

**Informal Science Education and Rural Science: A Case Study of Two Seventh Grade Life
Science Teachers**

by

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Abstract

The use of informal science education in rural areas, especially at rural middle schools has not been well documented. Although rural areas have accessible outdoor learning environments compared to urban areas, teachers are less likely to incorporate informal science activities. The purpose of this study was to evaluate two seventh grade life science teachers' interests and perspectives towards environmental literacy and stewardship while using a water monitoring curriculum. A total of 135 seventh grade students from 6 classes participated in this study. A case study strategy was used with purposeful sampling, which incorporated questionnaires, surveys, classroom observations, student artifacts, and teacher interviews to evaluate the interests and perspectives towards informal science.

Both teachers' interest in informal science initially came from their dads. In fact, their dad's interests in informal science education activities such as, visiting museums, gardening, farming, bee-keeping, and other outdoor activities transferred to the science interests of the two life science teachers in this study. Students showed a significant increase in their overall knowledge assessment scores after the water monitoring curriculum was implemented. Students significantly improved their environmental literacy knowledge (ELK) scores, but not in their stewardship knowledge (SK) scores. Although male students significantly improved their overall scores compared to females, females showed a significant increase in their ELK scores. The water monitoring curriculum enhanced teacher and student interest, and teachers highlighted their interest in implementing a water monitoring curriculum into the 7th grade life science

curriculum. The curriculum enhanced students' interests towards environmental literacy and water stewardship.

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Table of Contents

Abstract.....	ii
Acknowledgements.....	iv
List of Tables.....	ix
List of Abbreviations.....	x
Chapter 1	1
Statement of the Problem.....	1
Purpose of the Study.....	5
Subjectivity Statement.....	6
Role of the Researcher.....	8
The Role of Informal Science Education.....	9
Strategies Using an Informal Science Education Curriculum.....	12
Science Interests.....	16
Significance of the Study.....	18
Background on Environmental Literacy and the Field of Science Education.....	21
Theoretical Framework.....	23
Constructivism from a science teacher’s view on science.....	24
The Role of Misconceptions and How Students Understand Concepts.....	26
Chapter 2	28

Review of the Related Literature.....	28
Informal Science Education (ISE) and Rural Science Education (RSE).....	33
Citizen Science (CS) and Stewardship in Rural Science.....	39
Citizen Science and Water Monitoring.....	46
Public Participation in Scientific Research (PPSR).....	50
Chapter 3	53
Methodology.....	53
Limitations of the Study.....	62
Data Collection.....	65
Data Analysis.....	69
Researcher’s Role.....	72
Reliability.....	74
Validity.....	75
Chapter 4	77
Findings.....	77
Case Outline.....	78
Qualitative.....	79
Teacher Outdoor Observations.....	89

Interviews.....	92
Teacher Questionnaire.....	109
Student Artifacts.....	110
Water Monitoring Informal Science Activity.....	115
Quantitative.....	119
Chapter 5	128
Discussion and Implication.....	128
Discussion.....	130
Implications.....	143
References	145
Appendix 1 Foundational knowledge questionnaire to determine pre and post knowledge perspective changes for environmental literacy, stewardship, and informal science during the project. Subscales of this questionnaire were represented as adaptations from Jordan <i>et al.</i> (2011) for Environmental literacy, and Overdevest, Orr, & Stepenuck (2004) for Stewardship.....	172
Appendix 2 Science survey used in this study to determine students' interests towards science in rural areas. This survey was developed and used by Lamb, Annetta, Meldrum, & Vallett (2011).....	174
Appendix 3 Interview questions used to determine teacher's past lived informal science experiences and how these influenced current interests and perspectives towards teaching science. Interview question format has been adapted from King, Shumow, & Lietz (1999).....	176
Appendix 4 Interview questions used to determine teacher's perspectives after the completion of the water monitoring curriculum.....	178
Appendix 5 Environmental Literacy Quiz Multiple choice questionnaires adapted from Coyle (2005). True/False questionnaire adapted from Overdevest, Orr, & Stepenuck (2004)..	178
Appendix 6 Educator's guide evaluation for the water monitoring curriculum. The evaluation form is adapted from Georgia Adopt-A-Stream (2009). Please rate the following as: 1 = Poor, 2 = Below Average, 3 = Average, 4 = Good, 5 = Excellent.....	182

List of Tables

Table 1 Timeline of data collection throughout the phases of the research.....	82
Table 2 Code book for Mr. Clay.....	100
Table 3 Code book for Ms. May.....	102
Table 4 Overall responses by 7 th grade Life Science students (n=135, males = 78, females = 57, 6 classes) on the Student Science Interest survey.....	120
Table 5 Overall responses by 7 th grade life science male (N = 78) and female (N = 57) students on the environmental literacy knowledge (ELK) and stewardship knowledge (SK) quiz.....	125
Table 6 Illustration of the influence of gender on pre-post knowledge quizzes.....	125
Table 7 Illustration of teacher evaluation of the curriculum.....	126
Table 8 Report card showing student result on the Environmental Literacy Knowledge (ELK) and Stewardship Knowledge (SK) quizzes before and after the implementation of the curriculum.....	127

List of Abbreviations

NGSS	Next Generation Science Standards
EL	Environmental Literacy
ISE	Informal Science Education
SW	Stewardship

Informal Science Education and Rural Science: A Case Study of Two Seventh Grade Life
Science Teachers

Chapter 1: Statement of the Problem

Current interests related to the importance of environmental literacy needs to incur an increased interest and change in behavior towards the environment, as well as an awareness of the decisions citizens make that directly or indirectly affect their environment. These changes are becoming more necessary in rural areas where the environment is generally more available and conspicuous than in urban areas, and local knowledge of the flora and fauna has not been all lost. Informal science education can be used to promote science education in rural schools, and increase general environmental awareness.

Arnold, Newman, Gaddy, and Dean (2005) noted that rural schools typically face similar pressures as schools located in urban areas. For example, poverty among urban schools in Detroit transferred to low student scores on standardized tests, and similar outcomes are seen in rural areas (Arnold, Newman, Gaddy, & Dean, 2005). However, there are some unlikely differences that exist between rural and urban schools. For example, Abel and Sewell (1999) noted that teachers were likely to experience significantly more stress from poor working conditions and burnout at urban schools compared to rural schools. In fact, few studies have reported stress or burnout at rural schools (Rottier, Kelly, & Tomhave, 1983).

There are distinct barriers that exist between rural and urban schools in science, such as size, lack of funding, resources, specialized services, facilities, and retaining quality teachers (Barker, 1985; Burke & Edington, 1980; McCracken & Barcinas, 1991; Zuniga, Olsen, & Winter, 2005). Another distinct barrier between urban and rural schools is that rural schools are

isolated with respect to proximity to a metropolitan area, and may have difficulty with attracting qualified teachers, whom often shift their focus on schools located in urban areas (Arnold et al., 2005; Enochs, 1985). Not every barrier highlights a negative connotation. In fact, rural schools are noted to have a distinct feeling of family and community attention, which lean towards one positive aspect of attending a rural school (Dunne, 1983).

Surprisingly, the general belief of the public's view of science education in rural schools is that they are inferior in comparison to science education taught at urban settings (Ballou & Podgursky, 1998). One reason for this dilemma may be that rural schools mostly cover curriculum designed for an urban setting, which may or may not be appropriately based on limited access to resources (Ballou & Podgursky, 1998). Furthermore, teachers in rural settings lack the opportunity to collaborate with colleagues in their science-related fields to discuss relevant issues, because there are simply no avenues or resources to expand competitive advancement (Welch & Wagner, 1989; Zuniga, Olsen, & Winter, 2005).

The traditional formal science education setting, that is, the classroom, is designed to minimize external distractions from outside the classroom in order for students to successfully attain knowledge from their educators in a tightly restricted environment. Furthermore, it is where students acquire the skills and knowledge in learning science. This includes asking basic empirical questions about what things are, and how do these things generally work (Johnson & Mappin, 2005).

In the past, formal science education was highly dependent on rote learning through students memorizing difficult concepts, and science-related topics. Moreover, the classroom is where teachers depend on formative assessment to briefly determine how well students are

receiving the topic of discussion and/or instructional method. Consequently, the science classroom is the place of summative assessment where summary quizzes or tests are given to students, in order to determine for the most part, a test grade for the subject (Colburn, 2003).

Trends in science education have changed the learning and instructional methods of the past. For instance, rote learning techniques now give way to science inquiry and cooperative learning. However, evidence suggests that there are still issues pertaining to lack-luster test performances in science education for K-12. In fact, the National Science Board noted that students were declining in their interest of science and engineering-related fields in the mid-1980s (Drew, 2011). What has happened to the overall student interest in science taught in the formal classrooms in the United States?

In the past 25 years, secondary educators in science have noted that students are less likely to pursue future careers related to science (Rennie, 2006). Furthermore, students of diverse backgrounds and females have opted out of careers in science due to the lack of positive interests and acquisition of science literacy in the formal setting (Atwater, Colson, & Simpson, 1999; Roth & Barton, 2004). The lack of interest resulted from traditional pedagogy interests that reflected outdated information, boring content, and negligible instruction in science literacy, as well as a lack of opportunities for students of diverse backgrounds alienated students from pursuing science-related careers (Rennie, 2006).

Although there has been an overall decrease in the interest for science in the formal setting of the classroom, there is an increase interest in attending venues that harbor informal science. Venues such as zoos, museums, and hands-on centers like summer camps are continually providing examples where science is communicated in a positive manner to the

student (Braund & Reiss, 2006; Falk, 2001; Falk, 2002). For the most part, students are not aware of their knowledge acquisition throughout these informal visits, but they learn according to what interests them (Chandler & Swartzentruber, 2011; Falk, 2001).

The process of science learning involves acquiring knowledge and interests about the natural world, which is central to understanding scientific content. However, influencing formal education with topics of the environment is not easily implemented in the classroom. Educators revealed constant pressure to include current environmental issues into the broad spectrum of formal science, which are introduced in the classroom (Johnson & Mappin, 2005). Furthermore, although the importance of empowering both citizens and students to acquire knowledge and skills that highlight an increase in one's values to respect the environment is one goal of science education, educators experienced difficulties when managing curricula with topics pertaining to environmental issues (Johnson & Mappin, 2005). Ultimately, formal science education can utilize the resources of various types of trained professionals, as well as the experienced gained from doing actual science in the field through informal science education (Zoellick, Nelson, & Schauffler, 2012).

There are some barriers that may present a few issues with linking formal and informal education. For instance, formal education is cued by the application of knowledge through a guided course of study as noted in a set curriculum, whereas informal science focuses on interest and interaction. Furthermore, the goals of both are different, because formal education at schools is dominated by the pressures of accountability relative to students' test scores. Consequently, informal science learning provides experiences in a less stressful free-choice environment, compared to specific formal education learning agendas, which maintain stringent protocols (Fenichel & Schweingruber, 2010).

There are many challenges facing rural schools, such as high rates of poverty, low student academic achievements, younger staff members who are not equipped with the requirements to teach in the rural setting, and lower faculty salaries compared to their urban counterparts (Howley, Chadwick, & Howley, 2002; Welch & Wagner, 1989). In fact, the most common problem for rural teachers has been identified as isolation relative to proximity of larger cities where they may have access to resources and a better support system (Enochs, 1985; Howley, Chadwick, & Howley, 2002). The addition of new challenges, such as dynamic changes in state curricula may see teachers utilizing other popular ways to engage students. One popular method which can be used is the introduction of a citizen-based environmental monitoring program at school. These programs may be necessary to improve science interest in areas where outdoor learning environments are easily accessible.

Over the past 30 years, citizen volunteer monitoring programs have increased the participation of citizens involved in science, and have made monitoring programs popular in the United States (Overdeest, Orr, & Stepenuck, 2004). Citizen science brings together a better engagement between scientists and the public (Pocock & Evans, 2014). In fact, the term citizen science was coined as the public's participation in science research (Bonney et al., 2009). One goal of this research was to introduce the role and importance of citizen science as a form of informal science education to seventh grade life science classes in a rural area. Citizen science programs can increase both environmental and science literacy (Bonney et al., 2009; McCormick, Brown, & Zavestoski, 2003). Hence, teachers can eventually use the water monitoring curriculum introduced in this research to initiate student inquiry in an informal science setting. Students also can acquire knowledge on important environmental terms, such as pollution, sustainability, and stewardship.

Purpose of the Study

The purpose of this study was to examine the current science interests and perspectives of two 7th grade life science teachers and students at a rural middle school in the southeastern part of Alabama, in the United States. This study utilized two life science teachers to integrate a water monitoring curriculum developed by the Alabama Water Watch Program titled, “*Stream Biomonitoring*” to a total of 135 students in 6 classes. Additionally, this study investigated 7th grade life science student and teacher views towards how their current interests in science was shaped by prior experiences and influences. This study also evaluated the deep impact that past informal science experiences from the teachers’ backgrounds have had on their application of promoting informal science education. A case study format was used to answer the research questions.

The water monitoring curriculum was used to examine how informal science education can be used in a 7th grade rural classroom. Rural areas are ideal settings for understanding the complexity of nature and its relationship to the environment. Moreover, spatial biodiversity located in rural areas greatly outnumbers that of urban areas. Students living and attending rural schools may develop early concepts through their association with outdoor activities related with everyday life in their community. In fact, numerous students fail to make connections between what they learn in the classroom and what they see in their community.

Subjectivity Statement

The use of outdoor teaching experiences in a rural area can direct one’s future career path towards a science-related field. For example, my past experiences learning science in an informal setting illustrates an example that early exposure to science beyond the classroom can motivate

and increase one's interest in science, leading to a future science-related career. Additionally, the positive influence of a teacher on a student can foster the initial growth of science interest.

For example, my former high school biology teacher in Trinidad possessed the resources to take her students to the north eastern coast of Trinidad where students conducted ecological surveys of the coral reefs. Students developed their own research questions, which often were discussed with their peers. Each student sought input from others to improve their experimental designs. Additionally, almost every student required the assistance of their peers in order to complete their project, which illustrated corporation amongst young scientists.

This initial experience was the impetus for my M.S. thesis titled, “*Analysis of coral distribution and coral symbionts in a patch reef and fringing reef in the Southern Caribbean,*” more than a decade later at Middle Tennessee State University, Murfreesboro, Tennessee. Furthermore, an opportunity to meet other scientists in the field of my interest allowed me to determine specific research questions, which persuaded me to develop future collaborations with two major science laboratories at research institutions. Later on, research at these laboratories allowed me to gain experience on what scientists actually do in their laboratories. Additionally, these scientists encouraged me to continue research in my field of interest beyond the master’s level, hence the mentorship from these scientists motivated me to pursue an active role in informal science education.

With this knowledge to share science, I’ve taken the challenge to assist a rural community located near the only fringing coral reef in Trinidad by developing a coral reef ecosystem awareness plan. Currently, posters illustrating coral reef diversity have been strategically placed at visible areas within the community in order to increase public awareness

of coral reef ecosystems. I also have been invited as a guest speaker to present information on the status of coral reefs to local university student lectures where this opportunity provided a platform to share knowledge on the science of coral reefs.

Past research opportunities related to marine biology in the Indian and Atlantic Oceans have provided further educational experiences to assist me with promoting awareness about informal science education and the role it plays in enhancing environmental literacy and stewardship. Ultimately, the initial exposure to coral reefs allowed me to identify coral reef biodiversity as a resource that supplemented content knowledge obtained from prior science-related courses. Based on my own prior and lived experiences, exposure to informal science education through my local high school influenced my career choice and it is my goal to promote informal science education to hopefully encourage students from rural, underserved areas to pursue science-related careers, as well.

Role of the Researcher

I believe that students are explorers possessing prior knowledge from past experiences, seeking to add to an already existing foundation of what they know. Students learn in a variety of ways, and the skills and knowledge obtained are key facets in becoming a productive member of society. Students can learn in any environment, but environments that enhance their curiosity and interest, and related to their life are effectively added to their growing knowledge. The teaching environment is one that emphasizes open-ended questions, which initiate student discussion, and emphasize learning for all levels of diverse learners.

My role as a researcher for this study is to expand students' environmental awareness and literacy regarding the natural world around them. As a result of exposure to science in the

informal setting relative to their own community and neighboring areas, students will gain a better sense of stewardship and as their present and future behaviors towards the environment will have both direct and indirect effects on it. With this in mind, my instructional methods are based on a constructivism paradigm. Ultimately, my goals focus on determining (a) the quantity and quality of students' prior knowledge (b) the use of science-inquiry to initiate student-centered discussion and problem-solving, and (c) increase student interest in science by illustrating the importance of the scientific process in their lives and the environment around them.

Students will be responsible for obtaining the skills that will allow them to make future decisions, which will favor society and the environment. They will learn to problem solve, understand the consequences of decisions, and know the process that science undergoes in order to determine the best possible solution to answer a question. To achieve these important values, I will encourage students to explore science, and assist them in developing their interest towards science, because their growth results in the future growth of stewardship in our society. Moreover, students will learn that participatory action must follow stewardship.

The Role of Informal Science Education

In his book titled *Last Child in the Woods*, the author Richard Louv stated that there has been a general decline in outdoor activities and space available for children to connect with the natural world. He stated that "nature inspires creativity in a child by demanding visualization and the full use of the senses" (Louv, 2005, p.7). Presently, increased indoor activities brought about by advances in technology have changed society's interests toward pursuing outdoor playtime.

Such considerable decline was also brought about by safety concerns of children playing outdoors.

Louv (2005) eventually developed the term “nature-deficit disorder” to illustrate this paradigm. His disorder is a serious dilemma because most science learning is obtained outside the walls of the classroom (Falk & Dierking, 2010a). In fact, Falk and Dierking (2010a) further asserted that the public learns science, and the experience of learning at informal venues can persist for at least two years. Family trips to informal science venues, such as zoos, parks, and museums seem to be associated with family vacations. Interestingly, children are more likely to interact with a hands-on exhibit than parents (Dierking & Falk, 1994). Hence, informal science venues play an important role in transferring science information to children.

It is imperative that we expose students to informal science activities, by incorporating these activities to supplement content knowledge in the classroom. This exposure formulates initiating and generating student interest in science. In fact, exposure to informal science education at non-classroom settings also can influence underrepresented students to pursue science-related fields (Jones, 1997). We implement science research because we ask questions, which seek to add science knowledge during the process of answering these questions.

We learn something every day throughout our lives (Falk, 2002). This learning mostly takes place outside the classroom at informal science settings (Falk, 2001). As Jones (1997) stated, “the role of informal science setting in making science appealing to youth has become widely recognized” (see Rahm & Moore, 2005, p. 283). This change in attitude is not only due to a change in the physical location where the learning takes place, but is due to the learner’s choice of what is interesting at these informal science settings.

School field trips provide a supplemental learning experience away from the typical classroom experience (Fenichel & Schweingruber, 2010). These trips provide a bridge between the classroom and traditional informal science venues, such as museums and zoos, where students may enjoy a break from school. Museums are the typical school trip venues of choice. Falk and Dierking (2010b) noted that both students and adults could recall a school field trip. In fact, participants recalled where and when they visited, who were on the field trip, and some of the features of the trip. Falk and Dierking (2010b) stated that, “learning is the process of applying prior knowledge and experience to new experiences.” (p. 212). Moreover, concepts learned from these trips can assist in decision-making and problem-solving.

