i> <u>ETS1.C: Optimizing the Design Solution</u> <i>Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.</i>	Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World. <i>Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.</i>	

Possible Preconceptions/Misconceptions:

Students may believe water is pushed to the surface.

LESSON PLAN – 5-E Model (Bybee et al., 2006)**ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:**

Do you carry water camping or is there a way to get drinking water at the campground? Do you know what is in the picture?

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Pumps are used to move water and are very important in irrigation systems. Irrigation systems consist of pumps, pipes, canals, and sprinklers and are used to supply water to crops to help them grow. Today you and your team will build a PVC hand pump, test the flow rate, and come up with design improvements. A prototype is the very first model of a design and is used to conduct tests that will help improve future designs. You will first build a PVC hand pump using the instructions found here:

<https://www.instructables.com/id/How-To-Make-A-PVC-Water-Air-Vacuum-Pump/>



Video demonstration: <https://youtu.be/vaho7JSVS1I>

One person on your team should be operating the pump, one timing the test, one taking

notes, and others can help support the pumper and timer. Start with an empty 5-gallon bucket. When the timer says “go”, the pumper should start pumping. The timer will stop the time when the bucket is full. The recorder should record the time it took to fill the 5-gallon bucket. Repeat this test three times.

EXPLAIN: Concepts Explained and Vocabulary Defined:

Flow Rate

Your team will now test the flow rate of your pump. The flow rate is a measure of how much water you can move in a certain amount of time. For example, the faucet in our sink at home indicates a flow rate of 5 gallons per minute. This means our sink faucet should be able to fill a 5-gallon bucket in one minute.

Vocabulary: irrigate, prototype, irrigation

ELABORATE: Applications and Extensions:

Where are some places in your community that water is important? How does the water get moved to that place? Are there other ways of moving water besides pumps?

EVALUATE:

Formative Monitoring (Questioning / Discussion):

1. What is the flow rate for your pump? Use the units of gallons per minute. (Example calculation: Time: 3 minutes 46 seconds Volume: 5 gallons.....5 gallons divided by 3 minutes 46 seconds (3 minutes + 46/60 = 3.77 minutes) = 1.32 gallons/minute) Do this calculation for each of your 3 trials.
2. Why was the flow rate slightly different each time? What would you tell someone if you were asked for the flow rate of your pump?
3. If your team switched jobs (different person pumping, timing, recording) how might your results change?

Summative Assessment (Quiz / Project / Report):

1. It takes 27,154 gallons of water to irrigate one acre of land with an inch of water. How long would it take you to pump this much water with your pump?

Elaborate Further / Reflect: Enrichment:

1. Now that you’ve spent time using your pump, are there any changes to the design that would make it easier, or more comfortable, to use?
2. If you wanted to increase the flow rate of your pump, what changes might you make to the design?
3. Ask an older person in your family to tell you what pumps are in use at your house. What type of pumps are they? Did any of them ever use a hand pump to get water from a well?
4. Are there any places in your community that have trouble getting water? Ask why?

Items needed:

Pump pieces- 10 sets total

Reflection Journal- 28

Grade/ Grade Band:3-5	Topic: Water on the Farm	Lesson # 2 in a series of 3 lessons
Brief Lesson Description: Students will engage in a discussion with an Engineer and local Rancher/ Farmer		
Performance Expectation(s): 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.		
Specific Learning Outcomes: Students will be able to ask questions of panelist to understand the criteria and constraints of irrigation.		
Essential Question: <i>How does irrigation move water in your community?</i>		Big Idea: How does water get into our homes and farms? Is it difficult to move water from one place to another? How easy is it to find water underground?
Science & Engineering Practices: Asking Questions and Defining Problems <i>Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.</i>	Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems <i>Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.</i>	Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World. <i>People’s needs and wants change over time, as do their demands for new and improved technologies.</i>

ESS2.C: The Roles of Water in Earth's Surface Processes

Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.

Possible Preconceptions/Misconceptions:

Students may believe ground water is used for irrigation.

LESSON PLAN – 5-E Model (Bybee et al., 2006)

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Where is most of the fresh water on earth?

