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STEMulating Interest with a Rural Place-Conscious Curriculum

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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. Previous research focusing on place-conscious designs in rural locations has not explored how to increase student interest in STEM. 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 third through fifth grades who attended two local schools in one community. Results indicated STEM interest increased through collaborative work, new knowledge, and action research. This study will help fill the gap in rural-based empirical studies of STEM interest development, informal education, and youth ages 8–12.

***Keywords*: STEM interest, rural, place-conscious, informal programming, hands-on, role model, culminating project**

Over 50 years ago, educational policymakers in the United States increased their attention and funding toward strengthening education in the science, technology, engineering, and math (STEM) disciplines. At that time, the focus was on developing a better understanding of "changing societal contexts such as communicable diseases and manufacturing demands" (National Academies of Sciences, 2019, p. 23). Despite years of effort, students' STEM knowledge growth has not reached desired outcomes. This critical deficiency needs to be addressed, and rural communities could hold the answers. Rural communities may provide a more diverse viewpoint on the current global developments of STEM demands and offer a more varied approach to solutions and applications. In 2010, the President's Council of Advisors on Science and Technology (PCAST) developed the *Prepare and Inspire* report indicating a significant gap in interest levels and achievement for underrepresented groups in STEM disciplines.

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 .220).

Researchers' empirical and experimental studies have furthered the knowledge of interest and how it plays a crucial role in strengthening the learning process (Krapp, 1999). Conversely, researchers have also found that a lack of interest can result in apathy, unsuccessfulness, disengagement, inattentiveness, unskillfulness, and stagnation (Hidi, 1990; Renninger & Hidi, 2020). However, STEM interest can be increased through informal contexts and place-conscious curriculum design (Dierking et al., 2003; Eshach, 2006). This combination could decrease the equity and diversity gap for STEM pursuits by targeting a different audience (Vaziri et al., 2020).

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, p. 23–24). One place where STEM interest could be developed is in informal contexts where the learners operate outside of objectives and timelines and focus on seeking knowledge in everyday situations. 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). Because informal learning has been shown to increase student interest and performance in science, developing informal curricula that align with science standards taught in formal classroom settings could help support students' STEM outcomes.

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 (Showalter et al. 2019), and their contexts are irrelevant to rural participants' STEM interests (Mohr-Schroeder et al., 2014). Advantageous curricula would have a place-conscious focus to address a rural participant's interest. Gruenewald (2003b) defines place-conscious curricula as the inclusion of location factors with 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). Rural children bring a rich diversity to their understanding of STEM from their local rural knowledge. Previous research suggests that students in rural areas possess distinct funds of knowledge from their households and social networks (Moll et al., 1992).

Prior 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 action research (Buxton, 2010). However, little is known about which instructional methods utilized in a place-conscious informal STEM program supports the development of STEM interests. As previously reported, rural locations may lack programs that consider the rural narrative about STEM and the distinctiveness of their particular STEM background (Girl Scout Research Institute, 2012). Thus, this study illustrates the development, implementation, and assessment of 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, 2015)
2. Interaction with invited scientists and community members to share rural-based STEM knowledge (Kekelis & Joyce, 2014)
3. Participation in the development of rural STEM culminating projects (Buxton, 2010)

This study examined the 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). Flick and Lederman (2004) indicated that future research should incorporate cultural contexts, such as rural applications and inquiry methods, to generate STEM interest. This would allow participants to view STEM within their community and determine how it applies to everyday occurrences and generate STEM interest.

Therefore, the aim of this study was to examine the effectiveness of different instructional methods on STEM interest development for rural youth, ages eight to twelve, in an informal place-conscious STEM program. The following research question guided the study: What do youth words and actions tell us about the effectiveness of hands-on activities, role models, and culminating projects to increase STEM interest?