Consequently, school trips are organized by teachers, and it is the teachers that are the most important resources present in schools (King, Shumow, & Lietz, 1999). Past research has shown that teachers at the elementary education level fail to make an impression relative to science on students due to several issues, such as lack of resources, and being unqualified (Darling-Hammond & Hudson, 1989). Females also are excluded away from math and science courses (Beane, 1988). Ultimately, females and traditionally underrepresented groups have been steered away from science-related and engineering careers as a result of “tracking” in the past (Carter, 1970; Oakes, 2005; Oakes & Lipton, 1999; Russell, 2005, Zuniga, Olson, & Winter, 2005). Oakes (2005) described tracking as, “sorting students according to preconceptions based on race and social class and providing them with different and unequal access” (Oakes, 2005, p. 103). Additionally, Carter (1970) stated that tracking is, “an extreme form of ability grouping involving the permanent assignment of children to classrooms or sections composed of individuals assumed to have like abilities, interests, or other characteristics” (p. 87). These issues have transferred to lower representation in science and mathematics of underrepresented groups

at the undergraduate and graduate educational levels (Oakes, 1990). In fact, the K-12 science, technology, engineering, and mathematics (STEM) career-based interest in the United States have been described as “leaky” in terms of its overall science education (NGSS, 2013, p. xv).

Strategies Using an Informal Science Education Curriculum

The average American adult does not perform well on national testing in science knowledge (Coyle, 2005; Dierking & Falk, 2003). Moreover, past research has shown that at least a third of adults assert their knowledge in science to have developed primarily from school, and half of them attribute their science knowledge obtained from memories of specific leisure trips (Anderson, Piscitelli, Weier, Everett, & Taylor, 2002; Brody, Tomkiewicz, & Graves, 2002; Falk, 2002; Falk & Dierking, 2002; Dierking & Falk, 2003).

Free-choice learning is a way for students to experience science. Falk (2005) asserted that “free choice learning is relative, rather than an absolute construct and the operative issue is perceived choice and control by the learner” (Falk, 2005, p. 273). A lot of the research on free-choice learning has been done at museums, because it is one of the most popular free-choice learning environments, and regularly used during school field trips. For example, Bamberger and Tal (2006) observed 750 students at 4 museums and found four levels of choice that affected student learning. Moreover, they noted that students connected any type of choice learning with their own life experiences and prior knowledge. At schools, teachers can play a significant role in raising the environmental literacy of a population (Loubser, Swanepoel, & Chacko, 2001). An emphasis on informal science education is a way to alleviate this dilemma by exposing science to individuals in a more excited, relaxed and uplifting setting, and thus expanding positive interests for overall science literacy (Braund & Reiss, 2006).

More specifically, the current trend in population escalation and energy-use in urban areas is creating further disconnections between students and their understanding of the importance of their environment and stewardship. Learning can be initiated by an out-of-school visit to informal science venues (Braund & Reiss, 2006; Falk & Dierking, 1992; Falk, 2001). Hence, there is a need to connect out-of-school experiences with the formal content of environmental education. For example, water quality topics are excellent opportunities to expose students to the importance of environmental literacy and stewardship through the implementation of science activities. Carroll, Mueller, and Saul (2009) asserted that water quality topics enhance teacher confidence to implement science inquiry-based learning into their relative curriculum. Furthermore, teachers with more experience in content relative to environmental education and implementation (i.e. nature-based activities outside the class) became more effective environmental educators (Carroll, Mueller, & Saul, 2009). Relative to water quality, long-term monitoring initiatives may be necessary to better aid teachers to promote environmental literacy in their classrooms.

Additionally, widespread concerns about the impacts of anthropogenic effects on ecosystems have influenced the need, and importance of long-term environmental monitoring data sets that examine environmental change. Long-term monitoring is necessary to follow patterns in the environment (Parr, Sier, Battarbee, Mackay, & Burgess, 2003). The connection between science and environmental education has many benefits towards promoting environmental literacy and stewardship. Firth (1998) described this connection as most effective when coupling science education with discovery learning. “Discovery” learning approaches to teaching science are designed to introduce the content material in an engaging manner that encourages student inquiry (Hammer, 1997). Make no mistake, the last 25 years has brought

about a dynamic change between science and our society, in that the gap has lessened between these two entities, and thus has led to improvements in the relationship between both parties (Parr et al., 2003).

Informal science education is the utilization of out-of-school settings to acquire knowledge of the natural world (Falk, 2001; Falk, 2002; Rennie, 2007). In fact, informal science learning extends beyond the formal setting of the classroom, and is not restricted by structured curricula, where assessments are required (Hofstein & Rosenfeld, 1996). Surprisingly, much of the research on informal science has mainly focused on museums, zoos, and nature centers, which only represents a few cases where informal science learning occurs (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003). This research explored informal science education from a different perspective through a curriculum designed to be mostly used in outdoor settings, as in a school located in a rural area. Consequently, rural schools may not be located near “traditional” informal science venues, such as zoos, museums, and nature parks. Hence, there is a call to explore other types of informal science education opportunities in the rural setting. For example, many rural schools are situated next to lakes, streams, and ponds, which provide students with opportunities to experience outdoor activities through water monitoring programs.

Falk, Storksdiel, and Dierking (2007) investigated the public’s overall view of science. Their findings showed that almost half of the participants reported that their current knowledge in science was derived at informal science settings and venues. Participants did claim that their interests and curiosity played a large role in what they wanted to learn, as well as how these interests related to their lives. For instance, adults take vacations and sometimes visit nature centers, parks, and botanical gardens to relax, attain intellectual satisfaction, or find spiritual fulfillment (Ballantyne & Packer, 2005). Children experience fun, and learned science at these

informal science settings as a result of accompanying their parents on vacations (Dierking & Falk, 2003).

Current issues with applying informal science education as a source to supplement science learning in the classroom mainly revolves around the notion that schools are the only place where and when students learn (Falk & Dierking, 2010a). Additionally, children in the U.S. older than 12 years have less informal science learning opportunities than their younger counterparts at traditional informal science settings. Dierking and Falk (2003) asserted that an informal science learning sector is important for youth development in science, and evidence has shown that school, work, and informal science learning overlap well in youth's lives.

Informal science learning arguably first takes place in the home, and this is essential for children's first development of knowledge about the environment (Kola-Olusanya, 2005). Hence, parents and immediate family members play an important role in youth development of environmental awareness. Interestingly, friends serve as important social elements in learning as well. Falk and Dierking (2002) noted that playing outdoors allow children to investigate the natural world on their own terms. Hence, neighborhood yards, streets, and ponds serve as the initial places where children first begin to experience informal science. Moreover, streams and ponds located in rural areas are easily accessible relative to urban areas, hence can be used to introduce a water monitoring curriculum.

Relative to water monitoring, informal science education can be an essential tool, which can generate awareness for one of the most valuable commodities of the environment, which is water quality. Moreover, students demonstrating curiosity in water pollution and "health" of waterways in rural areas are exposed to macroinvertebrates, which are tiny organisms visible to

the naked eye, and their presence and abundance can provide a representative of “health” relative to the particular waterway (i.e. stream, pond, and river). The addition of relevant knowledge pertaining to the waterways of Alabama can give teachers and students a sense of how water monitoring is related to their everyday lives, and should be an essential program in rural areas.

Students in rural areas should have an opportunity to realize that science can be done outdoors. Water monitoring protocols can be used to illustrate that science does not necessarily only take place in some top secret lab, and experiments are not only carried out by men dressed in white laboratory coats. Furthermore, science teachers in rural areas can use water monitoring curriculum as an alternate informal science teaching resource in rural areas. The objective of science is to encourage an interest and awareness in our environment, and to share the knowledge obtained from the skills acquired during the process of learning.

Science Interests

Koballa (1988) noted that simple statements, such as, “I love to teach science” or “I like science” are expressions of interests towards science. Overall, expressions may illustrate an individual’s likes or dislikes for science, that is, “a positive or negative feeling about science” (Koballa & Crawley, 1985, p. 223). With this in mind, Aslan and Aslan (2009) agreed that the interests of teachers are very important in science.

In the United States, the use of science inquiry based teaching in schools has been encouraged for K-12, and many classroom teachers are committed to follow curriculum (King, 2007). Teachers are guided by the textbook content, and fail to even think about informal science as a method to peak student interests in science. In fact, teachers in elementary schools seldom engage students in science inquiry (Weiss, 1997). Bulunuz (2007) noted that teachers who

possess a negative attitude towards science will undoubtedly be less involved in teaching science through inquiry. Furthermore, an inexperienced science teacher who fails to develop science literacy in their students decreases the preparation of the next generation of policy makers. Overall, negative interests in elementary school teachers, which developed from past experiences at their former elementary and high schools transfer to the way they feel about science (Watters & Ginns, 2000).

The importance of students experiencing science outside the classroom in a rural setting promotes science literacy, environmental literacy, and stewardship. Moreover, encouraging students to view science relative to their lives through water monitoring allows them the opportunity to learn agriculture-related science, the ecology of streams, ponds, lakes, environmental pollution issues, and biodiversity in rural areas. Ultimately, although exposure to these informal science activities may play a significant role in keeping them in the science pipeline, it is up to their teachers to guide their interest in science.

Currently, there is a need for information on the interests that both students and science teachers have for after-school science in rural areas in Alabama. After-school programs may offer some hands-on activities, but these activities are focused on youth development and not informal science education (Delgado, 2002). However, transforming these programs to expand environmental literacy, and stewardship can serve to provide communities with vibrant youth curiosity, and a safe place to explore new ideas (Rahm & Moore, 2005). Additionally, participants in these after-school programs who may not pursue science can obtain the skills necessary to be successful in other areas (Atwater, Colson, & Simpson, 1999).

Teachers that may not have gained past exposure or familiarity to informal science education will not utilize their “back yard” located in rural areas. Both teachers and students’ perception of scientists may fail to veer away from the traditional view of scientists. For instance, students actively represented science being done strictly indoors, and scientists illustrated as elderly white males wearing glasses dressed in lab coats, and holding a test tube over a Bunsen burner (Korkmaz & Kavak, 2010). Additionally, students’ perception of scientists was generally similar across gender, age, and period of time (Finson, 2002).

Significance of the Study

Chepesiuk (2007) stated that “each day people make decisions that affect the environment” (Chepesiuk, 2007, p. 496). Environmental literacy has to incorporate youth as they are the next generation policy makers (Carroll, Mueller, & Saul, 2009). Additionally, all students should be knowledgeable about the natural world around them. This is essentially the goal of expanding environmental literacy. Moreover, science teachers should be more prepared at implementing curriculum that promotes environmental literacy and stewardship. Consequently, promoting interest in science allow children to share their knowledge with parents, which can impact all stakeholders in the community.

Increased environmental awareness enables a citizen to become a better consumer and steward for the environment. It allows a person to recycle more and pollute less. From energy conservation to increased physical activity, it’s economically viable to all stakeholders, especially those in rural areas. Teachers can assist students during the process of problem solving and decision making, which are important aspects of changing the way they use water. Ultimately, they can share their knowledge with family and friends in their community, and thus

make a positive impact on overall environmental sustainability. Using less energy and recycling is economical, and it positively impacts water quality and sustainability.

Acquiring awareness can initiate changes in citizen interest towards water quality and sustainability in rural areas. Policy changes can be influenced by community-based water monitoring programs. Student-based water monitoring implemented from using curricula can develop the need for ongoing data collection, which can be used to determine changes over a long period. Consequently, spontaneous change in water chemistry can initiate participatory action. Teacher collaborations with local scientists can foster a relationship, which benefits students by assisting them in pursuing science-related careers (Ledley, Haddad, Lockwood, & Brooks, 2003).

Additionally, science teachers can gain confidence in using lesson plans that utilize outdoor activities at informal science settings. Generally, educators believe that children learn the principles of stewardship at an early age (Chepesiuk, 2007). Furthermore, science teachers realize that science literacy is an important subject matter among youth (King, Shumow, & Lietz, 1999). Hence, the need to determine interests and perspectives involved in the teacher's use of informal science in rural areas to achieve environmental literacy and stewardship.

Positive interactions between the human-environment associations in science can enhance public knowledge of science in our society. In fact, a scientifically literate society must have a knowledge and understanding of science (Chiappetta & Koballa, 2006). The ever increasing human population (now 7 billion) has placed an undoubtedly heavy strain on the ecosystem services of the environment (Postel, 2000). There is a higher ecological footprint per person, and an increasingly insurmountable loss of species due to extinction from loss of habitat

(Hoekstra, 2009). Water monitoring collects environmental data over a long period of time, and results can be used to answer long-term changes in the environment. Teachers in rural areas may possess the right resources, such as ponds or streams to implement a sense of awareness concerning water pollution and environmental resource use. Additionally, by using various water monitoring protocols, teachers can initiate the topic of stewardship through outdoor lessons at informal settings.

This study was designed to investigate science interests of two 7th grade life science teachers and a total of 135 students they taught in 6 classes at a rural middle school in the southeastern part of the United States. This study examined the science teachers and students perspectives towards informal science education after participating in water monitoring outdoor activities that were implemented as an informal science education strategy based on a water monitoring curriculum. The study was guided by current 7th grade life science student and teacher current interests in science, which were shaped from prior experiences and influences. This study also determined the impact that past informal science experiences on the teacher's application of teaching science in their classroom. The impact on pre and post knowledge assessment quizzes relative to the implementation of a water monitoring curriculum presented further detail on perspectives on informal science learning in a rural setting.

This mixed methods study focused on two life science teachers at a rural school in the southeastern part of the United States and their interests and perspectives on using informal science education. Survey questionnaires, classroom observations, and interviews were used to collect data prior to and after the implementation of the curriculum. Research questions driving this investigation were as follows:

(1) How does implementation of a water monitoring curriculum impact 7th grade life science

teacher interests and perspectives towards environmental literacy and stewardship in the classroom?

(2) How does implementation of the curriculum impact 7th grade life science students' interests towards environmental literacy and stewardship?

(3) What are 7th grade life science students' science interests in a rural middle school?

(4) How has past informal science activities in the lives of 7th grade life science teachers influenced interests and perspectives towards teaching science?

Background on Environmental Literacy and the Field of Science Education

Definition of Terms

For the purpose of this research, the researcher defined the key aspects and terms that were used throughout the study:

Environmental Literacy. Golley (1998) suggested that environmental literacy was essentially the organized way to think about the environment. The term environmental science literacy is sometimes used synonymously with environmental literacy, and it is the capacity to understand and carry out evidence-based decisions related to human effects on the environment (Covitt, Gunkel, & Anderson, 2009). Overall, environmental literacy is viewed as interactions of the physical characteristics of the environment itself coupled with a change in behavior towards the environment (Roth, 1992).

Informal Science Education. This is the utilization of out-of-school settings to share knowledge about the natural world mostly to the public (Falk, 2001; Falk, 2002; Rennie, 2007). Informal science allows for learning in a less structured environment than represented in the classroom. The addition of knowledge related to science learning, which allow an individual to

positively enhance their behavior, and improve their responsibility to society is science literacy (Colburn, 2003). Moreover, science literacy is not only obtained in the formal classroom, but mostly acquired from events related to free-choice learning experiences, such as a visit to the zoo, museum, nature center, a walk in the park, or the use of media to gather information (Falk, 2002; Falk, 2005; Kola-Olusanya, 2005).

Free-Choice Learning. Learning at informal science venues and various informal science-related experiences is defined as free-choice learning, where the learning experiences are totally the responsibility of the participant (Falk, 2002; Falk & Dierking, 2002; Falk, 2005). In fact, participants control what, where, and how they learn, but everyone ultimately learns something at venues, such as museums, zoos, nature centers, or during activities like surfing the internet, watching nature programs on the television, and during field trips (Kola-Olusanya, 2005). However, free-choice science learning events may not provide the same educational experience to everyone (Falk & Adelman, 2003). The levels of learning through free-choice learning are dependent on the interests of the learner, as well as how the learning relates to their lives (Bamberger & Tal, 2006).

Science Literacy. Science literacy can be viewed as the acquisition of skills, knowledge, understanding of scientific concepts, and an overall positive outlook about the natural world required by all citizens to make decisions, and function in the society (Colburn, 2003, p. 5; DeBoer, 2000). It is an overall understanding of scientific content, and a change in thought processing related to science (Evans, Abrams, Reitsma, Roux, Salmonsens, & Marra, 2005). In other words, it allows an individual to make sense of the scientific world, using ever-increasing advances in technology, to answer scientific questions. Building literacy skills in science is important in gaining knowledge (NGSS, 2013). Furthermore, Schmidt et al. (2011) defined

science literacy as a functional knowledge of the laws that guide the behavior of the natural world, and appropriately applying these laws in various situations. Thus, an important goal of science literacy is to have citizens identify scientific issues, understand the issues involved in generating these situations, and use the former to develop conclusions from scientific arguments, which inevitably improves the overall job productivity and interests of society (Hsu, 2004).

Informal science education has the potential to be included as a strategy to increase SL at schools. For instance, informal environment, such as zoos, museums, and nature centers may broaden the participation in science and engineering in communities (NGSS, 2013). The Next Generation Science Standards (NGSS) stated, “informal environments for science learning should be developed and implemented with the interests and concerns of particular cultural groups and communities in mind.” (NGSS, 2013, p. 33). Additionally, the NGSS mentioned the importance of developing these informal environments in a manner that uses cultural practices.

Theoretical Framework

This study used constructivism as the theoretical framework in order to build on student and teacher awareness and knowledge in environmental literacy and stewardship. Constructivism is essentially a philosophical view, an epistemology, a theory of knowledge on how we come to know (Lorsbach & Tobin, 1997; Savery & Duffy, 1995). Lebow (1993) described constructivism as having several values, such as collaboration, reflectivity, active engagement, and personal relevance (Lebow, 1993, p. 5). Doran, Chan, Tamir, and Lenhardt (2002) noted that “the constructivist approach begins with a focus on what a person already know about the world around them and on their understanding of this world.” Fosnot (2005) described constructivism as “a theory of knowledge and learning, which highlights how a person comes to know what

he/she knows, that is, the theory of knowing” (Fosnot, 2005, *ix*; von Glasersfeld, 1989). Ernst von Glasersfeld further noted that, “knowledge does not exist outside a person’s mind” (Glasersfeld, 2005, p. 5). In fact, each person may learn a similar construct, but in a subjective manner, or as stated by Keiny (1994) “knowledge is a construction of the individual’s subjective reality” (Keiny, 1994, p. 157). It involves a deep understanding of the complex relationships between concepts of a topic acquired through experiences of the world. Additionally, ongoing cognitive development explores how the mental processes of the human mind acquire knowledge.

Constructivism does not include our discovery of knowledge, but it relies on our construction of new concepts through the experiences we gain (Schwandt, 2007). It does not view knowledge as a separate entity (Keiny, 1994). Creswell (2007) defined constructivism as an understanding of the world we live in using subjective meanings to describe lived experiences. These experiences form concepts, which may represent what we think about the world (Lincoln & Guba, 1985). Ultimately, it is the learners’ acquired concepts about the world and how it works, which are brought into any place where learning occurs (Colburn, 2003).

Constructivism from a Science Teacher’s View on Science

Tobin (1993) stated that teachers use the constructivism learning strategy to utilize what students already know, and design activities that incorporate social interaction between learners, with the intention to initiate an improvement in problem-solving skills, as well as providing new sensory experiences. These experiences can come through visual, auditory, olfactory, gustatory, and tactile interactions with the environment (Lorsback & Tobin, 1997). Furthermore, since all

learning must be constructed, it is essential to develop knowledge of science concepts, which the educators will need in their future.

One essential part of constructing new concepts is breaking acquired misconceptions. For instance, ethnicity, language, culture, gender, socioeconomic status, social justice, and equity are just a few factors involved in shaping student knowledge, which they eventually bring to the classroom (Banks et al., 2001; Nieto, 2000; Rupley & Slough, 2010). Furthermore, experiences such as movies influence the building of constructs, which may be perceived as misconceptions later on (Berumen, 2008).