Uncovering student ideas in Earth and Environmental Science (Keely and Tucker, 2016, P.29-31)

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Participants are introduced to guests. Guests are previously trained to talk about hobbies and activities that may help the children relate to them. Introductions for the entire group are made. Guests describe their career and how it relates to fresh water sources.

Participants are given question prompts in order to ask questions of Scientist or Rancher/Farmer; **Where are some places in our community that water is important? How does the water get moved to that place? Are there other ways of moving water besides pumps? Are there times where it is hard to get enough water to crops or animals? Do we ever run out of water?**

EXPLAIN: Concepts Explained and Vocabulary Defined:

Irrigation, Irrigation Ditch, Fresh Water

Fresh Water does not have salt in it, like the ocean. **Irrigation** is an artificial process of applying controlled amounts of water to land to assist in production of crops. **Irrigation Ditch** are manmade channels that deliver water

ELABORATE: Applications and Extensions:

What do farmers/Rancher use to move water? Does it ever break? Who fixes it?

EVALUATE:**Formative Monitoring (Questioning / Discussion):**

Participants are given time to take notes in the scientific journals about the panel discussion and ask any follow up questions they have.

Summative Assessment (Quiz / Project / Report):

Participants are asked to take pictures in the community of water sources and how water is moved from one place to another.

Elaborate Further / Reflect: Enrichment:

- 5. Are there water sources near your home? How does the water get to where it is needed?**
- 6. Are there any places in our community that have trouble getting water? Ask why?**
- 7. Take pictures of water sources and how the water moves to where it is needed.**

Items need: Reflection Journals, completed pumps

Grade/ Grade Band:3-5	Topic: Water on the Farm	Lesson # 2 in a series of 3 lessons
Brief Lesson Description: Students will engage in a discussion with an Engineer and local Rancher/ Farmer		
Performance Expectation(s): 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.		
Specific Learning Outcomes: Students will be able to ask questions of panelist to understand the criteria and constraints of irrigation.		
Essential Question: <i>How does irrigation move water in your community?</i>		Big Idea: How does water get into our homes and farms? Is it difficult to move water from one place to another? How easy is it to find water underground?
Science & Engineering Practices: Asking Questions and Defining Problems <i>Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.</i>	Disciplinary Core Ideas: ETS1.A: Defining and Delimiting Engineering Problems <i>Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.</i>	Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World. <i>People’s needs and wants change over time, as do their demands for new and improved technologies.</i>

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Students may believe ground water is used for irrigation.

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ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Where is most of the fresh water on earth?

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EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Participants are introduced to guests. Guests are previously trained to talk about hobbies and activities that may help the children relate to them. Introductions for the entire group are made. Guests describe their career and how it relates to fresh water sources.

Participants are given question prompts in order to ask questions of Scientist or Rancher/Farmer; **Where are some places in our community that water is important? How does the water get moved to that place? Are there other ways of moving water besides pumps? Are there times where it is hard to get enough water to crops or animals? Do we ever run out of water?**

EXPLAIN: Concepts Explained and Vocabulary Defined:

Irrigation, Irrigation Ditch, Fresh Water

Fresh Water does not have salt in it, like the ocean. **Irrigation** is an artificial process of applying controlled amounts of water to land to assist in production of crops. **Irrigation Ditch** are manmade channels that deliver water

ELABORATE: Applications and Extensions:

What do farmers/Rancher use to move water? Does it ever break? Who fixes it?

EVALUATE:**Formative Monitoring (Questioning / Discussion):**

Participants are given time to take notes in the scientific journals about the panel discussion and ask any follow up questions they have.

Summative Assessment (Quiz / Project / Report):

Participants are asked to take pictures in the community of water sources and how water is moved from one place to another.

Elaborate Further / Reflect: Enrichment:

8. Are there water sources near your home? How does the water get to where it is needed?
9. Are there any places in our community that have trouble getting water? Ask why?
10. Take pictures of water sources and how the water moves to where it is needed.