Background

Place-Conscious Pedagogy

Gruenewald and Smith **(**2014**)** noted that place-based design had been widely adopted, 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; Howley et al., 2011). Place-consciousness correlates with a pedagogy of place, referencing how a place can teach individuals about the world, how the occupants fit in the world picture, and how people identify themselves with a place (Gruenewald, 2003a; White & Corbett, 2014). 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).

To fully embrace a place-conscious pedagogy, educators should be mindful of aligning three factors: natural history, cultural journalism, and action research (Gruenewald, 2003a). Natural history can be established by asking subject-oriented questions about the community. Greenwood (2013) uses the question, "What happened here?" to guide the inquiry of historical discovery (p.97). Cultural journalism can link young and older members of the same community, where the younger member gathers direct knowledge from the more experienced member on a particular topic **(**Gruenewald & Smith, 2014**)**. When educating youth, emphasis should be placed on considering more than just observations of their surroundings. Youth need to understand their surroundings' local history, specifically from the community members (Simmons et al., 2022). To bring the connection full circle, educators should guide participants to observe their communities and hear cultural and historical accounts about their observations. With this knowledge, they could decide if they want to act. This is considered an ethical dimension, guided by the question, "What should happen here?" (Greenwood, 2013, p. 97).

To illustrate the connection between a place and its members, researchers would gain insights by using local funds of knowledge. Funds of knowledge are described as the skills and awareness developed over time and within 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 refers to students who are not interested in educational content and therefore not participating or achieving in classrooms. As indicated in the international study based on Programme for International Student Assessment (PISA), “prior informal science learning has a positive effect . . . and direct influence on science performance” (Tang & Zhang, 2020, p. 598). Therefore, funds of knowledge can be leveraged to help individuals gain insight and connect to educational content.

Place-conscious pedagogy demonstrates the ability to infuse natural history and cultural journalism along with funds of knowledge and action research into a STEM curriculum that captures an individual’s attention and potentially increases their interest. Additionally, place-conscious pedagogy arouses interest by focusing on an individual’s interest in their community context, thus influencing their situational interest (Rotgans & Schmidt, 2018). As Azano (2011) states, students are more engaged if curricula are relevant to them and “affirms their competencies” (p.2). These empirical studies point to increasing STEM interest through place-conscious inclusion of STEM content with similar ways of knowing.

As previously noted, place-conscious contextualization of STEM connections has increased interest and closed the gender gap in interest (Häussler, 1987). An 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 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 discern a useful purpose to math content (Cooper & Heaverlo, 2013). By furthering this idea with the incorporation of place-conscious pedagogy and informal programming, girls, as well as boys, may develop significant STEM interest.

Informal Programming

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 that often results in resources that can be used by others (Miller, 2012). The National Research Council (2015) noted that most definitions focus on science institutions, such as museums or science centers; however, community-based programs are becoming an essential infrastructure for STEM learning. Dierking et al. (2003) observed that science learning outside of school, such as community programs, lack empirical studies compared to museum-like settings. In informal program evaluation guidelines, particular attention has been paid to “cultural competency,” attention being given to the location of participant representation and the effects on the assessment protocol (Allen et al., 2008, p. 73).

Instructional Methods

Previous research has identified several instructional methods that have generated positive outcomes in informal programs (National Research Council, 2015; 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 the development of culminating projects (Buxton, 2010).

Hands-On

Instructional resources for informal programs characteristically contain hands-on activities, regardless of environment type (Allen et al., 2008). The activities require a participant's active physical involvement or manipulation (Flick & Lederman, 2004). Additionally, research has shown that situational interest/short-term interest can be fostered through hands-on activities and can maintain individual interest (Palmer et al., 2017; Renninger & Hidi, 2011).

Role Models

Research has demonstrated that role models influence the development of sustained STEM interest (National Research Council, 2009). A review of rural science education recommended nurturing dialogue between individuals, such as role models, in the community and their connection to STEM to increase students' value of rural knowledge and their connection with the STEM context (Avery, 2013). 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 that 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. 5). 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). 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 often learn science concepts in typical daily interactions with their rural community role models Avery & Kassam, 2011).