Constructivism in this study highlighted the interests and perspectives of students and teachers on environmental literacy and stewardship built from their past lived experiences, and brought to the classroom as their current beliefs. These beliefs more or less illustrated their current interests towards informal science education and science interest. An ontological perspective would be formed from the realities of current constructs illustrated from social experiences. Additionally, the epistemology of creating subjective beliefs from created findings can serve as critical points in the research, because past constructs form the foundation of their current knowledge played an important role in building new constructs (Creswell, 2013).

The constructivist perspectives guided the following research assumptions: (a) interests and perspectives of 7th grade life science teachers towards environmental literacy and stewardship will increase their use of informal science activities, and encourage water monitoring in their immediate rural area; (b) students' interests and perspectives towards environmental literacy and stewardship will improve their current knowledge in science as a result of the implementation of the water monitoring curriculum; (c) students' interests towards

science are dynamically related to free-choice learning settings, which they have experienced in their past; and (d) the interests and perspectives of 7th grade life science teachers have been constructed from informal science settings at particular junctions in their lives, and these experiences may have influenced some methods of how they currently teach science in their classrooms.

The Role of Misconceptions and How Students Understand Concepts

Learning can be family-oriented, or through group interactions (Finichel & Schweingruber, 2010). These learning experiences are short-term with respect to the science material presented, and they encourage participants to engage, and acquire knowledge in the field of science (Falk, 2002). Learning at these informal science venues is defined as free-choice learning where these experiences are totally the responsibility of the participant (Falk, 2002; Falk, 2005). In fact, participants control what, where, and how they learn, but everyone ultimately learns something at these venues. Free-choice science learning institutions may not provide the same educational experience to everyone (Falk & Adelman, 2003).

Falk and Dierking (2002) noted that the average American citizen spends a huge amount of time learning at various informal learning settings, which may vary from computer camp to tennis camp, or listening to poetry at a bookstore. In fact, Falk and Dierking (2002) reported on the misconception that many people believe learning only takes place in a classroom filled with rows of students being lectured by a teacher. Interestingly, you can find an informal learning setting almost anywhere, because it is all around us. Consequently, what you learn and how you learn is dependent on where you learn (Falk & Dierking, 2002). Moreover, the impact of

informal learning is dependent on what happens before, during, and after the particular experience (Fenichel & Schweingruber, 2010).

At any informal science learning venue, the amount of learning that occurs is dependent on the participant. For example, participants may choose not to pay attention to tour guides or docents, and therefore maintain an untrue concept, which had been acquired through some past experience (Falk & Adelman, 2003). However, this neglect should not alienate the sense of wonder, enthusiasm, and eagerness to learn at these informal science venues (Pedretti, 2002). In addition, the benefits of learning in nonthreatening environments enhance positive interests for girls learning challenging concepts, which are traditionally viewed as male-dominated (Ramey-Gassert, 1996).

Early misconceptions in science can be indirectly alleviated by parents when they take their children to parks, nature preserves, or aquaria during their vacation. Outreach programs can build credible knowledge because they generally encompass the work of faculty, scientists, and graduate students to assist in a variety of activities. These may range from giving seminars, presentations, and lectures at after-school programs to judging in science fairs. However, although the interactions of the above mentioned personnel with students and educators are a valuable tool for learning in an informal science setting, most participants view outreach as volunteer tasks or a chance to improve on their communication skills rather than an opportunity to assist in the development of science literacy (Andrews, Weaver, Hanley, Shamatha, & Melton, 2005).

Misconceptions about science exist because of participants' inability to build from lower to higher cognitive thinking (Goodwin & Metz, 2011). In other words, misconceptions about a

science concept may hinder corrections when new lived experiences become apparent. Many students may revert back to prior conceived misconceptions after the actual truth is revealed. Educators' concerns about how to break these misconceptions, introduce the correct idea, and then build on this through conceptual change may be difficult. Hence, the reason why informal science should be utilized to supplement science content to overcome common misconceptions in science received from various sources, such as parents, teachers, media, folklore, and textbooks.

Chapter 2: Review of the Related Literature

Promoting Environmental Literacy (EL) and Stewardship (SW)

Although Golley (1998) defined environmental literacy (EL) as the organized way to think about the environment, Gayford (2002) noted that environmental literacy was initially not well defined. In fact, environmental literacy was originally described as interactions of the physical characteristics of the environment itself, coupled with a change in behavior towards the environment (Roth, 1992). Additionally, interactions between organisms and the environment, as well as between organisms of different species are essential relationships that occur within the environment, and may be used to extend the definition of EL.

Environmental literacy has gained popularity due to global issues within the last fifty years. For example, current patterns of climate change influenced by human activities, known as anthropogenic effects, may alter direct and indirect relationships among species due in part to the dynamic nature of the human-environment relationship (Belford & Phillip, 2011). The loss of species habitat and degradation are just a few consequences of the current growing human population that can change the flow of associations within ecosystems. Consequently, science

literacy of any kind is used in an attempt to minimize these ongoing dilemmas.

Reynolds, Brondizio, and Robinson (2010, p.18) suggested that environmental literacy should include an understanding of how social and economic decisions influence the human-environment interactions. In general, the complexities of improving environmental literacy are dynamic because it involves various levels of education, gender, cultural diversity, and socio-economic status of all involved stakeholders.

Furthermore, at least four stages are representative of the overall process of gaining environmental literacy: (1) awareness, (2) attaining skills, (3) knowledge and behavior, and (4) stewardship. Additionally, understanding terms like ecosystem services, ecological footprints, and sustainability are all facets of teaching environmental literacy at any level (Reynolds, Brondizio, & Robinson, 2010). Falk and Dierking (1992) noted that increasing knowledge is a result of interactions with friends, family, educators, and other citizens in the society, which is filtered through prior knowledge and past experiences. Americans may not efficiently transfer correct knowledge from these interactions. For instance, Coyle (2005) noted that Americans think they know more about science than they actually do because of the improvement of how Americans acquire most of their knowledge, which is mainly through media.

The acquisition of science knowledge through media is another means of transferring EL to society, however there are both pros and cons. For example, although movies can present an innovative way to generate student interest about a particular topic, certain scenarios may add misconceptions to certain concepts (Berumen, 2008). Although media may present a steady source of public information, Coyle (2005) suggested that persons acquiring some form of environmental awareness are only somewhat likely to change their behaviors with respect to

energy use, recycling, purchase of environmentally-safe products, and the use of chemicals in their gardens.

Science can be defined as “the study of nature in an attempt to understand it and to form an organized body of knowledge that has predictive power and application in society” (Chiappetta & Koballa, Jr. 2006, p. 90). From a personal perspective, the process of learning science allowed me to connect prior content knowledge with future collaborations. For example, the importance of attaining valuable knowledge in science from higher courses can raise interest in environmental monitoring initiatives. For example, Belford and Phillip (2011) noted that collecting baseline data using a simple coral reef monitoring technique can be used as information to implement future student and community reef-monitoring initiatives. Furthermore, both authors were able to use their academic expertise to form a partnership, which focused on concerns about the nature of the surrounding coral reefs at the southern Caribbean island of Trinidad.

Environmental literacy involves positively changing practices, activities, and feelings that are based on knowledge of the environment, which is acquired by informative education about the environment. An increase in literacy promotes awareness and sensitivity of the environment, which can invigorate responsible planning and management of resources (i.e. stewardship) within a community through the formation of volunteer monitors (EPA, 2005). Many volunteer programs use informal science education as one method to transfer awareness. Informal science is the use of science experiences outside the traditional classroom setting (Falk and Dierking, 1992). Furthermore, informal science links citizen science, that is, citizens collecting information on science, which is used to answer scientific questions (Silverton, 2009). These programs

influence participatory action by all stakeholders in the community, and supplement local authorities and scientists with environmental data (EPA, 2002).

Both curriculum and teachers play significant roles in developing positive and/or negative interests in students. In fact, Russell and Atwater (2005) identified factors that impacted students from underrepresented groups (i.e. African Americans) persistence in science in college degree programs. Specifically, science teachers and course-taking patterns have an impact on persistence due to tracking (Oakes & Lipton, 1999; Oakes & Lipton, 2002; Oakes, 2005). Outcomes involved in designing curricula that focus on water monitoring protocols, and introduction into K-12 classrooms may offer a corridor to connect biology content with current environmental issues through informal science. Additionally, these curricula can be used to implement citizen science in an informal environment, as a method to foster positive relationships among educators, students, administrators, and their immediate communities.

In the past, educational outcomes of monitoring programs have been well documented. For example, Oberhauser and Prysby (2008) stated that many teachers and parents used the Monarch Larva Monitoring Project (a citizen science project) to engage children in the scientific process. However, although positive interests can be the result of engaging citizens about their environment, it does not necessarily led to participatory action (Stepath, 2000). The addition of curricula as a guideline and vessel to introduce and implement action can effectively ensure action after setting the tone for environmental education.

Water Monitoring Programs

Although environmental monitoring programs are on the rise, water monitoring programs are striving to fit in the grand scheme of informal science education. Currently, there is concern

for future demand of the global freshwater supply due to trends in human population growth. For example, water-use is currently parceled into three main categories according to human consumption: domestic, industrial, and agricultural. The bulk portion is used in agriculture, and only a lean 10% is reportedly used for domestic purposes (Zimmerman, Mihelcic, & Smith, 2008). It is important to share concerns about water quantity and quality, and one way to initiate conversation among citizens is through informal science and water monitoring activities.

Environmental water monitoring programs have increased over the years due in part to growing public concerns about the quality of the nation's water. The goal of any water monitoring program is to monitor changes over time, and detect any stress on the system (Buxton & Provenzo Jr., 2012, p. 131). Consequently, an attempt at alleviating these issues may begin with the students and science teachers. The empowerment of a change in behavior can be influenced by a teacher, and thus affect the attitude of the student. A student with a positive attitude in science tends to do well on science achievement (Beaton et al., 1996).

One well-known fact about volunteer monitoring programs is the cost-effective way of collecting data from large areas by volunteers committing their personal time and interest to the environment. Although this allows concerned citizens to develop positive interests about their environment, one major concern of monitoring programs has been the accuracy of data collected from volunteers. Research by Canfield, Brown, Bachmann, and Hoyer (2002) revealed that trained citizen monitors of the LAKEWATCH water monitoring program and professional biologists' showed little differences in the accuracy on data collected on parameters, such as total phosphorus, nitrogen, chlorophyll, pH, and total alkalinity.

Fore, Paulsen, and O’Laughlin (2001) were initially concerned about the accuracy of volunteer data collected field samples (benthic macroinvertebrates) at rural and urban streams. However, comparison of field data collected by volunteers and professionals revealed no significant difference between field samples. Luzar, Silvius, Overman, Giery, Read, and Fragoso (2011) noted mistakes in reported data and absenteeism of trained personnel in their large-scale wildlife monitoring project, which utilized indigenous Amazonian tribes to monitor densities of large vertebrates. Nevertheless, falsified data is not an uncommon issue whether collected by professionals or volunteers. Human error is definitely a factor during the initial phase of data collection. However, adequate training can successfully obtain similar accuracy as professional data collectors.

The waterways in the state of Alabama can serve as a prime example of a potential informal science resource. A total of 8% of the freshwater in the U.S. is in the state of Alabama. Hence, waterways can be used as a teaching resource to teach kids awareness, stewardship, and add skills related to science, such as obtaining data from water monitoring to determine stream “health.” In fact, Covitt, Gunckel, and Anderson (2009) reported that upper elementary through high school students possessed an overall understanding of water. Surprisingly, students knew where water was located, the positive and negative human impacts on water resources, and the quality, as well as distribution of water in environmental systems.

Informal Science Education (ISE) and Rural Science Education (RSE)

Informal science education (ISE) is learning science through experiences outside the classroom (Falk, 2001; Rennie, 2007). We spend a small amount of time in the classroom relative to our lifespan, yet we overlook informal science education obtained from outside the

classroom (National Research Council [NRC], 2009). In fact, informal science education is now seen as a growing field of research (Price & Lee, 2013).

Although the history of ISE dates back to the 1940s when it was known as the public understanding of science (PUS), changes in the last decade have veered away from the old thinking of using scientists and experts to provide knowledge to the public (Bonney et al., 2009). In fact, the use of citizen volunteers to collect data became one of the adaptations of ISE. Surprisingly, although an informal learning environment is more likely to initiate interest in science, as well as change in behaviors, participants were not as interested in PUS if the science did not pertain to their lives. In fact, this was one of the characteristics that dissolved the PUS model (Bonney et al., 2009).

Examples of these out-of-school environments include designed environments, such as museums, libraries, nature centers, after-school programs, aquariums, science clubs, planetariums, natural history sites, and botanical gardens (Falk, Randol, & Dierking, 2011; Hofstein & Rosenfeld, 1996). Additionally, everyday unstructured environments such as a casual walk in the woods, reading magazines or newspapers, watching television, and simple everyday family discussions provide informal science learning (Falk, 2001). In fact, Crane, Nicholson, and Chen (1994) defined informal science learning as referring to, “activities that occur outside the school setting, are not developed primarily for school use, are not developed to be part of an ongoing school curriculum, and are characterized by voluntary as opposed to mandatory participation as part of a credited school experience” (Crane, Nicholson, & Chen, 1994, p 3). Furthermore, students had significantly higher scientific reasoning when their curriculum included both science inquiry and informal learning environments compared to other students which lacked these instruction methods (Gerber, Cavallo, & Marek, 2001).

Consequently, although older children in the U.S. perform mediocre on science literacy measurements, adults outperform their international counterparts (Falk and Dierking, 2010a). This may reveal that science education may be better at the secondary education level than lower educational levels where teachers may not be qualified to effectively teach students science. Ultimately, an under qualified teacher may overly depend on textbooks to promote science literacy, and deny students' interest and inquiry in the subject (Ingersoll, 1999). Furthermore, Falk and Dierking suggested that the reason why adults perform well at science literacy measurements was due to more Americans visiting informal science venues, such as libraries, zoos, aquaria, natural history and science museums than citizens of China, Japan, Brazil, Russia, and the European community (Falk and Dierking, 2010a). Additionally, the U.S. has encouraged a greater use of digital media to disseminate science learning as an important resource.

For example, museums are now making a greater push towards using cell phone applications to engage visitors with notifications of special events. Websites are being upgraded to incorporate interactive ways to view museum collections should a visitor want to re-visit a specific section (Fenichel & Schweingruber, 2010).

The relevance of communication through science is an important fact when discussing stereotypical views of science. For instance, scientists communicate with their colleagues through informal settings, such as conferences and meetings, hence the notion of a scientist working in isolation in order to find evidence of the natural world can be dismissed. Furthermore, preservice teachers can be more prepared to enter the science education classroom when informal science is used in their prior training (Riedinger, Marbach-Ad, McGinnis, Hestness, & Pease, 2011)

The general premise behind science learning, whether it be formal or informal focuses on inquiry-based learning. This process allows student learning in science to be more student-centered than teacher-centered. Its proponent factor is the promotion of more minds-on, hands-on activities, and experiences for students. Many of these experiences connect nature with content in science in an effort to initiate inquiry from students. Initial questions can indicate the extent of students' prior knowledge, as well as acquired misconceptions.

Students may enter the science classroom with no background in science as a result of their lower socioeconomic status, or from negative experiences attained from an association with nature (Fisman, 2005). Additionally, our goals are to encourage children from diverse backgrounds to see the relevance of science in their lives (Jones, 1997). How can teachers be assured that students attain such a valuable source of prior information, and how can they build on it no matter what the student's diverse background?

It has become necessary to build on students' prior knowledge as they enter the classroom because meaningful learning from prior informal science exposure can create complex cognitive thinking over time (Brody, 2005). Both teachers and parents become the guides to suggest student visits to various informal science venues, where students attain valuable connections with science content (Fenichel & Schweingruber, 2010). This knowledge forms the construct, which new ideas build upon, and thus create critical thinking in science, problem solving, and decision making in the minds of students (Gooding & Metz, 2011). Essentially, teachers can adapt their current instruction in science as a result of their students' prior knowledge.

Basile (2000) noted that when third grade students were introduced to learning in informal settings, their science scores were notably higher than their peers who were not given the same opportunities to use these informal settings. Dierking and Falk (1997) suggested that students remember field trips for many years after their visits. Alternatively, Rupley and Slough (2010) suggested that prior knowledge simulates science learning. Furthermore, Krajcik and Sutherland (2010) encouraged educators to bridge students' prior knowledge to content in the science classroom. One of the goals of this research was to determine if students reading a wide range of science literature will score significantly higher on their science tests than students using a variety of textbooks to attain knowledge on marine biology topics (Krajcik & Sutherland, 2010).

Learning science in rural schools seems to be the most appropriate definition for rural science education. However, in order to discuss rural science education, the definition of "rural" must be first classified. Enochs (1985) defined a rural school as having < 600 students (K-12), and located > 80.5 km (50 miles) from a metropolitan area (i.e. > 100,000 population size). Welch and Wagner (1989) suggested that a rural school is located in open country, and has a population of < 25,000 individuals. An extreme rural area may also carry the tag of having < 10,000 individuals whom mostly are employed in agriculture (Welch & Wagner, 1989). Another example as defined by the U.S. Census Bureau is that rural areas have < 2500 individuals.

Past research has shown that rural schools struggle with many pressures (Arnold, Newman, Gaddy, & Dean, 2005). In fact, some rural schools have just as much challenges as urban schools (Zuniga, Olson, & Winter, 2005). These schools lack resources, such as translators, special education services, and out-of-school programs (Burke & Edington, 1980).

They share low student body populations, and poorly kept facilities, which are frequently the used for town activities (Zuniga, Olson, & Winter, 2005).

Rural science has been suggested to incorporate bountiful resources located in these settings. For instance, crops, animals, and farming machinery are easily accessible for students to design experiments or observe critical aspects of husbandry (Colton, 1981). However, the most common problem for rural teachers is seen to be isolation (Enochs, 1985). Moreover, rural schools often cover curriculum designed primarily for the urban setting, which may or may not be applicable depending upon resources available. Welch and Wagner (1989) reported that rural students had less opportunity to learn science, carry out experiments, or participate in informal science activities.

Rural environments can serve as outdoor classrooms with teaching material, such as plants, animals, soil, rocks, wind, and rain. Kifer (2001) indicated that rural schools were “doubly blessed” because of the small numbers of students per classroom. Furthermore, the development of farm machinery, together with an increase in crop production had an indirect effect on the study of weeds, pests, and diseases. This directly affects the economy, and it potentially can create meaningful avenues to advance rural science education (Colton, 1981). Rural science education increased because of these outdoor resources, and advantages such as smaller student: teacher ratios allowed for a flexible schedule, as well as time for planning (Colton, 1981).

Although past research on rural science in America has focused on identifying issues with academic achievement in science, lack of availability of laboratory classrooms, inadequate instructional training for science teachers and development of activities that utilizes the rural

environment, current research has not suggested that we have alleviated the stigma of rural schools being inferior to urban schools. Mann, Price, and Kellogg (1993) noted that southern states had ~75% of rural teachers responding to varying issues like inadequate supplies, science instructional resources, and instructional capabilities designed to develop and improve science inquiry. Ultimately, research in rural science education using the rural environment as a resource can add knowledge, and improve science inquiry in these schools altogether.

Although the main reason for rural teachers not staying in rural areas is isolation relative to metropolitan areas, Collins (1999) asserted that rural teachers are more likely to stay if they are involved in community education and cultural programs. In fact, Collins further stated that “rural schools and their communities have many tools at their disposal for recruiting and retaining teachers” (Collins, 1999, p. 3). Ultimately, the use of an informal science curriculum can provide a resource, which may be used by rural science teachers to supplement content knowledge obtained in the classroom. It will be important to prepare these science teachers in order for them to effectively transfer informal science education to students.