Items need: Reflection Journals, completed pumps

APPENDIX B

STEM INTEREST SURVEY

Playing outside

Playing Outside		
	Not Fun 	Fun 
Is playing outside fun?	☐	☐

Informal Place-conscious STEM

STEM Interest	A lot not 	A little not 	A little 	A lot 
How much is playing outside FUN or not FUN?	☐	☐	☐	☐
I enjoyed working on this STEM topic	☐	☐	☐	☐
I want to know more about this STEM topic	☐	☐	☐	☐
I think this STEM topic is interesting.	☐	☐	☐	☐
I expect to master this STEM topic well.	☐	☐	☐	☐
I was fully focused on this STEM topic; I am not distracted by other things.	☐	☐	☐	☐
I was bored with today's STEM topic.	☐	☐	☐	☐

About You

What grade are you in? (3,4,5,6)

https://montana.ca1.qualtrics.com/Q/EditSection/Blocks/Ajax/GetSurveyPrintPreview?ContextSurveyID=SV_emrCZMhku9anMwd&ContextLibraryID=...

1/3/2021

Qualtrics Survey Software

Are you a boy, a girl, or prefer not to say?

APPENDIX C

STEM INTEREST OBSERVATIONAL TOOL

Observer: _____ Location: _____

Date: _____ Instructional Method: _____

of participants: _____ # of other adults: _____

of groups: _____

Record behavior of each group per individual every 1 minute.

Record with a check mark per Activity type and by level.

Activity Type	High- lots of movement and talking	Med- some movement and talking during activity	Low- quietly sitting during activity
Autonomy			
Challenge			
Computer/technology			
Group Work			
Hands-on activity			
Instructional conversation			
Novelty			
Personal Relevance			

Activity Type	Reflections
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Autonomy

Challenge

Computer/technology

Group Work

Hands-on activity

Instructional
conversation

Novelty

Personal Relevance

APPENDIX D

FOCUS GROUP PROTOCOL AND SEMI-
STRUCTURED INTERVIEW QUESTIONS

Focus Group Interview Protocol

- Props: Finished hand-pump, Picture of the Role Model Panel members, or Culminating Project Poster (each focus group members), paper and markers
- Prefer to sit at a table with the group to be more formal and instill a more serious nature.

Introduction to the Study

My name is Elaine and I am a student at Montana State University. I am going to be talking with kids like you from both Willow Creek and Harrison. I am trying to learn from you about what kinds of things you find interesting, especially about STEM (science, technology, engineering and math). Adults have their ideas about what kids might find interesting while learning but I think kids have a lot of their own ideas about what is interesting. So, I would like to talk to kids and find out what parts of the STEM program are interesting or not interesting.

I would like to learn more from you. I am going to ask you a few questions about the STEM program last week. There are no right or wrong answers. I just really want to hear what you thought about the activities you did last week. You can be the teacher and teach me about what you think.

If you decide you want to talk with me, we will spend 30-45 minutes together. I'll ask you some questions about what you thought about last week's STEM program. When we are talking today I am going to record our conversation and write some notes to myself. If you want to say something, let's raise our hand so that I can hear each of you on the recording. If there are any questions that make you uncomfortable, you do not have to answer. And at any point or for any reason, you can stop talking to me. I want you to know the answers you give me will be kept as private as possible. The tape of your answers will be stored in a locked cabinet. No one else will be allowed to listen to it and it will be erased when the study is finished. When I write up my final report I will combine all the kids' answers together so that no one will be able to tell what each person said. If I use some of your answers in my final paper, your name will not be used.

Your answers will be very important because they will help teachers and other adults about what children find interesting during learning. You will get two things out of participating in this project. First, you will get a chance to tell me your ideas about what is interesting to you. Second, when we are all done, I will donate a book that you pick out to your school's library with your name in it to say thank you for talking to me.

Can each of you color a name card? You can fold in half like mine and place it on the table in front of you.

Interview Questions

1. To get us started tell me about your favorite subjects in school.
 - Clarification there are no wrong answers and I am listening to each of them. If they do not know, I will skip to the next participant, but if they want to tell me later they can.

Transition: Now, let's talk about what you did in the program last week. I'll ask you some questions and you tell me what you think.

- Put the prop on the table from the week before.