Culminating Projects

Historically, inquiry-based scientific education was geared toward student interest projects, including 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-interest levels in science (National Academies of Sciences, 2019). In rural science educational pedagogy, photo documentation allowed 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 participants' continued STEM interest (Ginorio et al., 2002).

STEM Interest

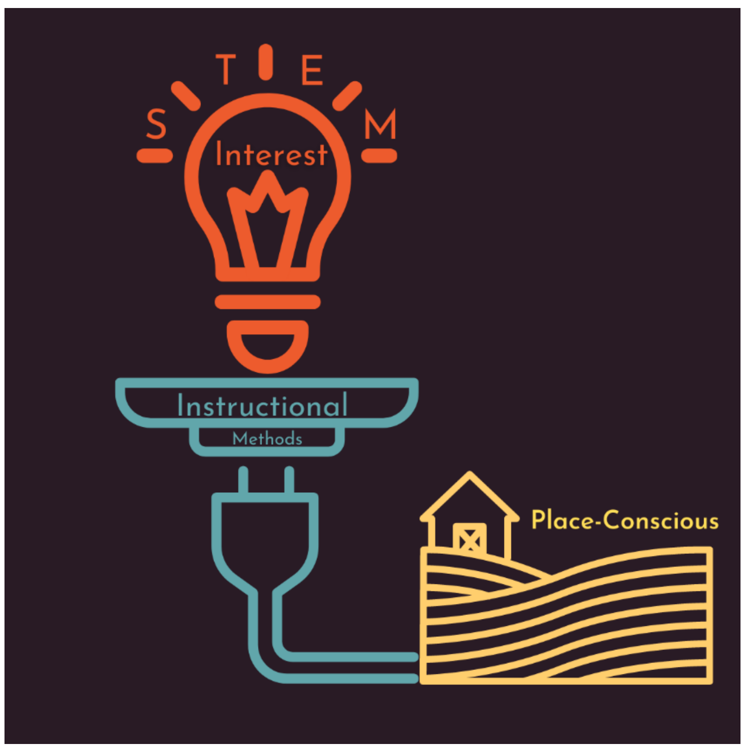
Informal learning programs "allow for the extended pursuit of learning agendas, the refinement of interests, the sharing of relevant learning resources and feedback, access to future learning experiences, and opportunities to be identified as having science-related interests" (National Research Council, 2009, p. 44). Interest, an influential factor in teaching and learning, has been explored for over 100 years yet remains elusive to researchers. A resurgence of research has been predominately geared toward its generation with text (Hidi, 1990). In research, interest has been described as having affective and cognitive components that help to increase student motivation to learn and increase understanding of the content (Silvia, 2008).

Conceptual Framework

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 framework has been informed by several theories, including those undergirding learning in informal contexts (Rogoff et al., 2016); the role of place-conscious pedagogy (Gruenewald, 2003b); and constructivist theories regarding how children develop STEM interest (Lent et al., 1994). (See Figure 1). By identifying place-conscious STEM factors prior to curriculum development, these STEM topics can be used to inform the informal STEM program's development and give a personal linkage to the participants' culture.

Figure 1

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



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. An informal program design allows for exploring youth STEM interest development based on instructional methods of an informal STEM program. 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).

In this conceptual framework, 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 and 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 participants' 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, 2003b), which achieves relevancy to a goal (Harackiewicz et al., 2016; Renninger, 2009). Next, 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, the 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.