Citizen Science (CS) and Stewardship in Rural Science

Informal science education has given rise to volunteer participation, which provides a platform for citizen science where scientist and non-scientist participants work together to achieve a science-related goal. Citizen Science (CS) is the use of volunteers, whom may be members of the public, to participate in the collection and transfer of data in the field to scientists, for the purpose of research (Bonney et al., 2009; Cohn, 2008; Kimball, Myers-Pigg, Clay, Neibauer, & Keil, 2009; Oberhauser & Prysby, 2008; Surasinghe & Courter, 2012). It extends towards public outreach, and combines data collection both locally, regionally, and

geographically in the field (Cooper, Dickinson, Phillips, & Bonney, 2007). Schnoor (2007) described CS as a method of making unlimited observations that can lead to increasing public knowledge, and support for their local environment, while educating potential students to seek careers related to environmental science. Furthermore, a partnership between professional scientists and amateur volunteers are key characteristics of citizen science projects where it is necessary for data to be collected by citizen volunteers interested in an environmental issue (Rushing, Primack, & Bonney, 2012).

Many CS projects place citizens, which in most cases are the stakeholders, at central roles rather than assistant roles in the overall project. This produces a citizen-driven approach and is important to developing alternative ways to improve citizen involvement (Hulse, Branscomb, & Payne, 2004). In fact, ecological questions concerned with distribution and abundance across space and time are now utilizing large-scale CS. The use of volunteer participation in ecological research has essentially become part of the research process aimed at conservation efforts (Dickinson, Zuckerberg, & Bonter, 2010), hence the utilization of citizens more and more in the field.

Although the term citizen science itself is a relatively new term, it is not a new method, because there have been many programs developed with volunteers assisting in science. Cornell University first used the term in the 1990s, where researchers at the university used volunteers since the 1960s in bird monitoring projects (Cohn, 2008). Another example would be the Christmas Bird Count project of the 1900s, where bird counts were done by the National Audubon Society of the USA (Butcher & Niven, 2007). One of the best examples of a citizen science program is the internet based Journey North program, which uses citizen monitors such as students, educators, and public volunteers to report the monarch butterflies' first sighting each

spring (Davis & Howard, 2005). These sightings provide the location, date, and year of the first adult monarch butterfly sightings, which are used to determine the recolonization rate every year.

CS has become more prevalent today, as a result of more experts willing to educate, and work with these volunteers through training them to use easily available technical tools, together with easy accessible hand guides to assist citizens with data collection (Silvertown, 2009).

Community members who are interested in their environment collect scientific data, which are used by scientists to broaden their research, as well as continually educate and collaborate with local communities (Cohn, 2008).

Kimball et al. (2009) noted that citizen science programs that focused on environmental sciences were geared towards three types of programs. These are contributory, collaborative, and co-created (see Bonney et al., 2009). However, all are focused on citizens collecting long-term data, which is the goal of monitoring programs. Also, programs can be designed to answer an environmental question, which may be short-term in nature. Finally, some programs already have large databases, which require citizens to analyze those using online resources, such as websites.

Although having the public participating in scientific research by collecting data is viewed as a free source of labor, scientists realize that citizen volunteers are an economically viable resource, especially when large-scale environmental monitoring projects are in the forefront (Silvertown, 2009). In fact, there are documented success stories that highlight the involvement of citizen scientists in ecological projects in developed countries (Braschler, 2009). For example, in 2010, Bruce Hudson, a citizen monitor, used the Stardust@home internet based

program to identify the first probable evidence of stardust, which he named Orion and Sirius (Hand, 2010).

Citizen volunteers can extend to students and their educators, regardless of grade. For instance, students (grades 3-10) were trained to collect data on Oregon's white oak (*Quercus garryana*) to determine species type, diameter at breast height, and crown shape of the oaks. The study reported that both students and professionals collected data that were consistent for diameter at breast height, and tree counts (Galloway, Tudor, & Vander Haegen, 2006). Hence, students obtained knowledge of oak distribution, and fundamentals involved with the scientific process, such as data collection.

Tudor and Dvornich (2001) demonstrated that students and volunteers were effectively used to collect data on mapping wildlife sightings and habitat through the NatureMapping Program. This program encouraged students (K-12) and volunteers to use skills, which allowed them to collect data and answer their questions. In fact, all participants (students, educators, resource agencies personnel) improved with their decision-making and community involvement. Educators can train and participate in volunteer programs, which eventually allow them to transfer their experience to the classroom. For instance, teachers can use technology to stir interest in student-based data collection.

Moore and Popiolkowski (2011) illustrated that teachers introduced students to collecting data on cloud cover, and then assisted them with uploading their observations onto a web-based data collection site, which used a few satellites to monitor cloud cover from space. NASA's CERES Students' Cloud Observations On-line (S'COOL) allows students to schedule a satellite fly-over, in conjunction to using personal cloud cover observations to use as problem-based

learning. Teachers are able to register their class, and utilize S'COOL, which is a hands-on project that supports NASA's research on Earth's climate. Teachers use skills such as peer-training, data collection, data analysis, and communication amongst peers to allow students to use critical thinking to ask questions, communicate and problem-solve.

Undergraduate students can become valuable CS volunteers. For instance, the Monarch Larva Monitoring Project and the Great Sunflower Project allows undergraduate students to collect and analyze data, as well as conduct research. Furthermore, their volunteerism does not halt only with an involvement with data, but it also extends students to become trainers, mentors, or experts in their program's research field (Oberhauser & LeBuhn, 2012). These programs have led to suggestions that can improve undergraduate inquiry-based learning by allowing students to utilize their expertise in class projects.

Another example of a successful citizen science program that utilizes undergraduate students is the eBird program, which uses undergraduate ecology classes to collect data based on ornithology. In fact, it has been deemed one of the largest biodiversity resources run by the Cornell Lab of Ornithology (Surasinghe & Courter, 2012). Such citizen science programs can yield essential avenues to assist with obtaining knowledge about science, where many students may not know about citizen science.

Advantages of CS are derived from the community's involvement in their environment, which is a result of more conservative concern due to the effects of the increasing human population, and their activities correlating in the adverse effects on biodiversity. Additionally, the collaboration between scientists and volunteers fosters an important relationship in communities by building awareness of important environmental factors, such as pollution, long-

term monitoring, decisions that lead to policy changes, and environmental impacts. The ultimate goal is to make volunteers become more aware of the science involved in their data collection (Braschler, 2009).

One major concern with CS is the accuracy of the data collected by citizens. Interestingly, Delaney, Sperling, Adams, and Leung (2008) showed that citizens between the ages of 3-78 years of age can determine crab species and gender at 52 sites across the coastal states from New Jersey to Maine with an accuracy of at least 80%. Furthermore, this accuracy increased to 95% for citizens with at least 2 years of college education. Delaney et al. (2008) noted that the 1 hour training was adequate enough for citizens to collect data with a high accuracy level, and that these volunteers played an important role in establishing a database for the monitoring of marine introduced species (invasive crabs: *Carcinus maenas* and *Hemigrapsus sanguineus*).

Jordan, Brooks, Howe, and Ehrenfeld (2011) reported sufficiently accurate results when they compared data collected by volunteers and professionals in a program designed to map invasive plants in New York and New Jersey. However, although data were reliable for volunteers, there was reportedly high variability for data collected in certain environmental habitats. Consequently, the program also reported high accuracy if the quality of the volunteer training session prior to collection was enhanced.

Additionally, Goffredo et al. (2010) concluded that trained recreational scuba divers can collect data on biological taxa and the presence of litter at dive sites with an acceptable level of reliability and accuracy. Furthermore, the cost and manpower for a professional to collect the above data would be astronomical. However, citizen volunteers became necessary assistants to

alleviate financial costs of this marine monitoring program. Fogleman and Curran (2008) expressed the need for citizens to become more involved in their concern to protect valuable waterways. Training both citizens and student groups to collect adequate water collected data can assist the government with their efforts to preserve environmental habitats. Student groups can be educated on the importance of preserving their environment if they are involved with data collection.

Fogleman and Curran (2008) suggested that programs, such as Georgia's Adopt-A-Stream group can initiate the proper training of both citizen volunteers and educators, whom can assist student groups with their water-monitoring projects. Such hands-on projects allow students to use various facets of scientific thinking, such as critical thinking, problem-solving, and decision making. Furthermore, students can assist in community decisions concerning environmental issues, as a result of analyzing and discussing their data. Inevitably, research has shown that students who are involved with positive experiences with nature awareness show a high correlation with increased science scores (Chandler & Swartzentruber, 2011).

Lawless and Rock (1998) reported that students became more aware of the importance of collecting data, and therefore were more prone to think critically about the results of their collected data. Consequently, they became more aware of their resources, and more involved in their community due to their involvement in a citizen informal science-based water monitoring program. Overall, the hands on water monitoring project gave students control, while allowing them to use scientific thought processing, which increased their involvement with society using decision making as a tool to transfer the results of their project, while making it meaningful to their life.

Citizen Science and Water Monitoring

Silvertown (1999) noted that, “a citizen scientist is a volunteer who collects and/or processes data as part of a science enquiry” (Silvertown, 1999, p. 476). Most citizen scientists play important roles in long-term environmental monitoring in various citizen science projects. Currently, there are more than 200 projects, which potentially can associate with the plethora of interests in science. Examples of these projects are the monarch migration monitoring, bird surveys, water monitoring, and frog watchers (Mueller & Tippins, 2012).

Recently, water monitoring interest seems to be increasing as citizen science projects relating to monitoring municipal water have increased. Overall, although two-thirds of the Earth is covered by water, the majority (97%) is undrinkable saltwater, only a mere 3% freshwater, which is distributed in the polar ice caps, rivers, lakes, and ground water (Jurkowski & Menardiere, 2008). Surprisingly, human beings, together with all our industrial, recreational, and utility-based activities depend on just 1% of the total freshwater available from lakes, rivers, and to some extent, groundwater. Generally, individuals will agree that water is precious to life, and that we should preserve this valuable resource. Consequently, freshwater supply in the future will endure scarcity, due in part to the increasing demand, as well as effects that pollution will have on the supply.

The use of the world’s freshwater supply is unevenly distributed depending on the geographical region of the world (Postel, 2000). For instance, Egypt uses 98% of its freshwater for irrigation compared to 40% in the United States for the same task. Irrigation currently uses 70% of the global freshwater supply, which means industry and domestic water use accounts for the other 30%. Global stressors to the sustainability of our water supply are the increase growth

of the human population, climate change, and urbanization, which the latter causes pollution and sediment load (Zimmerman, Mihelcic, & Smith, 2008).

Mayer et al. (2011) illustrated that most residential homes in America use approximately 26 % of their water supply on toilets, 22% on washing clothes, 19% on showers and baths, 14% is loss to leaks, and 16% in faucet use. Additionally, 42 % and 58% of household faucet use are allocated to indoor and outdoor use respectively. Undoubtedly, these data highlight the inadequate use of water by the average American household, which shows some indication of how we overuse our water resources. Consequently, citizens of America are becoming more concerned about the quantity, quality, and availability of their water. For example, the topic of awareness has improved with the increase citizen-based monitoring programs in southeast America, such as the Alabama Water Watch, Georgia Adopt-A-Stream, and Choctawhatchee basin Alliance, which all train citizens to collect data on water quality.

Some citizen science projects provide their data to local water protection agencies, which use these data to monitor streams for a long-term duration (Eick, Deutsch, Fuller, & Scott, 2008). Presently, there is a growing concern for water quality in the United States. For instance, current research has shown that there has been a decrease in stream biofilm, which is the slippery coating on rocks due to antihistamines. In fact, most water treatment plants are not equipped to treat stimulants, antibiotics, and antihistamines, which form a cocktail of synthetic substances in streams (Rosi-Marshall, 2013).

Addition of structured outdoor lessons may partially prove to be a worthy solution to this dilemma. Currently, local levels of environmental literacy for K-12 students in Alabama are astounding. For instance, one report stated that at least 50% of 4th and 8th grade students in the

state of Alabama never or hardly ever wrote reports on science projects. In fact, 25% of 8th grade students had never seen their teacher perform an experiment. Consequently, although 63% of 8th grade teachers possess a major or minor in math, only 15% of students attained a bachelor's degree in Science Technology and Mathematics (STEM) related fields in the state of Alabama (NAEP, 2009).

Current trends in human population growth (8 billion by 2030, United Nations, 1998), increased demand for food, water, and higher affinity for pollution are current challenges we face in the 21st century (Postel, 2000). Two main adjustments must be made to counteract the above statement. Firstly, educational awareness of the public and students in K-12 grades is necessary to improve the general public's attitude on the environment. Secondly, the role of the teacher will be important to transfer positive changes in interests and increase interest towards the environment through experience, and exposure of structured lesson plans designed for informal science settings.

Citizen science can teach us stewardship, and stewardship is essentially an important factor in sustainability. However, sustainability, which is the capacity to endure, essentially encircles stewardship. Currently, global concerns with loss of terrestrial and aquatic biodiversity, environmental limits to resources, and trends in human population growth are just a few problems, which force our society to develop sustainability. Postel (2009) noted that two-thirds of the global freshwater-use accounts for irrigation, while man-made dams are the main threat of aquatic ecosystems or habitat destruction of local aquatic fauna. Although climate change is currently the major deterrent of sustainability development (Galli, Wiedmann, Ercin, Knoblauch, Ewing, & Giljum, 2012), one reason to continue this development is that sustainability science

views the dynamic interactions that take place between nature and society (Clark & Dickson, 2003).

Although some people living in the U.S. are concerned about water sustainability, they are not aware that they consume an average of 500,000 gallons of water per person annually in some form of direct and indirect manner (Buxton & Provenzo, Jr., 2012, p.38). In fact, the average American uses 300 liters of water per day, or ~32,911 glasses per day, which are mostly hidden in the various things we use to make what we eat, wear, and use to make energy (Golley, 1998). Surprisingly, approximately 884 million people from around the world lack access to clean drinking water (O'Brien & Walton, 2012). The global strain on current freshwater resources will increase as a result of the increasing demand for food, animal feed, fiber, and energy crops (Hoekstra, 2008).

In terms of water sustainability, water footprint is used to illustrate the link between the human consumption of water, and its use in global trade and resource management (Hoekstra, 2009). A definition of water footprint is the measurement of the human (e.g. individual or community) use of freshwater to produce both goods and services, which are essentially consumed by humans (Hoekstra & Chapagain, 2008; Hoekstra, 2008). Freshwater is measured from 3 criteria: blue water, which is consumption of surface or ground water, green water is the consumption of rain water stored in the soil, and grey water which refers to pollution (Hoekstra, 2009). These 3 criteria are measured to determine our water footprint, but more importantly, this information can assist us in changing our behavior towards water sustainability.

There is a lack of priority given to the public's understanding of water resources. Cockerill (2010) noted that although there was low public turnout to a highly publicized

presentation about valuable information on water quantity, the project offered an example of successfully educating people about how water works. Furthermore, the lack of water literacy among students of all ages should not disregard the importance of educating people, as concerns about water resources will likely increase in the near future.

Public Participation in Scientific Research (PPSR)

The Center for the Advancement of Informal Science Education (CAISE) defined public participation in scientific research (PPSR) as the intentional collaboration of citizens from the public to engage in research that leads to the addition of science-based knowledge (Bonney et al., 2009). Collaborative efforts of trained researchers and numerous levels of the public, such as amateurs, community members, and students make up the research team in many instances. Furthermore, these teams have done more monitoring projects to date, and these interests range from ornithology, astrology, entomology, as well as coral and water monitoring.

These citizen science-type monitoring projects include public participation in scientific research (PPSR), which revolves around particular questions that require long-term data collection. These data are usually part of volunteer monitoring projects, which involve collaboration between scientists and volunteers. In fact, it is safe to say that it is an interaction between scientists and the public. Unlike past outreach programs where participants were only on the receiving end of attaining information (Braschler, 2009), volunteers relinquish their data to scientists that publish findings from the collected data. Ultimately, if volunteers are properly trained to collect data, these data can be of high quality as those obtained by professionals (Schnoor, 2007).

In the past, non-scientist volunteers have been recruited to collect animals, plants, and other specimen types for scientists, whom publish findings from these collections. The absence of collections would certainly not have allowed curators to obtain information on biodiversity. In fact, observations by non-scientists are important in many ways, because it incorporates a partnership between members seeking to understand and add knowledge to particular interests of humans.

Nevertheless, partnerships can be formed through a variety of project categories in PPSR. These are contractual, contributory, collaborative, co-created, and collegial (reviewed in Shirk et al., 2012). Contractual projects in PPSR take place when citizens of a community ask professionals to conduct research, and report their findings. In contributory PPSR, scientists design the overall project, but allow citizens to contribute data to the project. Collaborative PPSR differs from the above in that it allows citizens to help refine the project, and discuss the overall findings of the project. Co-created PPSR uses projects initially designed by both scientists and citizens, but with non-professionals conceiving most of the ideas for the project. Lastly, collegial refers to projects entirely conceived and carried out by non-professionals to advance scientific knowledge. Altogether, the overall goal in these categories are to engage all participants (i.e. citizens and scientists) in collecting data, which is used to answer research questions (Zoellick, Nelson, & Schaffler, 2012).

It is important to discuss a few issues pertaining to participation since this is one of the characteristics of PPSR. The degree and quality of participation are two characteristics, which determine the outcome in any PPSR project. Participants are more committed to a project if it's interesting to them, and if it has an impact on their lives. They also are more involved in the project if there is a good collaboration with the professional involved. In fact, increasing degree

and quality of participation still does not amount to an absence of other difficulties experienced throughout the project.

For instance, since informal science education settings are mostly located in natural settings, the problem of access to these areas may be a dilemma in certain cases. For example, this may be a key issue in urban areas due to the presence of vast concrete buildings associated with densely populated cities. Surprisingly, although parks may be present in these areas, the busy lifestyle of city dwellers may add to the lack of interest. Members of the community may be uncomfortable with the science behind the project, which can alienate participatory action.

Levine, González, and Sussmann (2009) stated that many people share a common discomfort in natural settings. Discomforts range from heat exhaustion, allergies due to pollen, phobia of harmless insects, and a disdain for being dirty or wet. Furthermore, these discomforts seem to be passed from parents to their children. Hence, there is a large part of society that stays away from participating in volunteer projects aimed at gathering and interpreting data for scientific research.

Consequently, a large part of the potential volunteer sector representing traditionally underrepresented groups, such as African Americans, Native Americans, and Latino/a are less likely to participate in scientific research due to many factors (Trumbull, Bonney, Bascom, & Cabral, 2000). One typical example is due to greater low-income families in these groups. Also, transportation is an issue because research sites may not be accessible through local public transportation routes. Nevertheless, in order to decrease these issues, projects should involve the community members in order to bridge the gap between participants and researchers.

Another concern of PPSR is the use of various technologies to collect and upload data to

databases. For instance, mobile applications (apps) are now showing great promise for many citizen science projects (Newman, Wiggins, Crall, Graham, Newman, & Crowston, 2012). This will improve spatial data collection efforts because citizens can carry field guide apps on their phones to assist them with species identification. Websites can be accessed at any point in time, and this enhances the uploading process. Interestingly, advanced technologies may further alienate diverse volunteer groups as mentioned earlier in this section.