2. Did you learn something you didn't know last week? PAUSE
 - a. How did you learn about that? (AWARENESS)
 - b. Tell me more about _____.
3. Did you like trying something new? (OPENNESS)
 - a. Tell me more about _____.
4. What would you tell a friend that doesn't go to this school about last week's STEM program?
 - a. What kinds of things helped you feel more interested? Or less interested?
 - b. Why do kids like that? What makes that fun?
5. Last week I saw you (behavior). What was exciting about that? (REACTIVITY, MOOD, EMOTIONALITY)
6. Did you like working with your group last week or would you have preferred to work alone? (INDEPENDENCE or SOCIABILITY)
7. Do you like to know how things work?
 - a. Tell me more about that? (ACTIVITY LEVEL)
8. What should teachers know about how to make lessons interesting?
9. What do you think the other kids thought about the meeting?
 - a. Did you talk to your family or friends about the meeting?
 - b. What did you say to them?

Closure

I think that is good for our discussion today. Could I ask one more question to make sure I understood what you meant by _____. “

Can you write the name of your favorite book or author on your name card? I am going to buy some books for your school library and dedicate them to each of you. Show an example.

Thank you for talking with me and helping me understand what interests you about the STEM program.

APPENDIX E

OBSERVATIONAL SITUATIONAL INTEREST CATEGORIES

Activity Code	Detail Description	Inclusion Criteria	Typical Exemplar
Autonomy	Focus on personal achievement, independence and works alone	Participant is engaged in activity alone.	Participant took pieces to another table to construct a pump without the group.
Challenge	An attempt to grasp a concept or reality, sometimes viewed as contradictory to participant's held belief	Relates to the STE topic or activity, should include an activity code	Participants are frustrated on how to put materials together, Participant verbalizes their frustration, "I quit!"
Computer/technology	Computer or technological equipment is utilized	Participant is using equipment or anticipation of equipment use.	I can take pictures with my iPad and upload to the website?
Group Work	Participants interactively working together on an activity or task	Must include more than one participant and activity/task related to program topic	Group of participants are building a water pump
Hands-on activity	Participant is actively participating in a tangible activity.	Activity is related to STEM topic of the program	Participant is handling a piece of PVC and another is placing an O-ring onto it.
Instructional conversation	Adult or group participant listens to participant and responds to clarify intending meaning	Participant is interacting with an Adult or another participant in the group during program.	"You mean a creek when you are saying irrigation ditch?"
Novelty	Quality of event is new as well as, striking, original or unusual	Participant learns something new, does something for the first time, or find an event unusual	"I've never done something like this before."

Personal Relevance	Participant connects activity topic to their own interests, aspirations, and life experiences	Relates activity to a community context or personal context.	"I have water pump like that at my house."
Characteristic Code	Detail Description	Inclusion Criteria	Typical Exemplar
Activity Level	How involved in cognitive engagement or physical involvement with an event	Should include activity that participant is involved in	Participant was highly engaged with the building of the pump. They were thinking out-loud and verbalizing their own movements.
Awareness	Participant's ability to draw from past experiences, i.e. perception or knowledge of something	Participant is referring to STEM topic and their personal knowledge of that topic	My dad always says if there isn't enough snow, we will have bad forest fires.
Emotionality*	Participants feeling resulting from a physical or physiological responses that influences thought and behavior	Participant express this through a change in facial expression, body language, or tone of voice.	"I got the water to come out!" shouts while jumping up and down.
Independence	Participant wants to act on their own thoughts or feelings and not be influenced by others	Participant's behavior is towards an activity or STEM topic	Participant does not want to work with the group.
Mood**	An affective state, less specific and intense and less likely to be provoked by a stimulus	Participant involved in a program activity has a general affective state	Participant's mood was typically melancholy.
Openness	Participant is willing to try new things	Participant is involved in an activity about the topic	Participant wants to be involved, and states "Building is for not just for boys."
Reactivity	Participant changes their behavior and are aware they are being observed	Participant is observed to behave abnormally during observation, should be	Participant states, "Climate change is fake." When presented

	verified with another Adult.	with scientific evidence.	
Sociability	Participant seeks out companion, engages in interpersonal relations, participates socially	Participant is engaged in a STEM activity	Participant invites their friend to work with them on a project.

*Can include happiness, sadness, disgust, fear, surprise, anger, pride, shame, embarrassment, and excitement.

** Can include cheerful, reflective, gloomy, humorous, melancholy, whimsical, calm, hopeful, angry, and fearful.