Methodology

A case study design using multiple data collection methods (Bloomberg & Volpe, 2018; Yin, 1981) was employed to best answer the research question to gather and analyze qualitative data (Graue & Walsh, 1998). This 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 embedded in this work to increase STEM interest in an informal place-conscious STEM education program (Creswell, 2007). Qualitative data collected through observations and surveys 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). Primary data was collected with focus group interviews and provided an opportunity for youth to describe if and how the instructional method effectively supported their STEM interest development. Secondary data sources, observations, and self-report surveys provided an opportunity to present "converging lines of inquiry," which corroborated evidence from multiple sources (Yin 1994, p. 92). As noted by Polit and Beck (2010), "The goal of most qualitative studies is to provide a rich, contextualized understanding of human experience through the intensive study of particular cases" (p. 1452). Aptly, the goal of this study is to generate a rich 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 in a state that contains the largest number of rural school districts in the country (Showalter et al., 2019; 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 identified schools for this study. This NCES definition states that 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, 2007), the researcher identified the first district willing to participate in the study. Then, the superintendent provided recommendations for a neighboring school that would also 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-6 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.

Some grade levels are combined into one classroom in each school to accommodate the small populations and maximize classroom efficiency. Each school in this study has combined classrooms for the third and fourth grades and their fifth and sixth grades. Their class sizes range from three to thirteen students.

The two communities are similar in composition. Each has a post office, volunteer fire department, church building, and at least one restaurant. Each town comprises approximately one or two blocks of businesses 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, part paved and part 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. Both rural communities share a backdrop of scenic mountain skylines and a county border.

Currently, neither school has a comprehensive after-school program. One location previously offered a study hall but not a structured program for its youth. Geographic and student busing limitations impact the ability for these schools to provide after-school programming. Limited funding and human resources also prevent offering a regular informal program.

An Informal Place-Conscious STEM Program

In order to develop an informal place-conscious STEM program, a program should start with the core of gaining insight into funds of knowledge, and a more profound 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 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 are applied in an informal STEM program and provide opportunities to connect with youth’s own experiences (Renninger et al., 2015).

To further develop community knowledge, 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 (Montana State Legislature, 2018a, 2018b). These sources provide vital 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 their areas of expertise. This component 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: (a) hands-on activity, (b) role model discussion, and (c) a culminating project. The content was delivered every other week over a six-week timeline. An adult volunteer and a pre-service science educator facilitated each informal program lesson. Each lesson was scripted and piloted in a summer camp to ensure fidelity between the two sites. Each youth received a STEM journal and was prompted to record their reflections and thoughts during and after each lesson. Journaling has been shown to increase interest when paired with other activities for informal STEM programs (Ardoin et al., 2014).

The hands-on lesson included the building and testing of a water pump. This instructional method was presented as an inquiry with little instructional assistance. The youth were placed in groups of three, given an iPad with an instructional video (https://www.instructables.com/How-To-Make-A-PVC-Water-Air-Vacuum-Pump/), a bag of PVC pieces and PVC pipes, and two buckets, one of which one was filled with water. The students were instructed to build a pump with the given materials by watching the video. Additionally, they were instructed to move the water from one bucket to the other bucket with their constructed pump. They were able to test and calculate their pump’s flow rate with water by timing the flow from one bucket to another. They recorded some of their results in their notebooks. This allowed them to simulate the effort required to move water from one location to another.

Lastly, they were asked to reflect on where they have seen pumps or other means of moving water in their community. These reflections in 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 of natural history (Gruenewald, 2003b), this instructional method demonstrated 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. Initially, these role models assisted in curriculum design and program implementation. All identified STEM role models were invited to participate in training to support their communication with elementary school students. Hour-long training sessions were based on Techbridge's Role Models Matter Toolkit (https://www.techbridgegirls.org/rolemodelsmatter/toolkit/) to support the ability of role models to engage in relatable and child-friendly dialogue (Kekelis & Joyce, 2014). The researcher was 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 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 by STEM experts, can connect academic knowledge to local experience.

In the role model lesson, 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 of cultural journalism (Gruenewald, 2003b); 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, culminating projects, youth were placed in groups of two. They were invited to take photographs relating to their interpretation of pumps and irrigation in their community. Some provided the researcher local community water pictures, and others 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

1. Name and School or Town
2. Introduction–What I knew before about water
3. Pump Building–What I learned
4. Community Role Models-–What I learned
5. What I think about water now
6. What I think others should know.