Chapter 3: Methodology

Research Design

The research design was tailored towards a mixed method approach, which utilized qualitative and quantitative strategies to collect data. When qualitative and quantitative strategies are used in the context of collecting data in a single research project, the research design is called a mixed method design (Morse, 2003). Tashakkori and Teddlie (1998) used the term “mixed model studies” to illustrate a combination of both qualitative and quantitative approaches within different phases of the research process. Denzin and Lincoln (2000) mentioned that the decision to choose either qualitative, quantitative or both methods depended on the research questions. In fact, the research questions in this study required qualitative and quantitative methods to obtain data that would provide an in-depth understanding of the culture of a rural 7th grade life science classroom relative to expanding environmental literacy and stewardship using informal science as an educational resource.

The mixed method approach was the most appropriate research strategy for this study, in order to gain insight into student and teacher interests and perspectives towards informal science, specifically on the topics related to environmental literacy and stewardship in a rural area.

Additionally, qualitative and quantitative data for 7th grade life science students and teachers prior to and after the process of implementing the informal science-based curriculum on water monitoring assisted with evaluating any changes in their overall perspective of science.

The strategies used to collect data during each phase of this study made it possible to build a rapport with all participants over a period of time. Classroom observations were completed at least twice per week during August through December 2013. This timeframe allowed students to become accustomed to the researcher's presence, while allowing the researcher to observe in the best natural classroom setting. Additionally, qualitative strategies allowed teachers to share intimate events from their past experiences relative to learning science at informal science settings. Interviews and informal conversations were conducted during both life science teachers' planning period. Overall, the mixed method assisted with the collection of various sources of data that would otherwise be non-attainable to answer the research questions of this study.

The primary goal of this study was to examine the current interests and perspectives shared by two 7th grade life science teachers and how they viewed the implementation of an outdoor activity based on a water monitoring curriculum. Teacher perspectives on environmental literacy and stewardship were determined throughout the implementation process. Students' current interest in science prior to the implementation of the curriculum at this rural middle school also was determined in this study. A constructivist paradigm was the overall view of this research, because an important aspect of using the constructivist view was to really get to know what students and teachers already know, and determine if informal science activities related to expanding environmental literacy and stewardship changed the science interest in 7th grade life

science students. Furthermore, this study determined what ways an informal science-based curriculum impacted both students and teachers.

A second goal of this study examined if past exposure or lack thereof to informal science learning have made an impression on the teacher's perspectives towards informal science, and teaching science in the classroom. The influence of family or teachers relative to informal science, which took place throughout their lives, formed a timeline of events in order to form stories for both 7th grade life science teachers. Teacher interviews illustrated how an interest in science began and developed over the course of their lives, how they were initially exposed, what experiences changed, and who influenced the course of their interest in science. The research questions that guided this study were:

- (1) How does implementation of a water monitoring curriculum impact 7th grade life science teacher interests and perspectives towards environmental literacy and stewardship in the classroom?
- (2) How does implementation of the curriculum impact 7th grade life science students' interests towards environmental literacy and stewardship?
- (3) What are 7th grade life science students' science interests in a rural middle school?
- (4) How has past informal science activities in the lives of 7th grade life science teachers influenced interests and perspectives towards teaching science?

Qualitative Strategies

The qualitative research strategy adopted in this study that analyzed the interests and perspectives of two 7th grade life science teachers towards informal science was a case study research strategy. The case study was the desired research strategy as it is frequently used where

no prior research has been done (Butvilas & Zygmantas, 2011). In fact, Lancy (1993) stated that “the case study used alone, or as part of large-scale quantitative study, is the method of choice for studying interventions or innovations” (Lancy, 1993, p. 140).

Yin (1994) defined a case study as an investigation of “a contemporary phenomenon within its real-life context” (p. 13), and the identification of a specific case is a necessary feature of a case study (Creswell, 2013). Yin (2003) also noted that the case study strategy can be used to investigate a phenomenon that takes place in a real-life context. The process and discovery of case studies are the main focus in an in-depth understanding of a situation of interest (Merriam, 1998, p. 19). The identification of the specific case in point was a key component in choosing various strategies, which were used to answer the research questions. For instance, the case in point for this research was the 7th grade life science teachers’ interests and perspectives on an informal science curriculum based on water monitoring at a rural middle school in southern Alabama. This research has a case study feature because its scope is limited to a single rural school. Furthermore, this study was incorporated into a case study to gain insight into the interests and perspectives of the 7th grade life science students and teachers towards informal science education, specifically using water monitoring activities in a rural area.

Interviews were essential to examine and determine if the past lived experiences of two inservice 7th grade life science teachers had motivated or influenced them. Informal conversations were collected from their experiences through dialogue between the researcher and the teacher. The study focused on gathering a collection of stories from each individual in a chronological manner to examine the junctions in their lives where key informal science education took place. For this study, interviews obtained stories, which were transcribed in a chronological order and illustrated a beginning, middle, and end to their stories. This was an

essential element because the research question obtained a deeper meaning about each teacher's past experiences.

I used semi-structured interviews, as these provided a deeper meaning about teachers' prior exposure to science and outdoor activities throughout their lives. Fontana and Frey (2000) stated that interviews are informal conversations between the participant and researcher that involve asking questions and listening. Kvale and Brinkman (2009) noted that "the interviewer's questions should be brief and simple" (p. 134). Overall, these interviews determined the teacher's perspectives during the process of implementation of the curriculum into their science teaching over the course of this study.

Classroom and field observations captured the 7th grade life science environment. Student journals also revealed classroom rituals or customs within the classroom. Meier (2012) suggested that the impact of a school's unique culture on teaching has rarely been questioned in research. Hence, these observations provided an insight into the basic classroom rituals, beliefs, norms, problems, and customs shared on a day to day basis at a rural setting. I used rich thick descriptions of participants' behaviors each time I visited the school to determine their interests towards science.

Quantitative Strategies

The quantitative research strategy determined changes in student responses on environmental literacy and stewardship knowledge quizzes prior to and after the implementation of the water monitoring curriculum used by the life science teachers. This method determined if the overall impact of the curriculum on students' interests and perspectives relative to their knowledge scores significantly changed through the curriculum implementation process.

Additionally, the students' current interest in science relative to (i) family encouragement, (ii) peer interests towards science, (iii) teacher influence, (iv) informal learning experience, and (v) science classroom experience provided descriptive statistics, which determined any patterns in science interest.

Sampling Strategy

The entire 7th grade life science student and teacher population at a rural middle school was purposely chosen to answer the research questions, which were based on their interests and perspectives towards environmental literacy and stewardship using an informal science-based water monitoring curriculum. Several visits to the rural middle schools were initially made to determine if the site was adequate to conduct this study. Schatzman and Strauss (1973) noted that it was necessary to visit and observe the sites prior to making a decision on the population to use in the study. Patton (1990) stated, "Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research," (p. 169). Hence, the purposeful sampling strategy aligned with the overall purpose of the research.

Participants

Case Site. The target population for this study was a 7th grade life science public middle school located in a rural area in south Alabama. This school had < 800 students (5-8 grade), and was located > 80.5 km (50 miles) from a metropolitan area. For the purpose of determining a target population for this study, I defined a rural school as one located in open country, or "hidden" on the outskirts of inner town activities, and located >50 miles from a metropolitan area. The school selected for this study had <800 students with a teacher to student ratio of less than 27 students per teacher. The school's faculty and staff are divided into 45 certificated

faculty members and 24 support staff members. All certificated staff members are highly qualified. This rural middle school served grades 5-8, and had a student population of 740. The overall ethnic breakdown of the school was 73% white, 24% black, and 3% of Asian, Native American, or Hispanic descent. Classrooms were equipped with smart pads, computers, and multimedia projections. The school has a total of 262 laptops which have internet access. Teachers have access to 21 smart pads/tablets for educational use. The school was easily accessible with respect to driving distance and was located in open country, and was somewhat hidden from the closest respective town (population of ~ 13,000), as defined by the aforementioned definition of a rural school.

Teachers. Two 7th grade life science teachers' currently teaching 7th grade Life Science students at this school served as participants for this study. Pseudonyms were used instead of real names to hide their true identity. Both life science teachers were certified teachers with a Bachelors of Science and/or Masters in Education degrees. Teachers were purposely selected because questions focused on interests and perspectives experienced in the culture of a rural school. Teachers and students in the 7th grade classes were representative of rural participants, the rural classroom environment, and the overall culture of a rural life science class, therefore it was deemed necessary to use purposeful sampling.

The male teacher, Mr. Clay (pseudonym) had a total of 7 years teaching experience, 5 years teaching 8th grade physical science, and 2 years teaching 7th grade life science (current school). He was 30 years of age at the time of this study. The female participant, Ms. May (pseudonym) had only co-taught for 1 year at a high school for 9th grade Biology, 11th grade Botany, and 11th grade Zoology. At the beginning of this study, she had been teaching (on her own) for a total of 1 month, and currently taught two 7th grade life science, and two 8th grade

physical science classes at the school. She was 24 years old at the time of this study. Both teachers were of European decent and spent their childhood years living in predominantly white rural areas or moving between U.S. military bases as is the case for Ms. May.

Students. Students selected in this rural area represented a diverse background with respect to gender and ethnicity. For instance, there were 57 female and 78 male students altogether. Their ethnic backgrounds were ~ 75% white, 24% black, and ~1% Hispanic, Asian, and Native American. The water monitoring curriculum used in this study captured the overall interests and perspectives of informal science, and more specifically knowledge on water stewardship for 7th grade life science students in six classes. The goal was to sample all 7th grade life science students at the middle school, which totaled 162 students, however a total of 135 students were granted consent from their parents/guardians. This would be the sample population used for the quantitative part of this study, which constituted the population being introduced to the informal science curriculum for the pre and post knowledge assessment.

Selection Procedures

An initial email was sent to the principal, which provided a synopsis of the research questions, the researcher's background, and a request to meet and discuss benefits of conducting the research at the institution. This was followed by several phone calls, which focused on answering more questions concerning the benefits to the participants and the school. Eventually, this led to a meeting with the principal of the school at an appropriate time within a month of the initial email. During the meeting with the principal, an overview of the research protocol was discussed in relation to the timeline and topics being taught in the classroom. This allowed the principal to have the information required to determine how the research protocols maximized

benefits to the students at various junctions in the school's Fall 2013 timeline, where the water monitoring curriculum coincided with the classroom content being taught.

The principal and I discussed my past experiences in informal science, and how these experiences applied to the research interest at hand. Additionally, we discussed the research questions, the target population (7th grade life science classroom) for the study, the possible strategies used to collect data to answer these questions, and the water monitoring curriculum. At the end of this meeting, we concluded that the curriculum to be implemented closely aligned with the school's objective to implement and increase project-based lessons with the 7th grade life science curriculum.

The principal was allowed 2 weeks to meet with the 7th grade teachers to determine the teachers would agree to accommodate and incorporate the research study in their classroom. After the principal and teachers verbally approved the selection of the school for this study, the 7th grade life science teachers were contacted through an introductory email. This was followed by another email that requested a one-on-one meeting with each teacher at a convenient time in the near future. I visited each teacher twice to build rapport and provided information on the study, and information on the projected timeline to collect data. This was an essential procedure because participants, such as the principal and the 7th grade life science teachers shared their time by scheduling meetings during their planning periods. This was a sacrifice on their behalf.

The principal required a meeting with the life science teachers, and at the conclusion of this meeting, an authorization letter with the official school's letterhead was provided to the Institutional Review Board (IRB). Approval to conduct the research from the IRB committee authorized the approval to proceed with obtaining signed consent forms from all participants.

Approval for conducting this study was granted by Auburn University IRB committee under Protocol # 13-136 EP 1304. Copies of the IRB approved stamped consent forms and copies of the instruments used in this study were provided to the life science teachers and questions stemming from their use were reviewed prior to any data collection.

After IRB permission was granted, a meeting was scheduled during each teacher's planning period or after school to discuss the study protocol, and decision to take part in this study. At this meeting, we both initialed and signed the consent form prior to the first semi-structured interview. The teacher also completed a questionnaire after they signed the consent form. Parent consent forms were sent home to obtain consent for their children's participation in the study prior to the implementation of the curriculum. These forms were included in a parent packet, which contained other documents that parents receive from the teacher during the start of each school year. The teacher received all the consent forms, and created a numerical code for each student that had parental permission to take part in the study. Each student code served as an identification number that was used for the knowledge quizzes and which was not viewed by the researcher.

Case: Life Science Teachers at a Rural Middle School

Two 7th grade life science teachers at a rural middle school was exposed to an informal science-based curriculum and their interests and perspectives pertaining to the implementation of the curriculum into their teaching schedule was examined.

Limitations of the Study

There were several limitations to this study. One limitation with this research study was the small population size, which included two life science teachers. The small sample size of two

life science teachers used to determine interests and perspectives of science teachers using an informal science curriculum as a teaching resource will not provide information about the general perspectives that rural middle school life science teachers have towards informal science education. Another issue was that of external validity. Validity may have been an issue because the target population of the study was purposefully selected due to the characteristics of the site (rural). Careful consideration of the research site was maintained in order to keep the criteria of a rural school, as defined in this study. Another major concern was the time required to effectively collect data.

A mixed method research design used measurement instruments adapted from published sources and these were appropriate to answer the research questions. This demanded a lot of time from both the researcher and the teachers involved, therefore a good working relationship between all parties was necessary at the beginning of the study.

The case study strategy used in this study was appropriate to follow the perspectives of both rural 7th grade teachers and how well their science classes viewed the process of implementing an informal science-based curriculum. In addition, students in these areas may also not have been exposed to the traditional informal science venues, such as zoos, museums, or aquaria. In contrast, this may provide interesting data on student acquisition of science learning in rural areas.

Ultimately, this research was highly dependent on thorough review and selection of the proposed study site, and collection of data using the following methods: (1) semi-structured interviews, (2) questionnaires, (3) science interest survey, and (4) an evaluation form, and (5) reflective journaling, and various student artifacts. The Institutional Review Board (IRB)

reviewed the proposed questions and methods for the data collection process for this research, and the committee granted approval to conduct research at the site. There were a few recommended changes suggested by the IRB committee, which assisted in the approval process, however this definitely increased the period of time prior to obtaining access to the site, as well as to participants. The initial timeline to begin the study was delayed as a result of this.

Accessibility to the teachers was acquired through obtaining permission from the principal, and informed consent forms were signed prior to the start of the study. This process took a lot of time before permission was obtained, because email responses, phone conversations, and scheduled meetings took a lot of planning and time. Interviews gathered narratives from the participants, and it was necessary to journal the process. The interests of the science teachers throughout the entire meeting were documented to gain an idea of the entire process leading to and after the implementation of the curriculum. Since the researcher was part of the instrument for data collection and analysis, member checks were used to ensure credibility of the data.

It was paramount that the teachers felt a sense of assurance throughout the process of implementing an informal science-based curriculum. Initially, the goal was to ensure that the teacher felt comfortable during each interview. Fontana and Frey (2000) noted that researchers must be diligent to protect their subjects by possessing the following: (a) informed consent, (b) right to privacy, and (c) protection from harm. A well-constructed consent form included elements, such as purpose of the study, confidentiality, risks involved, participant withdrawal at any time, and signature of all parties involved. This illustrated the required professionalism in this research.

As a researcher with past informal science experience, it was important not to interject personal views during the interviews. The formation of codes and themes were chosen after many readings in order to capture the deeper meanings. Hence, triangulation of data was used to determine an in-debt view of the interests and perspectives of rural participants towards environmental literacy and stewardship.

Data Collection

Multiple sources of data were collected during the school period between March-May 2013, and mid-August to end of December 2013, and included the following sources of data collection: a questionnaire, a survey, 4 semi-structured interviews, environmental and stewardship knowledge quizzes, field observation notes, student and researcher journal articles, an evaluation form, and various student artifacts.

Qualitative Data

The first method used was a questionnaire, which focused on prior teacher knowledge on the topics of environmental literacy adapted from Jordan, Gray, Howe, Brooks, and Ehrenfeld (2011) and Overdevest, Orr, and Stepenuck (2004) for stewardship (see Appendix 1). The questionnaire was designed to ask open-ended questions, with subscales embedded where appropriate. Both 7th grade life science teachers completed this questionnaire prior and after the water monitoring curriculum was implemented to determine changes (if any) on science teachers' interests and perspectives about environmental literacy and stewardship (Appendix 1).

A total of four 30-45 min. semi-structured interviews were conducted throughout the study. Open-ended questions used in the interviewing process invited each participant to share more about their perspectives and provided key themes throughout their stories. Notes on any

reactions or change in voice tone of the interviewee were noted and any relevant body language or gestures assisting in the overall analysis of these interviews were recorded for later analysis.

All interviews were conducted with confidentiality after the informed consent form was signed by all members involved in the interview process. At each interview, the participant was initially briefed on anonymity and confidentiality, as well as the participant's right to desist from taking part in the research at any point in time. This took place at the beginning of the interview in order to build rapport, and initiated a calm relaxed mood throughout the interview.

The first interview was done after the consent form and questionnaire (Appendix 1) was signed and completed. The interview was conducted during either the teacher's planning period or after regular school hours if deemed necessary. The conversations focused on past lived experiences related to informal science, and the way these experiences have, or have not influenced the interests and perspectives towards their current methods of teaching science (Appendix 3). This interview also included open-ended questions related to current teaching methods and issues faced while incorporating these methods. Persons that influenced the life of the science teacher at various junctions in their life was recorded with the goal of charting a timeline of events, and how each event coincided with a particular life changing decision.

The second interview required the teacher to discuss a typical day of teaching science in the classroom. A few open-ended questions guided the interview with the intent on providing an insight to the daily rituals done at a rural 7th grade life science classroom. The third interview was conducted directly after the teacher was allowed a week to review the water monitoring curriculum. This interview recorded the views and perspectives prior to the implementation of the curriculum. This interview collected data related to the teacher's initial perspectives on key

topics illustrated in the curriculum. Open-ended questions on topics, such as point-source pollution, water quality, quantity, sustainability, water chemistry, and macroinvertebrate diversity were asked during the interview. Additionally, teacher's thoughts on the process of including topics mentioned in the curriculum into their classroom content knowledge were recorded in this interview. Suggestions were noted as a method to follow the process of incorporating this informal science based curriculum in rural life science classrooms.

The fourth interview was conducted at the conclusion of the informal science activities. The life science teacher decided on the particular models to use from the water monitoring curriculum, and then introduced each class to activities from these modules. The interview determined how the curriculum impacted the teacher's interests and perspectives relative to environmental literacy and stewardship (Appendix 4). The perspectives for the overall process of introducing informal science activities were obtained from this interview. Additional interviews were conducted later on in order to acquire further changes and patterns in interests and perspectives of the teachers related to the overall process of implementing the curriculum.

Teacher responses were compared to responses from the general public (as mentioned in Coyle, 2005). An evaluation form adopted from the Georgia Adopt-A-Stream *Educator's Guide* was used to obtain feedback on the various modules within the water monitoring curriculum (Appendix 6). Furthermore, comments on any aspect of the curriculum recorded information used to gain knowledge on the overall perspective relative to using informal science activities as a resource to supplement science content.

Throughout the process of the study, rich thick reflective journaling was used to record any characteristic influences to the interests and perspectives of all participants. Students

recorded their interactions with the informal science activities through science journaling, and these reflections were used to determine student interests and perspectives relative to the curriculum. Additionally, artifacts from students' science journals were used to analyze their current perceptions on science and scientists. I used open-ended questions to document their responses towards science related questions, and their interests towards the informal science activity.

Quantitative Data

A science survey determined students' interests towards science (Appendix 2). This survey was developed and used by Lamb, Annetta, Meldrum, and Vallett (2011) and included the following response options: 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree. Each participating student was provided with a numerical code as a pseudonym, so that their identity was protected. The survey was completed one month prior to students' introduction of informal science activities that incorporated the water monitoring curriculum. I analyzed whether influences, such as family, peer, teacher, informal science, and learning science in the classroom are related to current student interest in science.

An environmental literacy and stewardship knowledge quiz were assessed using an adaptation of quizzes from Overdeest, Orr, and Stepenuck (2004), Coyle (2005) (see Appendix 5). Students completed the quiz prior to the informal science activities, and then completed it afterwards, which essentially gained pre and post responses. Each participating student was provided a code by their science teacher to keep track of their performance on the knowledge quiz prior to and after the implementation of the curriculum.

Data Analysis

Qualitative

Teacher interviews were done at integral junctions throughout the process prior to, during, and after the application of the curriculum in six 7th grade life science classes. At the conclusion of the implementation of the curriculum, data was analyzed to illustrate any changes in the teacher's perspectives on the overall process of the application of the curriculum.

Interviews were initially transcribed, and the open coding method was used. In general, open coding refers to the process of "breaking down, examining, comparing, conceptualizing and categorizing data" (Strauss & Corbin, 1990, p.61). Data-driven codes were used, since these codes only developed as the text was read. These were combined to form themes as they emerged from the text. Codes were combined to formulate themes, which determined teacher's perspectives on the implementation of the curriculum, or past exposure to informal science.

All semi-structured interviews were transcribed by the researcher and saved as Word document files. These transcriptions were printed and stored in a secured location behind 2 locked doors. For analysis, each transcript was read at least three times before the initial coding process began. This led to an initial draft of a code book, which illustrated thematic codes and exemplars were formed on the fourth read-through of each transcript. The initial open coding was done by hand, and a color marker was used to highlight each distinct code for visual identification. After manual analyses, coded transcripts were transferred to computer files for storage and future analysis. Codes were combined where appropriate to form emergent themes, which were used to answer the research questions of this study.

For research question four the teacher was interviewed prior to the implementation of the curriculum and determined their story relative to their experiences in informal science. This initial interview illustrated key junctions in their lived experiences relative to informal science activities. Additionally, it showed how influential specific persons and places shaped their perspectives of science. This ensured that there was no influence of the curriculum on the teacher's interests and perspectives with respect to current teaching tactics in science. Additional interviews were done to analyze detailed description of the process of implementing an informal science water monitoring curriculum.

Quantitative

In order to determine how the implementation of a water monitoring curriculum would impact 7th grade life science teacher's interest and perspective towards environmental literacy and stewardship, a questionnaire was one method used to gather data before and after the implementation of the curriculum. Interests towards environmental literacy and stewardship were tracked and reported over the course of this study, and determined the overall process of implementing an informal science-based curriculum in a rural school.

The initial questionnaire subscale of environmental literacy (Appendix 1) was analyzed first, and determined the initial foundational knowledge on environmental literacy of the life science teacher. A follow-up questionnaire determined if there were changes relative to implementation of the water monitoring curriculum at the completion of the study. The Stewardship subscale was similarly analyzed and determined changes in the life science teacher's perspectives on water stewardship.

The results from the science interest survey were illustrated as descriptive statistics for the relative subscales mentioned in Lamb, Annetta, Meldrum, and Vallett (2011), and the individual's responses to these items were analyzed. Students completed these surveys before the curriculum was introduced to the class. This provided a general idea of how family encouragement, peer interest towards science, teacher influence, informal learning experiences, and science classroom experiences have influenced students at this rural school.

The science interest survey was used to answer research question three on what are 7th grade life science students' interests towards science interest in rural areas. The 18 question survey consisted of 5 subscales: These subscales showed adequate levels of internal reliability relative to Cronbach's alpha (Lamb et al. 2011). Cronbach's alpha is displayed in parentheses for the following subscales: Family encouragement ((0.7) questions 1, 7, 10, 13), Peer interests toward science ((0.6) questions 2, 9, 12), Teacher influence ((0.7) questions 3, 8, 14, 18), Informal learning experiences ((0.5) questions 4, 6, 11), and Science classroom experiences ((0.6) questions 5, 15, 16, 17). Lamb et al. (2011) further noted that the science interest survey is a valid instrument for assessing science interest levels (Appendix 2).

A pre and post environmental and stewardship knowledge quiz determined how the implementation of a water monitoring curriculum impacted 7th grade life science students. I assessed students' knowledge and determined if their knowledge significantly increased or not using the SPSS statistical software for a T-Test. I also analyzed gender relative to the environmental and stewardship knowledge quiz using a 2 × 2 mixed analysis of variance (ANOVA). The environmental literacy knowledge subscale (Appendix 5) was analyzed by following each individual's quiz performance prior to and after they completed the informal science activity. A "Report Card" with a total of 9-10 correctly answered questions indicated an

A grade. A score of 8 was a B, a score of 7 a C, and scores of 5-6 were graded as a D. Questions were related to the knowledge of water, pollution, and environmental issues. Questions that were correctly or incorrectly answered by all participants were compared to the national averages mentioned in Coyle (2005).

Students pre-test knowledge quizzes were done one month before the curriculum was implemented. The “Report Card” grade for each student was placed in an Excel file where students’ names were coded with numbers to ensure that all identities were protected. This allowed changes in students’ responses in the post-test to be followed before and after the implementation of the curriculum. Any significant changes were determined from statistical analysis. The stewardship knowledge subscale (Appendix 5) was analyzed using information from the pretest and follow-up responses by each individual. This information determined if there were improvements in their content knowledge.

Lastly, the evaluation form added information on interests towards using the water monitoring curriculum to advance knowledge on water and environmental issues. This evaluation sheet served as an informative tool and analyzed the effectiveness of the curriculum relative to the teacher’s views on the use of it as a supplemental resource for their classroom.

Researcher’s Role

Merriam (1998) described the role of the researcher as the primary instrument for collecting and analyzing data, and making decisive decisions during the process to represent its findings (Merriam, 1998, p. 20). The main goal of the researcher was to ensure safety, confidentiality and anonymity for all participants involved in the study. Safety was a priority due to the nature of outdoor activities involved with water monitoring. Both life science teachers and

I maintained safety throughout the informal science activities. The teachers decided not to allow students to get into the pond as an essential measure to avoid any accidents. All participants' identities were protected, and pseudonyms were used when reporting results. Anonymity ensured that participants were nameless as well. Informed consent maintained participants' knowledge of their free-choice to participate in this study, possible benefits and risks, overall purpose and procedures that are associated in the research design.

Although earlier youth experiences in learning science through informal science education shaped my current interests and perspectives in environmental literacy and stewardship through my rural experiences, my initial goal was not to misinterpret the data from both teachers and students' perspectives. In fact, it was important to collect data from multiple sources, because emergent themes from past informal science experiences, and current views of science interest shed light on perspectives relative to environmental literacy and stewardship in rural areas. Ultimately, it was important to determine the initial concepts both students and teachers possessed (constructivist paradigm), because this definitely affected their current interests and perspectives on any topic in science.

Although the limitation to this study was the small sample size of life science teachers and number of schools involved, it was still important to determine current interests and perspectives in this rural area when a water monitoring curriculum was implemented by science teachers. I recorded the overall process involved in the development of choosing activities from the curriculum, and my prior experience assisted with the interpretation of the data. Several characteristics of qualitative research, such as member checks minimized bias interpretation and any possibility of subjectivity by the researcher. Although these interviews were guided by semi-structured questions, it was important to record emergent themes within these interviews. The

findings of this research served to advance knowledge about the potential use of a water monitoring curriculum as a resource for science teachers in rural areas.

Reflective journaling involved both classroom and field observations, and reflected the researcher's personal experiences, opinions, and feelings on the interests and perspectives of participants throughout the process of implementing the curriculum. Although the objective of research journaling supplemented other data sources in this research, it essentially assisted with the analysis and interpretation of data collected from the other resources mentioned in this research.

Reliability

The instruments used in this study evaluated student environmental literacy and water stewardship, and was adapted from questionnaires initially used by Overdeest, Orr, and Stepenuck (2004), and Jordan, Brooks, Howe, and Ehrenfeld (2011). One questionnaire (Overdeest et al., 2004) provided information on frequency, duration, and type of volunteer involvement in a stream monitoring program located in Wisconsin. This article reported no difference between experienced versus inexperienced volunteers relative to learning about the stream and water resources.

Another questionnaire (Jordan et al. 2011) discussed the reliability of participants in the citizen science program, which mapped invasive plants in New York and New Jersey. In the study by Jordan et al. (2011), participants were trained in an all-day session before being allowed to collect data. For example, two participants surveyed the length of the trail to provide each report. Hence, there was always someone in close vicinity to compare knowledge obtained from the process of data collection. Volunteers collected samples to be preserved, and determined the

abundance of each invasive plant species. Results indicated that volunteers accurately identified invasive plant species specimens they collected. Jordan and her colleagues reported that data accuracy can be increased by improving the quality of the training prior to collection. Questions are clearly stated and represented topics on both environmental literacy and water sustainability. The life science teachers and I closely worked together throughout the process of choosing specific modules from the curriculum.

Interviews determined current interests using alternative outdoor lessons at informal science settings in close vicinity to the school. The interview questions were designed in a manner that obtained answers to the research questions. Semi-structured questions were adapted for the teacher, and the responses were coded and analyzed as mentioned above. Interview questions were adapted from King, Shumow, and Lietz (1999). All transcripts were coded multiple times, and member checking was incorporated in order to establish credibility with the participant (i.e. life science teachers).

Validity

Jordan, Brooks, Howe, and Ehrenfeld (2011) used their knowledge questionnaire to report change in behavior and awareness of participants involved in a citizen science volunteer program, which focused on the identification and prevalence of non-native invasive plants. Although participation in citizen science data collection by 82 participants over a two year period resulted in changes in behavior, content knowledge did not change much. Furthermore, results showed that participants were highly motivated to take action, which indicated a change in behavior, which is a facet of the questionnaire.

Similarly, Overdeest, Orr, and Stepenuck (2004) developed a questionnaire, which

evaluated participatory action in a stream monitoring program relative to increased learning, political participation, and social networking. Additionally, a science interest survey determined student interest in science in this study. This survey was evaluated for validity and reliability relative to measuring science interest levels by Lamb, Annette, Meldrum, and Vallett (2011).

The semi-structured interview adapted from King, Shumow, and Lietz (1999) assessed life science teacher's perspectives on lived experiences through informal science learning education. Moreover, the interview was initially used in case studies of teacher beliefs in science as one method to determine the perspectives of teacher instruction in the classroom. The interview was adapted to gain a valid perspective of informal science experiences, and how these experiences have affected science instruction in the rural classroom.

The environmental literacy quiz originally developed by the National Environmental Education and Training Foundation (NEETF), and used in the Roper reports (see Coyle, 2005) was used in a study conducted in Minnesota to assess environmental literacy. The NEETF/Roper questions measured environmental literacy, and reported that 50-70 % of adults have "heard of" water pollution, energy efficiency, habitat loss, and climate change, and 95 % support environmental education in public schools. Hence, this quiz measured the changes in knowledge prior to and after the implementation of a water monitoring curriculum, designed to add environmental knowledge to students and teachers. Reports by NEETF/Roper surveys on environmental knowledge, interests, and behavior have been done 10 years prior to Coyle's report in 2005. The environmental knowledge assessment was initially developed in 1997 by a social scientist and educator, Dr. Lynn Musser. Furthermore, Dr. Musser was able to select questions, pre-test and screen them for confusion and bias, to eventually form the environmental knowledge quiz.

Triangulation can be described as, “the combination of methodologies in the study of the same phenomenon” (Denzin, 1989, p. 291). For the purpose of this study, questionnaires, surveys, knowledge quizzes, artifacts, observations and interviews were used as different data sources in this mixed methods research design in order to increase the validity of the study. No single strategy could be used to answer the research questions of this study, hence the use of various data collection strategies to increase validity.

Chapter 4: Findings

The strategies used in this mixed method research design required qualitative and quantitative techniques to answer the research questions. The selected instruments used to obtain data were semi-structured interviews, a questionnaire, science interest survey, pre and post knowledge quizzes, and an evaluation form. Additionally, reflective journaling from classroom observations also were used together with several types of student artifacts, such as student journaling and the Draw-A-Scientist test. These provided information that was used to examine and determine the interests and perspectives of students and teachers towards environmental literacy and stewardship in a rural school. Additionally, teacher’s past stories provided information on current perspectives relating to the use of informal science within the rural school setting.

A case study research strategy was used to obtain data that were necessary to decipher a deeper meaning of the interests and perception of two life science teachers relative to past informal science experiences and how these experiences transferred to the science classroom of the rural school. This study used informal science activities related to water monitoring as the innovation in a 5-8 grade rural public institution. Hence, the preferred methods required for data

collection required the case study research strategy, as well as quantitative analyses, which were guided by the following research questions:

(1) How does implementation of a water monitoring curriculum impact 7th grade life science teacher interests and perspectives towards environmental literacy and stewardship in the classroom?

(2) How does implementation of the curriculum impact 7th grade life science students' interests towards environmental literacy and stewardship?

(3) What are 7th grade life science students' science interests in a rural middle school?

(4) How has past informal science activities in the lives of 7th grade life science teachers influenced interests and perspectives towards teaching science?

Case Outline

The case in this study was two life science teachers at a rural school in the southeastern part of the United States and their interests and perspectives on using informal science education to increase environmental literacy and water stewardship.

Teacher A: Mr. Clay

Mr. Clay is a 30 year old white male teacher who grew up in a small predominantly white neighborhood. He is currently married and has 2 children (ages 3-5), one of whom was adopted. He moved once at the age of 5 years old to a rural area where farming was the major source of outdoor activities. Mr. Clay acknowledged that his dad was a veterinarian whom had a major influence on his decision to pursue an animal science degree. Mr. Clay has at least 7 years of teaching in the K-12 system, 5 years teaching 8th grade physical science, and 2 years (at his current school) teaching 7th grade life science.

Teacher B: Ms. May

Ms. May is a 24 year old white female teacher who grew up living on several U.S. army bases due to her parent's military background. Her dad was very interested in museums and had an interest in bee-keeping, which is still a hobby of Ms. May. She has only co-taught for 1 year at a high school for 9th grade Biology, 11th grade Botany, and 11th grade Zoology. At the beginning of this study, she had been teaching (on her own) for a total of 1 month, and currently taught two 7th grade life science, and two 8th grade physical science classes at the school.

Qualitative

Teacher Classroom Observations

Weekly classroom observations during a period from August-December 2013 (Table 1) revealed current information on teacher interest and perspectives toward informal science in a rural area. Initial observations showed that both teachers used various science inquiry-based activities to enhance students' scientific literacy through hands-on learning. Their positive perspectives toward science inquiry showed support for the implementation of informal science-based activities. Both 7th grade Life Science teachers discussed weekly topics during their planning periods (Monday-Friday: 8:51 – 9:51 a.m.), so that all six 7th grade Life Science classes were basically being taught the same topics at the same time. Teacher A (Mr. Clay) had a total of four life science classes (3rd-6th periods), while Ms. May had 2 life science classes (3rd and 4th periods) and two 8th grade physical science classes (5th and 6th period).

Additionally, initial informal conversations with both teachers revealed their enjoyment for hands-on activities related to past experiences with informal science experiences. Their past exposure to informal science activities maintained an ongoing dynamic interest in outdoor

informal science. In fact, both teachers asserted their push for more creative classroom activities based on science inquiry or discovery. Mr. Clay described it as “lab-esque,” while Ms. May stated, “hands-on, minds-on, knees-on,” which illustrated their inquiry based perspective on teaching science.

Both teachers agreed that the addition of outdoor science related activities to supplement in-class topics as an important addition to students’ gaining science literacy. Both teachers provided positive feedback on the use of outdoor informal science as a method to increase environmental inquiry and water stewardship. The principal also expressed the need for project-based science that involved outdoor informal science related activities. Hence, the initial support for this study assisted with the implementation of the curriculum during the fall 2013 school semester.

The initial phase of classroom observations were done August 27th – September 27th 2013 and revealed that there was a set schedule of routine events, which occurred like clockwork on a daily basis at the school. Each teacher prepared a syllabus and weekly schedule of topics being taught throughout the semester, and made these available to parents on the teacher’s online school web page. For the most part, online access to classroom activities was important to keep parents involved with the topics being taught during each week of the semester. In fact, both teachers included guest lecturers into the weekly online school webpage. Hence, at any point in time, parents knew where their child was and what they were being taught, because there was a set protocol for all school-related activities.

A typical day at the middle school began with first period (7:48 a.m. – 8:48 a.m.), which was dedicated to reading and math enrichment. A total of five 7th grade teachers rotated with

each group of students for a period of 9 weeks. Each group of students worked on different reading and math skills using various resources. These 5 teachers include the following: 2 Science, 1 English, 1 Social Studies, and 1 Special Education teacher. The activities were all different depending on each teacher's specialty. The second period (8:51 a.m. – 9:51 a.m.) was allocated as the teacher's planning period. Third period (9:55 a.m. – 11:45 a.m.) was divided into a 20 min. reading period (9:55 a.m. – 10:20 a.m.), lunch (10:25 a.m. – 10:50 a.m.), and classroom time (10:55 a.m. – 11:45 a.m.). Fourth (11:48 a.m. – 12:48 p.m.), fifth (12:51 p.m. – 1:51 p.m.), and sixth (1:55 p.m. – 2:55 p.m.) periods were all hour long classes, which concluded the school day.

The school was very strict on guided rules and protocols. There was no tolerance for deviating from these protocols. For instance, during lunch, although teachers ate at a separate table, each was within range of their class. Students were immediately disciplined if they broke rules during the lunch period.

The ability to observe the classroom on a weekly basis provided an insight on each teacher's individuality relative to teaching science in an inquiry based atmosphere. It was in the classroom where students initially learned the method of discovery, because the lessons assisted in directing students to accomplish this during class.

Interestingly, at this school students were allowed "smart devices" (cell phones, kindles, iPads) to engage in various classroom activities, such as reading articles, viewing animated concepts, and practicing problem-solving. Students also had the ability to call their parents once they obtained permission from their respective teachers. Both 7th grade life science teachers allowed their students to use these smart devices during the 20 min. reading time (3rd period).

Table 1.

Timeline of data collection throughout the phases of the research.

Date	Research Phase	Remarks
Jan 1 st – March 1 st 2013	Preparation of the Institutional Review Board (IRB) forms	Complete all necessary Collaborative Institutional Training Initiative (CITI) forms
March 1 st – March 23 rd 2013	Revised IRB forms	All revisions suggested by the IRB committee to be completed.
April 3 rd	IRB Approval	Contact the principal and begin teacher recruitment for the study
April 4 th –September 4 th	Teacher conferences	Contact teachers and sign consent forms. Begin initial interviews
September 30 th	Provide the teacher with the research forms	Teachers receive parent and student consent forms together with research information.
August 1 st -20 th	Collect forms	Teachers collect all forms from parents and students.
August 27 th – September 27 th	Classroom observations and student survey/artifacts	Total immersion 2-3 times per week to observe 6 7 th grade life science classes
September 28 th –October 28 th	Teacher observations and interviews. Student questionnaire and pre-test	Complete 2 interviews per teacher.
October 29 th – November 8 th	Water monitoring outdoor activities	Students and teachers completed all water monitoring activities.
November 9 th – December 9 th	Final teacher interviews and student post-test	Begin analysis of all data.