Groups responded under each of the headings and selected pictures to add to their poster. Posters were printed and delivered to the school sites a week after the project was completed.

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 and provide an opportunity to share with their community. In alignment with place-conscious pedagogy of action research (Gruenewald, 2003b), this instructional method served as a platform for how youths' self-generated water data could help solve local community water sources and connect to similar global water issues.

Data Analysis

The data analyzed in this study were drawn from researcher developed observation protocol and focus group interview data and was analyzed using NVIVO™ software. Interest codes were determined a priori and loaded as nodes for both data sets into the software. Each participant was identified with attribute codes to anonymize them except for location, gender, and grade. Videos 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 activity levels. 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.

Frequencies were generated for the observation and focus group interview codes. The frequencies were used for pattern evaluation to represent the impact of each instructional method on STEM interest. Multiple 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, 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: a) physical interest indicators and b) emotional interest indicators. The data in each category were then partitioned into four naturally occurring clusters – labeled many, some, few, and very few – to represent the frequency of participants' responses or actions about STEM interest. This partitioning process 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 generated themes that spoke to the impact of each instructional method. Participants' quotes provided additional contextual details to tell a rich, detailed story of how interest developed during each instructional method.

Results

Effectiveness of Hands-On Activities on STEM Interest

Hands-on activities increased STEM interest through opportunities for collaboration. The youth were observed actively working together to build a pump with little direct instruction. They were focused on the hands-on build of the pump and observed putting together and taking apart the pump many times. Many participants did this until the pump moved water to the second bucket. The youth noted that the activity was challenging and was only successful if all group members worked together. They noted that their previous building experiences assisted them during the hands-on STEM activity. A participant 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. They were challenged by the pump building and left to figure out the build with limited resources. They were skeptical that a bag of PVC parts and PVC pipes would become a pump. As stated by participant, "I never knew you had to have all those parts to build one." They expressed interest in working in groups stating conflicting opinions about whether to work alone or with others. They were interested in the act of building with their hands. They 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. A participant stated, "I did not know that using so much force could make like water go into another bucket." They expressed interest in learning from mistakes, similar to a challenge or growth mindset (Dweck, 2008). These emotions and challenges are expressed by a participant, "*Like sometimes we get things wrong and then it's like, oh, I got it right, you kind of feel like YAY* [emphasis added]!" 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 of the youth. The table below displays data analysis of the focus groups.

Table 1

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**	

Effectiveness of Role Models on STEM Interest

The main finding for increasing STEM interest during the role model instructional method was discovering new community knowledge. The participants were particularly interested in the discussions about local water-related activities, including drilling wells and examples of ranching and farming pumps. Additionally, they were interested in writing their thoughts about the discussion, especially the younger participants, who enjoyed writing in their science notebooks. As expressed by a participant, “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.”

The youth appeared to be cognitively engaged at a higher activity level when understanding concepts explained by the community role models. They express mostly positive emotions about the ability to write during the role model activity, although once described themselves as “*happy with a sprinkle of bored [emphasis added]”* when needing to sit and listen. The novelty of the information was of interest to them, as noted by their comments and questions about drilling under the ground to reach the water. Many participants were able to connect the information to their home and community experiences and sometimes to future events like starting their family farm, which is also an indicator of interest. They were interested in learning new information and its relevance to their community, especially concerning ranch animals and people. A participant 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.” They were aware of the 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 actively engaged in constructing an understanding of the STEM water information for themselves. Table 2 below displays data analysis from focus groups.

Table 2.

Frequencies and percentages of variables coded during focus group from transcripts.