A Typical Day in Mr. Clay’s Classroom

The 7th grade Life Science teachers’ planning period takes place during the second class period from 8:51 – 9:51 a.m. During this time, teachers are involved in a variety of activities, such as lesson planning, teacher meetings, phone conferences with parents, and grading. Mr. Clay’s classroom was equipped with 7 large immovable desks, which had 4 individual chairs

surrounding each desk. A table located at the front of the class was equipped with a sink, and seemed to be the focal point for various teacher demonstrations. The room was spacious and contained 3 storage cupboards that housed science-related equipment, such as microscopes, balance scales, beakers, pipettes, and science kits. The walls of the class contained a collage of science-related photographs and diagrams illustrating human anatomy and physiology, photosynthesis, creatures of Alabama, and a coral reef poster. There were two shelving units at the front of the classroom that stored an assorted science-related books and magazines. These were used during the 20 min. reading time each day at the beginning of third period.

Mr. Clay's class typically begins with him directing his students to complete a response to a question in their science journals, which was written on the dry erase board prior to them entering the classroom. Students completed this assignment at the end of a 20 min. reading period. At the conclusion of these activities, students prepared themselves for lunch at the cafeteria, which took place at a similar time for both 3rd grade Life Science classes (10:25 a.m. – 10:50 a.m.). After lunch, Mr. Clay called on students to discuss the science-related statement located on the "Cool Fact" dry erase board that was generally followed by an interactive student response session related to the science journal question. Consequently, this "bell ringer" used by Mr. Clay was what students answered at the beginning of the 3rd period.

Mr. Clay then proceeded with the topic being taught for the week. The daily topics for the week were displayed on another dry erase board located at the opposite end of the classroom. Mr. Clay informed me that students are trained to pay attention to this information during student orientation at the beginning of each school semester.

Many of his topics involved hands-on science activities. For example, he had students bring animal and plant cell models as part of their “at-home” science projects. He provided an instruction sheet, and allowed them 2 weeks to complete the assignment. Results from these projects showed that students were very articulate when they constructed both animal cells and plant cells. Students articulated each organelle and structure of the cell using various colors, shapes, and displays. There also were displays that illustrated the functions of the various cell structures. The best projects were displayed at the school’s library for viewing after grading was completed.

Mr. Clay also used in-class assignments to assist students with challenging topics. For example, he used an activity titled, “paper plate” Mitosis, which basically allowed students to construct the various phases of the Mitotic process (i.e. prophase, metaphase, anaphase, telophase) using materials, such as paper plates, glue, and different colored yarn. Mr. Clay provided students with an instruction sheet, and his goal was to alert students to practice carefully reading and following instructions, while visually learning to identify what happens to the chromatids during each phase. Mr. Clay assisted students as he moved throughout the classroom, however he continually asserted, “read the instructions carefully,” as he received questions from the students.

Classroom observations and reflective journaling allowed me to gain an insight to the daily routines, which occurred during each class period. For instance, an example of Mr. Clay’s typical 3rd period class was as follows:

At 9:55 a.m. the 3rd period class entered the classroom and proceeded to their seating assignments, which seemed to be already designated by Mr. Clay. He briefly relayed a

message to students concerning their science journal. He alerted them to the dry erase board located at the front of the classroom, where the following statement was written, “How can you add 5 lines to this (I I I I I) to make 9?” Additionally, there also was a “Cool Fact” displayed on another smaller dry erase board that stated, “The United States consumes 25% of all the world’s energy.” After all the students were seated, Mr. Clay closed the door and walked around the classroom, while he talked to students about yesterday’s class notes on the topic titled, “Characteristics of a cell.” He alerted students to his PowerPoint slide, located at the front of the class with notes on unicellular and multicellular characteristics of a cell. Students copied these notes word for word into their science journal. Throughout the class period, there were knocks at the door, which periodically drew Mr. Clay’s attention away from the classroom activities. The classroom door was always locked during class time, and this was part of the school’s security protocol. Once students completed their note-taking task, they were allowed a period of time (20 mins.) to get a book from the classroom’s library to read. Interestingly, students also were allowed to use their smart phones or iPads to find articles online to read during this time. The students were extremely quiet during their reading period.

At 10:20 a.m. students formed a line and prepared to walk to the cafeteria for lunch. During lunch students sat in their respective groups under the watchful eye of their teacher. While at lunch, students would periodically ask Mr. Clay’s permission to use the restroom, which was located in the cafeteria. I noticed that Mr. Clay always scanned the lunch table area where his students were located. This vantage point allowed him to call on students if they broke any rules during lunch. At least three teachers sat together during lunch and in many cases they discussed issues with specific students. In my

opinion, this showed that a team effort was necessary to maintain student discipline. At approximately 10:50 a.m. students formed an ordered line and returned to class. In class, their first assignment was to answer the journal question. Students lead the discussion together with the teacher and answered the journal question. The eventual answer to the “science riddle” brought a crescendo of student “awwwws.” The teacher’s planned lecture followed with differences between unicellular and multicellular organisms as a review before the new lesson. The teacher explained what students should be doing for the rest of the week from the board with the week’s objectives and outcomes located on the dry erase board located at the opposite end of the classroom. Students used a sheet of paper to write 5 facts from videos they viewed during the remainder of the class period. The teacher steadily paced the classroom, and his voice was clear, strong, and projected clearly throughout the classroom. The teacher then proceeded to dim the lights in order for students to view a few videos pertaining to the lesson. The videos shown were (1) Microscope video (Bill Nye) and (2) 1665 Antoine Hooke built a microscope that discovered protozoa (single celled organisms). Students were quiet and focused throughout the video. I too found these videos really educational. Although the classroom was completely dark, students were focused on the video. At the conclusion, the teacher noted that discoveries in science required microscopes, which tied into his upcoming topic: Microscopes.

The teacher assigned a reading on page 12 of the life science textbook, which was located at the center of each desk, and alerted students to answer a few questions from the slide at the front of the class. The teacher walked around the class answering questions from students. He goes into great detail in his explanations, which relate to life and the society.

In conclusion, Mr. Clay's class followed a set protocol of events, which students have grown acquainted too. The only difference seemed to be the topic being taught.

A Typical day in Ms. May's Classroom

Unlike Mr. Clay's classroom, Ms. May's classroom only contained individual student desk chairs, hence Ms. May can physically change her students' seating assignments throughout the semester. The classroom was half the size as Mr. Clay's classroom, however Ms. May also had access to another classroom next door, which she utilized as a science laboratory. This lab had a fish tank, lab equipment, preserved animals, and current student related science projects on the desks.

Although Ms. May was new to teaching 7th grade Life Science students, she utilized her fellow science cohorts' expertise and advice in her lesson planning and development. Both 7th grade and 8th grade life science teachers shared the same planning period time, therefore they regularly met to discuss issues and share resources. Ms. May used a similar out-of-class animal and plant cell project as Mr. Clay for her student cell project, but differentiated from him by allowing students to make edible cells. There were animal cell cakes, plant cell jello, cookie-shaped cells, together with other non-edible projects. Ms. May allowed students to present their cells to their fellow peers, while she partially assessed their projects by questioning their knowledge of cell structure and function.

An example of Ms. May's typical classroom activity was as follows:

At 10:20 a.m. Ms. May allowed her 3rd period students into the class and immediately announced, "it is D.E.A.R. time," which is an acronym for Drop Everything And Read. A few

students obtained books or magazines, mostly National Geographic magazines from the shelf located at the back of the classroom. The seating arrangement was designed in a semi-circular manner to accommodate student testing for the later 5th and 6th periods. Ms. May walked around the classroom and observed what students were reading continually pausing and asking her students questions about what they were reading. This brought complete silence in the classroom.

At about 10:20 a.m. the students proceeded to lunch. On returning from lunch at 10:55 a.m., Ms. May asked students to take out a piece of paper and stated, “In your own words tweet your perception about what is science.” A few students (about 3 males) questioned how they should complete the assignment, but Ms. May explained it to them in detail.

On completion of the above assignment, they began project presentations in a pre-designated manner, which was determined prior to the completion of the projects. Students were grouped in pairs, and they presented their 3-dimensional animal cells. Although the first group was not as confident with their presentation, the following two presentations were well articulated, and constructed from Styrofoam balls. Presentations were less than a minute long, and a few presentations were made from edible materials, such as jello, gummy worms, and hard candy. These edible characteristics drew the attention of other students in the class. One student had a glowing Styrofoam representation of an animal cell, which students expressed amazement over. A couple of students used rectangular cereal boxes to represent their plant cells. Ms. May asked each presenter to highlight at least 2 structures from their 3D projects, which allowed students to demonstrate their knowledge of cell structure and function.

Another in-class group project completed by students in Ms. May's class was the "Photosynthesis poster" project. She allowed students to represent the process of photosynthesis using clippings entirely from National Geographic magazines. Student groups were provided a 25 cm × 40 cm cardboard template, glue, markers, and scissors for this project. Their objective was to illustrate photosynthesis using photographic clippings located in various magazines. Each group discussed what picture could be used to represent each part of the equation for photosynthesis. A couple of these representations highlighted their thoughts on how they represented glucose, carbon dioxide, oxygen, and water. Interestingly, students knew they had to complete a group project when they entered the classroom due to the seating arrangements. Unlike Mr. Clay's classroom, Ms. May's classroom only contained individual student desks, therefore if four individual desks were grouped together students mentally prepared for an in-class group project.

Teacher Outdoor Observations

Overall, the two life science teachers in this study utilized science inquiry-based techniques, together with in-class note taking as techniques to introduce new topics in science. I noticed that techniques used by these teachers required students interacting with each other in groups of 2-4 where appropriate. Further observation revealed that most students communicated well with each other. It was necessary for students to communicate and troubleshoot issues relative to science related group projects, as this was one method of assessing communication within groups.

Although students were mostly confined to secured classrooms, they were allowed outdoors for physical education activities. Students from various classes can be seen walking

around the exercise track throughout the day, and they are accompanied by their respective teachers/coaches. Teachers were always equipped with communication devices, such as cell phones and walkie-talkies when they take their students to the exercise track or outdoor classroom. Informal conversations with the two life science teachers revealed that they take their students to the outdoor classroom located approximately 50 meters from their formal classrooms, and within the school's boundary. Furthermore, in the past, 7th grade life students were allowed to check the bird nesting structure to determine bird activity. Currently, Ms. May is an avid volunteer for Project Bird Feeder Watch (Cornell Lab of Ornithology) and she expressed interest in using the school's bird nesting structure for related student projects in the future.

Mr. Clay and Ms. May were aware that a small man-made freshwater pond is located within close vicinity of the outdoor class. In 2009, the pond was dug by a teacher currently employed by the rural middle school. In the past, the pond was routinely stocked with various fishes and turtles, and there has been sporadic maintenance of the area around the pond. Both teachers were initially supportive of this initial research proposal to use this pond to implement an informal science curriculum based on water monitoring. Essentially, the life science teachers have similar ideas on how they want to apply science in an inquiry-based manner to their students. They share the same perspective on utilizing the school's pond, which was located on the school's premises, and both shared a positive attitude for informal science education.

Mr. Clay's classes

On Tuesday October 22, 2013 we implemented the macroinvertebrate activity from the water monitoring curriculum (Module 4). We used the pond located at the back of the school, where we divided students into groups of four, and provided one student in the group with a

macroinvertebrate scoring sheet, as well as a macroinvertebrate identification sheet. Students either used a dip net with 0.1 mm mesh or a white rectangular container, which they used to directly scoop water from the pond. Mr. Clay and I assisted with the initial macroinvertebrate identification, and scoring protocol for the macroinvertebrate sheet. Throughout each class (3rd – 6th period), Mr. Clay showed comfort with assisting students to identify various macroinvertebrates. He showed excitement as students found various aquatic insects in different life cycle stages. He showed patience while assisting students, and he mostly interacted with them when explaining concepts with various student groups. In fact, Mr. Clay alerted me that there were 9 students in his largest class (31 students) that were special need students, but in this outdoor environment, he stated, “they all look the same and you can’t tell who they are.”

At the conclusion of the informal science water monitoring related activity, Mr. Clay’s overall evaluation of the curriculum revealed that he was positively in favor of using various parts of the curriculum in his class. He concluded that various parts of it were clearly demonstrated, and matched curriculum guidelines for his classroom. His only concern was the fact that he felt that he would not have time to complete certain aspects of the informal science curriculum, such as watershed, build a critter, and water chemistry related topics. He did mention that the macroinvertebrate water monitoring section would be incorporated as a mainstay topic in his classroom curriculum.

Ms. May’s Classes

On Tuesday October 29th 2013, Ms. May and I took her 3rd and 4th period 7th grade life science students to the pond located at the back of the school to implement the informal science activity related to macroinvertebrate water monitoring (Module 4). Students were first given

instructions on the task of macroinvertebrate identification. Additionally, they were provided with instructions on how to complete their monitoring sheets in order to collect data, which was analyzed at the end of each class. We assisted students with species identification throughout each hour long class. Although the outdoor temperature was a bit colder than when we completed the macroinvertebrate activity for Mr. Clay's classes, students showed great interest in the activity.

Interviews

Past Informal Science Experiences

Mr. Clay's initial interview revealed that his teaching philosophy was based on exposing students to the world of science, and being the "facilitator" in providing this exposure. He highlighted his role as a science teacher in the following:

And so, I think just exposing them to those things, and and and helping them learn, when they have questions, a way to figure out the answers, and to not just tell em always, but but to help em learn how to think, and how to, to decide for themselves...I think some days it's the role of the facilitator, but some days its its its, you know, you gotta tell them some things obviously, but um, just kinda facilitate their learning, and provide opportunities for them to learn, and see those situations when they can learn, and and and it does not always have to look the same, and so help em understand that.

Mr. Clay's interview highlighted 11 open codes (see Table 2). These codes were divided into two themes. Theme 1A combined codes that were related to the initial exposure to science provided by Mr. Clay's dad. These codes were Timeline, Teaching Qualifications, Teaching

Experience, Personal Decision, and People Influence. Theme 1B combined Teaching Philosophy, Bold Statement, Place of Interest, Action, and Change in Attitude, and Reminiscing on past experiences.

Ms. May saw her teaching philosophy as one of being a “promoter” of discovery. She illustrated this in the following:

To promote students to kind of discover on their own. I really want a lot of self-discovery. I try to present material, and then allow them to find out more indebt details on their own, um, as far as they wanna take it...Hands on, minds on, knees on, um, your hands are on, your minds on, and you’re on the floor doing something, moving around, yeah, always moving.

Like Mr. Clay, Ms. May’s was influenced by her dad at a very young age. Open codes were similarly divided into two themes, which represented a similar structure as Mr. Clay’s story, but with some differences.

Theme 1: The Parent Initiates the Initial Informal Science Interest

Mr. Clay’s story begins with the influence of his father, a Veterinarian by profession, whom encouraged his 5 year old son (Mr. Clay) to visit the Veterinary, which was located next to their home. Mr. Clay gave a partial account of a few of his childhood experiences at the Veterinary. He stated, “...doing surgery on a dog, or putting a dog back together, doing C-sections, helping him resuscitate puppies.” These were only a few examples of the initial experiences between Mr. Clay and his father. Additional activities at the clinic involved learning about vaccines, such as rabies, and listening to his father speak to clients about issues with the

animals they brought to the clinic. Although his father was a Veterinarian by profession, Mr. Clay also described his father as an “outdoorsman” and this led to Mr. Clay’s early childhood exposure to hunting and fishing, which are informal science settings. He stated, “we would hunt, and fish , and so I remember fishing with him when I was young , so we didn’t go on excursions for science education purposes I wouldn’t say, but I was learning about science.” He assisted his dad with delivering calves and foals, as well as other farming duties, such as driving farm equipment, raising cows, cleaning deer, and taking care of their pets.

Mr. Clay explained, “I was learning about science, about the disease that caused that animal to do that, you know, the virus that caused it to to, and how you get back to aiding against that.” So his statement signified that he learned science or more specifically animal science at an early age.

Mr. Clay mentioned that he did not go to any field trips during Kindergarten. In fact, he stated, “my father was a veterinarian, so every day was a field trip.” Mr. Clay remembered his class tending to baby chickens in the classroom.

He stated:

we didn’t do a lot of, you know, outdoor hikes for that purpose, but for science or education purposes, but there was a lot of science built in to that, I mean when we would raise animals, we raised cows, and we had horses always, and so, dogs and cats obviously, but um, and and you kinda understood the reasoning for why you had to feed them and the nutrition behind that, and so, um, we would raise calves if their mother died, and so feed um by bottle.

He also remembered his mother fondly telling everyone the story of him planting beans he had received from the school in her flower bed, and picking 3-4 beans from the plant, and placing them in the freezer at home.

He mentioned:

we potted pod beans , and I brought that home and planted my little bean plant, in her rose bed, outside the house and it grew 3 or 4 beans, and I took those off, and I put em in the freezer bag, and put em in the freezer, because that's what you do with vegetables, you freeze um (laughs). So I had me a little zip lock baggy of 3 or 4 green beans from my bean plant, that I froze, and so, but we also gardened, I mean so I had a pretty good grasp on that pretty early on about gardening.

As a teenager, Mr. Clay obtained a B.S. degree in Animal Science, seemingly from his close relationship with his dad and his dad's profession as he explained, "that's why I started off in Animal Sciences, and why I have an Animal Science degree, cuz I started off, and said, I wanted to be a Veterinarian." Mr. Clay made an important decision when he decided to pursue a Master's in Education. He explained, "I realized I like people more than I do animals." During this time, he was involved in an Outreach program, where he was first contacted by an acquaintance to apply for a teaching job, because the person who made this suggestion thought he would be perfect for the job. His job hire was strictly by chance as he noted, "so that's how I got my first job, was they needed somebody kinda fast, and so, in lieu of my internship, I gotta job teaching."

As a collegiate student in the College of Education, he was hired as a Physical Science teacher in lieu of his teaching internship. This was a major part of his life, as he would later marry, and have children.

May's story begins early in her childhood with a connection to the outdoors. Her parents' involvement with the U.S. military provided a means for her to visit many places, but it was her dad that showed her insects, frogs, and reptiles. In fact, she was in 5th grade when her dad introduced her to bee-keeping. She stated, "got home and dad said we're gonna do this together, so we extended it, you know, splitting hives, and just growing the business." Ms. May retains a great relationship with her dad, because they still continue to run the business of bee-keeping. Although she described the business as "break evenness" its an important part of her life. She explained, "you shove a lot of money in, we shove a lot of money out, and it's fun."

Her dad provided her with exposure to both traditional and non-traditional free-choice learning experiences. For instance, she mentioned that her dad's favorite past time was to visit the local museums. She stated,

yeah, well I mean museums are my dad's favorite so off course we did all of the local museums, ah, I've been, Jeckel island is the one I remember the most museums cause that's ah usually family vacation and you know the sea turtle life, the birds, we did get to see a lot of the birds, you know that's more Dauphin island, there is a small population that goes through Jeckel island, um, oh gosh, it's a lot.

She remembered these experiences the most because they were family vacations. Hence, Ms. May was exposed to the love of museums from her dad, because he led their family to many such trips. Ms. May noted that she travelled a lot as a kid.

She also stated,

Oh I went on bunches, ah, so we went to ah, what was that place, Jeckel Island, it's the mud trip, we get to bog through big mud things. We did that in 7th grade, which I would like to bring here, ah they go to Georgia and go to the mud bogs. Just walk through em, and then, oh gosh, um, in high school my parents travelled a lot and I got to go with em, um, the east coast, the west coast, ah, California, yeah.

She illustrated her love for insects by demonstrating bee-keeping during her collegiate internship. Ms. May used her bee-keeping suit to explain the hobby. She stated, "I did a whole presentation on bee-keeping." Additionally, during her collegiate internship, she stated, "I caught some Salamanders, and then during reptiles, I actually had the students participate in Frog Watch U.S.A. and they had to document the type of frogs they hear."