Instructional Method Role Model			
Interest Variable	**n**	**%**	**Qualitative Category**
Autonomy: Independence	7	10.7	Some
Challenge: Belief Conflict	7	10.7	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	13.8	Some
Novelty: New and Unusual	21	32.3	Many
Personal Relevance: Self Connection	9	13.8	Some
Activity Codes (N)	**65**	**100**	
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**	

Effectiveness of Culminating Projects on STEM Interest

The main finding for the culminating project is represented as active research (Gruenewald, 2003b), 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 work preparing and presenting the newly acquired knowledge actively. This included a desire for sharing that STEM knowledge with others in their community. A study sponsor had indicated the resulting posters could be publicly shared in a future event with their organization. As stated by a participant, “Because knowing that a lot of people are going to see it and you’re going to see how much kids can really do.” Another interesting finding during this third instructional method was how it correlated 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. The hands-on and culminating project shared most interest development through group work, whereas the role model and culminating project shared the majority of interest development through personal relevance.

This finding is supported by expressing many emotions, including happiness, pride, and excitement about designing posters and presenting them to their community. They showed physical and verbal signs of enjoyment during and after making their posters. Several individuals expressed being proud of creating a poster and presenting it to adults. A participant stated “*knowing that like the whole, like a lot of people could see it [emphasis added].*” There were mixed opinions of working alone or working in a group. The 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. They appeared to have deep knowledge of their partners since they attended school together. Some were aware of difficulties with specific individuals, and some noted strengths and comfortability with other individuals. A participant explained, “Not fun because of my partner, he is tired in the afternoon,” which is contrasted by another individual, “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.” They were interested in working with computers and learning new technology skills because of the higher cognitive and physical engagement of creating a digital poster. They 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 in their aspirations, as stated by one participant, “it made it more interesting to make stories, made me want to be an author one day.” They are interested in trying new things, demonstrating openness. Another participant stated, “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 the culminating project compounds interest development. Table 3 below displays data analysis from focus groups.

Table 3.

Frequencies and percentages of variables coded during focus group from transcripts.

Instructional Method			
Culminating Project			
Interest Variable	**n**	**%**	**Qualitative Category**
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
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**	

Overall Analysis

STEM interest was 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 grew from similar previous sources of group work and personal relevance and differently through autonomy and computers and technology. Please see Table 4 for meaningful STEM interest indicators during the overall study. Finally, these STEM interest findings indicate that an informal place-conscious curriculum can cultivate short-term situational interest. Future research should explore how this situational interest can be further developed into a longer lasting individual interest for the same individuals.

Table 4

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 *Group Work* Hands-On	**Emotionality** *Awareness*
Role Model	Cultural Journalism	New Community Knowledge	Novelty *Personal Relevance*	**Emotionality** *Activity Level*
Culminating Project	Action Research	Action Research	*Group Work* Autonomy Computer/Technology *Personal Relevance*	**Emotionality** *Activity Level* *Awareness*

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

Conclusions

Contributions to the Literature

Previous research has outlined five characteristics of students' interest development 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 their communities' critical environmental factor, water. Furthermore, this illustrates the importance of a place-conscious curriculum Greenwood, 2013) as a significant factor in 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 over six weeks allowing for time to reflect and notice water and pumps in their community. Youth revisited community water sources and engineering practices to interact with the content and build their interest (National Research Council, 2009).

Third, interest is displayed and observed in 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 use their knowledge in each instructional method while noting their interest feelings.

Fourth, previous research suggests that some younger individuals are not always aware of their interests (Renninger & Hidi, 2011). This was supported in the current study, as even when they 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 moving 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 and 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). Youth expressed their desire to share their knowledge even though there was no requirement. These study findings align with the five characteristics of interest development, and the study provides specific active and characteristic indicators that an informal place-conscious STEM program can develop interest in rural youth.

Future recommendations

Future studies should 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 and community relationship-building to assist with the recruitment of role models for cultural journalism with place-conscious pedagogy. This research provides a foundation for future work to extend these findings and develop additional pedagogical methodologies for informal and place-conscious designs.

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