Theme 2: Past Informal Science Experiences Connects With a Science Perspective

Mr. Clay's informal science experiences from his dad's clinic played a key role with forming his overall perspective of science. He stated,

I was learning about science, about the disease that caused that animal to do that, you know, the virus that caused it to to, and how you get back to aiding against that, and you know, so you know, learned about vaccines from an early age, and you know, and and I teach about vaccines now, and my kids are like, that for, you know, they don't understand how a vaccine works, I don't understand, and I knew that pretty early on, cuz we had to get rabies shots, when growing up, and to protect us if we got bitten by an animal in the clinic, and so, you know, so I don't remember, we didn't do a lot of, you know, outdoor

hikes for that purpose, but for science or education purposes, but there was a lot of science built in to that...

Another experience that again described how his perspectives of science was shaped was mentioned,

I remember being young and talking about that, and my dad, he is an educator. I mean, he's a Veterinarian, but I can remember him sitting in there talking to clients , in his office about what he was, what he was doing and why he was doing it, and just kinda helping train them...

As for Mr. Clay's teaching style, he mentioned that he was currently taking steps to make his lessons more hands on, and if possible, introduce more outdoor-related activities into his classroom, and into daily lesson activities. He stated, "...that's something I wanna develop and get better at," to highlight his goal to add more hands-on experiences to his classroom.

He also stated,

...this is important in being able to communicate your observations, and and your conclusions, and and doing those things I feel like, I do a fairly good job of tying that stuff in. It's not about just getting out there and just playing around, you have to actually communicate what it is you're doing, and what it is you've seen, and and and produce a product that somebody else can look at your work, and understand what it is you get and understand why, and so, cuz that's life...

In terms of teaching lessons, Mr. Clay exclaimed, "I don't feel like I'm there yet as far as my career." However, he noted that he had changed some lessons by 40-50 % this year, and has

made an effort to teach at least one “lab-esque” lesson a month. An important aspect of improving his teaching in science is his support from his administrator as stated, “...but as far as support from my administration, I think I’m pretty blessed as far as that goes.”

Interestingly, Mr. Clay has transferred his childhood father-son experiences with his own son in that he exposed his son (4 years old) to various outdoor activities. For example, he stated, “had him (son) take the earthworms and, and pick em out of the dirt for me, and I got him to hold em, and talked to him about em, and then I got him to put em in the dirt.” Mr. Clay shared another example where he noted that his brother would take time to explain things to his niece. He added, “I remember him very distinctively taking the time to answer her questions, and just, giving more of an explanation, almost to the point that she was like O.K. and stop listening, you know, and so I do that with my son.” He practices a similar protocol when his son asks a question.

Overall, this interview shared a story about Mr. Clay where his journey was initiated by his father and currently shares a similar resemblance between Mr. Clay and his son. The narrative showed a connection between early outdoor activities and a desire to transfer these experiences in some manner related to his teaching style. Additionally, Mr. Clay’s story showed that an influential parent at the beginning directed the decision to follow a career during the middle part of his life (collegiate), and then ending with a yearning to expose informal science to the classroom as an adult. Both themes involved early exposure to free-choice learning environments, where the learner (Mr. Clay) was influenced by the teacher, hence deciding what he wanted to learn, and how much he wanted to learn.

When asked if Ms. May went to any trips as a young child, she responded, “I mean museums are my dad’s favorite so off course we did all of the local museums.” She mentioned family vacations to San Francisco, New York, and Louisiana during her childhood. Additionally, she remembered an Elementary school trip to the Birmingham Zoo and to the Fern Bank. These trips exposed her to informal science and the outdoors.

Ms. May spoke a lot about Jeckel Island where she visited while she attended 7th grade. She stated, “7th grade, yeah, it was nothing but science.” It was during this time when she got to pet turtles, touch sea anemones, and visit the mud bogs. These trips have influenced some of the things she currently enjoys, such as insects, frogs, and reptiles. The ultimate influence to her can be summarized in the statement, “...in 5th grade, got home and dad said Em we’re gonna do this together, so we extended it, you know, splitting hives, and just growing the business.” Bee-Keeping became her passion as a result of her exposure, and she stated that she would love to show her students an active hive in a controlled environment.

Ms. May is no stranger to citizen science projects. She mentioned participating in projects, such as Frog Watch and Bird Feeder, where both involve observing and recording data. She hoped to get students involved in these types of outdoor projects. This essentially illustrated her goal to have students display hands on, minds on, and knees on.

Table 2.

Code book for Mr. Clay.

Code	Abbreviation	Definition	Exemplar	Transcript Line #
Timeline	T	Important time	“our garden in	93

		periods of the participant	Tennessee before I was 5”	
Teaching Qualifications	Q	Teacher qualifications	“BSc. degree in Animal Sciences	4
Teaching experience	TE	Years teaching and types of teaching	“2 nd year teaching 7 th grade Life Sciences”	6
Personal Decision	PD	A decision made that relates to a life changing event	“seeing a good fit and that was right	13
Teaching Philosophy	TP	Statements about the way he teaches	“exposing these kids to the way things happen”	27
Bold Statement	S	A statement about any experience	“the mothers are the ones that have the issues”	129
People Influence	PI	Participant’s mention of people in the interview	“my father was a veterinarian”	47
Place of Interest	PL	Any mention of a place by the participants	“next door to his clinic”	49
Action	Action	The participant performs an action	“putting a dog back together”	51
Change in Attitude	CA	There is a change in the way the participant	“I wanna develop and get better”	189

		teaches		
Reminiscing on past experiences	R	The participant focuses on a past memory	“I remember my brother whenever she would ask”	316

Table 3.

Code book for Ms. May.

Code	Abbreviation	Definition	Exemplar	Transcript Line #
Timeline	T	Important time periods of the participant	“We did that in 7 th grade”	15
Teaching Qualifications	Q	Teacher qualifications	“BSc. in Secondary Ed. Science in biology	3
Teaching experience	TE	Years teaching and types of teaching	“One, first one, ah a month”	6
Teaching Philosophy	TP	Statements about the way he teaches	“To promote students to kind of discover on their own”	10
Bold Statement	S	A statement about any experience	“I just like the whole unit of life”	55
People Influence	PI	Participant’s mention of people in the interview	“got home and dad said we’re gonna do this together”	131

Place of Interest	PL	Any mention of a place by the participants	“Jeckel Island, it’s the mud trip”	14
Action	Action	The participant performs an action	“went through and got to pet turtles”	42
Change in Attitude	CA	There is a change in the way the participant teaches	“I’m learning just as them”	85

Theme 3: Teacher Interests and Perspectives Increased for the Water Monitoring

Curriculum

Mr. Clay reviewed the water-monitoring curriculum, and wrote comments on several sticky notes in order to discuss his views on the implementation of the curriculum. The overall goal was to collaborate, discuss, and document what would be the right method to implement a particular module(s) from the curriculum. Mr. Clay noted his interest in the module 1 activity and stated:

Yeah, yeah, that’s amazing, ok, um, yeah I was, I think, you may know these facts, and one of your videos may address that, but it was talking about how the domestic use for water in the United States here, I thought that was interesting about flushing is 40%, washing and bathing 30%, but how much of that do we actually, what percentage of that makes it back into the water supply, as as grey water.

Mr. Clay seemed very keen and demonstrated his awareness of water issues, and his knowledge of a few topics was evident during this interview. For example, he stated, “...what

percentage of that makes it back into the water supply, as as grey water.” He showed prior knowledge of water classification where grey water is designated as polluted water. Additionally, Mr. Clay mentioned, “I did the Water Watch training when I was working on my Masters,” and this further highlighted his knowledge on the procedures and methods used in water monitoring. He did mention that he assisted a friend who worked at a water treatment plant in this informal science setting probably allowed him an avenue to gain more information about water.

There were a few parts of the water monitoring curriculum that interested Mr. Clay, and he was very adamant on using a few activities in his class during this term. For example, Mr. Clay was very interested in Module 4, “*Stream Critters as Pollution Indicators*,” which allowed students to identify macroinvertebrates to determine stream or pond “health”, which can illustrate a variety issues, such as pollution, low oxygen, and algae over growth.

He asserted:

I think that that’s great, something they can walk out with ID cards or an ID sheet like you’ll had, and and, with very little preparation to have an idea, you know they don’t have to know much to have a knowledge of ph, or dissolved oxygen... Things like that you can do the chemistry side of that, but with the macroinvertebrates I think it’s great.

Mr. Clay shared some light on his views of water stewardship. This was evident by his knowledge of water sustainability.

He stated:

...it’s amazing too that people complain about the price of gas and if they actually thought about how much they pay for bottle water... I’d believe that most of them don’t

know what happens to their water when it goes down the drain...I thought it was interesting about flushing is 40%, washing and bathing 30%, but how much of that do we actually, what percent of that makes it back into the water supply, as as grey water.

He expressed enthusiasm about some major topics, such as watershed, water treatment plant, sewage, pollution, and bacteria. Although Mr. Clay revealed that he covers bacteria in class, he related concern about students not being aware of the whereabouts of how water transfers through different systems.

He stated:

Your in their watershed, right, right, I'm sure they don't want to think bout that, but, and hopefully by the time it gets to, even to the sewage pond, you know, its just like pond water, ideally, but its not always I'm sure, but you know, I'm sure they treat it, and so I think that's, I think that's great for them to think about, because I'd believe that most of them don't know what happens to their water when it goes down the drain.

Overall, Mr. Clay displayed a generally positive interest towards the curriculum and agreed that certain modules would be great to implement in his 7th grade life science classes. He noted, "You can do the chemistry side of that, but with the macroinvertebrates I think it's great." Furthermore, he added, "we got several kids who are really excited about that sort of thing," to highlight his positive attitude towards the outdoor macroinvertebrate activity.

As we proceeded with the interview, Mr. Clay explained that the science articles towards the end of Module 2 did not seem relevant to implement in his 7th grade class due to its advanced

level, as well as the amount of time required to explain certain words. There are two peer reviewed science articles at the end of Module 1 and Module 2, which are 6-8 pages in length, hence his concern towards introducing this element to his students.

He stated:

Cause most of these words, they've never heard before, and then I was thinking, it would take a huge amount of time to do the prep work for that module, that would be tricky, just because, I mean, you can talk about it, and just use the very basic terms, but getting into the actual different things, I mean, especially when you get to the organics, that's when they're like what, that's when you're gonna lose them, they're not gonna know what you're talking about, you know, ah mean you can say, you know, metals like lead, things like that in the water, copper, iron, things like that, but, or you can take, talk about bacteria, but getting into individual ones, I don't.

Ms. May also reviewed the curriculum prior to its implementation. She commented on her changed view towards the water monitoring curriculum as she remarked, "We are 2 miles to a river in every direction in Alabama. That was really fascinating and that really changed my point of view on how I look at this curriculum."

This positive view increased as she mentioned various features of the curriculum, which she wanted to implement in her class. For instance, she asserted,

I wish we had a set, you know, 6 weeks where we could talk about stuff that mainly involve this area. For like Alabama water, uh, for New York environment control, uh, you know Wyoming, I guess farming, cattle, you know, stuff that pertains directly to the students, especially those in environmental science. I wish we could bring it back

because, ah, talking about stuff I do, oh I can't naturally relate to is kinda hard to motivate them on that, but if we're talking about water quality then, and they have a stream in their back yard, I think it really hits home, uh, that was something I really thought about, took to heart, and maybe one day dream world.

Ms. May agreed that Module 1 would be a great activity to implement in her class. She stated, "This first one I think is very good. The water supply where you judge how much water you use and how much you waste." This module focused on water stewardship and Ms. May revealed her interest towards student responses to questions related to their water-use.

Like Mr. Clay, she too was interested in the watershed topic, and she stated,

...the build your own watershed, I want to do this one. I feel like it is very, I think it would be very fun. Bring like, cause a watershed, what is that really? The students ask themselves, and they actually make one. I would just have to gather up all these resources, which might take a couple years, but that one seems fun. I think my students would understand that they can't wash pesticides close to a watershed, watch, you know, throwing trash from your watershed.

She also mentioned:

"Let's see, let's start with module 1, "water and the environment." This first one I feel like is very good. The water supply where you judge how much water you use and how much you waste, and then, let's see, what was this one. OK, the limiting resources, and stuff like that. That would be an easy one for me to reproduce.

Unlike Mr. Clay who explained that the science articles were too advanced, Ms. May expressed:

Um, ok, the only difficult, the one I don't know if the students would really take home is the reading one, but they need to start learning how to do more reading and what is this called, the Alabama surface waters, treasure taken for granted, I really, I think they'll have a hard time and not really like it at first, but I think if I pull the right article as an interest article and then build up to a more difficult ones, this will be part of the most challenging one I had to get motivated for, but all the other ones seem fine.

Module 3 has an activity called "create a critter," and Ms. May expressed her science inquiry foresight, and her joy for using hands-on activities as she mentioned, "I love anything with the title "create" so off course I would create a critter, actually do an activity called create a critter, not with microorganisms."

When asked about what modules in the curriculum Ms. May thought would work in her class, she responded:

I know yours will work (referring to the macroinvertebrate monitoring in Module 4), ah, the going out, they wanna go outside, and I wanna take em outside. Another one that would work right now is like the how much water do you use (referring to Module 1)...I want to get a copy of that watershed one, because what is a watershed (referring to Module 2).

Ms. May did express that she had prior knowledge about making a watershed at a past camp where it was done as a demonstration. She asserted, "the students loved it so I think that a demonstration, and letting them build one is a plus." Additionally, Ms. May also has prior

experience with building a critter, which she has done in the past using an arthropod as the theme. She maintained, “the only difficult, the one I don’t know if the students would really take home is the reading one.” Although there was concern about the reading, she did agree that it is an important feature to learn, but would present challenges for many students. Apart from the science-related articles in the curriculum, Ms. May agreed that all the other modules could be incorporated into her class teaching protocol.

Surprisingly, Ms. May explained that Module 4 would present her with the most challenge. Mr. Clay viewed this module as his strongest, but Ms. May described, “I will have to study up on ID-ing, I’m worried about getting out there and students would be like, so what’s this, and I’m like, where’s my ID guide.” Furthermore, she addressed a lack of confidence in macroinvertebrate identification as she stated, “I’m just worried about myself ID-ing, I’m not the strongest person microscope ID er, I can ID anything I can touch, but the microscope, I will be working on it though.”

Teacher Questionnaire

The completion of the initial questionnaire (see Appendix I) by the two life science teachers in this study showed that they felt like they had a slight to moderate extent of environmental literacy pertaining to environmental science, non-point source water pollution, wasting water, stream habitat, water protection, and desire in taking a future water monitoring course. Mr. Clay and Ms. May also felt that they can make a difference in protecting the environment.

In terms of stewardship, Mr. Clay and Ms. May had similar responses (slight to moderate extent) with respect to watching nature programs on TV, concern for global climate change,

water pollution, and water treatment plants, as well as involvement in outdoor activities, such as fishing, hiking, and gardening.

Interestingly, although both life science teachers mentioned that they had water filters at their homes, Ms. May recycled plastic to a great extent compared to only a slight extent for the other. Additionally, although both were very interested in taking a water monitoring course neither had used the internet to search for information about Alabama's rivers nor streams in the past 6 months. In fact, Ms. May stated, "I went home and looked it up and you were right, I never knew that about, what you said, being able to stand in one place, and get to a river or stream within two miles." Hence, prior to this study, she had no idea that the state of Alabama has the most amounts of navigable waterways in the United States.

Student Artifacts

What is Science?

An example of a student artifact used to determine students' interests towards science was the "tweet" assignment. When students were asked to "tweet" on a blank piece of paper their response to the question, "What is Science?" as part of their in-class science journaling, the general responses for both male and female students illustrated the following:

...science is a class or subject, where they learned about living things like plants and animals...science is the study of life, or learning about life, death, the human body, the Earth, and mixing chemicals...science is learning about nature, and learning about interesting "stuff" that they did not know about.

Interestingly, most male students of the six 7th grade classes wrote brief one-line responses, which represented their general attitude and perspectives of science. Some examples of these responses were as follows:

Student 1: “Science is the study of plants and animals.”

Student 2: “I think science is what we use to find the answer to most things.”

Student 3: “Science is the study of living things.”

Student 4: “It’s a lot of nasty bugs that you look through microscopes.”

Student 5: “The study of life.”

Surprisingly, the few negative interests towards science in this exercise came from male students. Some of the examples are illustrated in the following:

Student 6: “I think that science is studies of scientific things #science class ☹ boring.”

Student 7: “Science is a very very boring subject that I don’t like.”

Most female students responded with at least 3 lines or more when asked about what their perception of science was as illustrated in the following:

Student 1: “Science is the study of life of all living things. In science you can learn about cells, plants, trees, and the way babies are born. A tool that you can use for science is a microscope so you can see cells!”

Student 2 stated:

Twewbie here! So whatz science? Well science is everything about the world. Science is about the environment, human body, earth, space, and many other things 2. U can learn many different and interesting things n science that u may not know. U also may learn some things that u didn't want to know, but may still be really interesting. Science is all around us! Science is our life, many inventions, our future, our past, living, fun, exciting, adventurous, creativity, and the air we breathe. Science is our everything and anything. Well TAFN. ☺

Student 3 stated:

“Science explains nature and people. It is the study of all living things and how they interact with the environment. In science you learn from the basics of living things to things you can't see. Without it, the world would be less excited about the world and everything in it.

Student 4: “Science is the following: ecology, human biology, astronomy, astrophysics, physics, cosmology, oceanography, biology, chemistry, nurology, archaeology.”

Student 5: “Science is about a lot of things for example about Cells, Heredity, Life Over Time, Diversity of Living Things, Ecology, and Human Biology. It is also about cells, and animal and plant cells.”

Student 6: “Science is where we learn about things in our body like cells or our blood and things like DNA, and the people who discovered cells. And the solar system and what's in Space.”

Student 7 stated:

Science is a group of characteristics that tell you what you are made of and what other living things are made of. If it was physical science it would be more about what would happen if you put these chemicals together. To me science is more about what is this made of, what would happen to this, or what would is this.

Although a few males shared some negative interests towards science, females easily shared positive interests towards their teachers and science. For instance, a few female students made the following comments about science teachers, “Science is fun when you have a fun teacher like Ms. May,” or “I have the best Science teacher,” and “My science teacher is Awesome.”

What is a Scientist?

Another artifact used to gather students’ perception of science was their drawings of what they perceived to be scientists, and what they think scientists do all day. In fact, past research using the Draw-A-Scientist-Test (DAST) can be used to determine the perception held by students illustrating their interests towards science (Chambers, 1983; Mead & Métraux, 1957). For instance, all six 7th grade life science students (Males n = 78, Females n = 57) in this study mostly drew illustrations of their scientist with similar attributes as mentioned in Mead and Métraux’s study (1957, pp. 386, 387)

The authors stated:

The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses...he may be bald...he may wear a beard, may be unshaven...He is surrounded by equipment: test tubes, Bunsen burners, flasks and bottles...He spends his days doing experiments...he pours chemicals from one test-tube

to another...One day he may straighten up and shout: "I've found it! I've found it!...His work is dangerous...Chemicals may explode.

This study also found that students represented the image of a scientist in 6 out of the 7 indicators chosen by Chambers (1983), which were as follows:

- (1) Lab coat
- (2) Eyeglasses or protective eyewear
- (3) Facial hair growth (beards, mustaches)
- (4) Symbols of research (laboratory equipment)
- (5) Symbols of knowledge (books and filing cabinets)
- (6) Technology (rockets)
- (7) Relevant captions (formulae, the "eureka"! syndrome)

All but criteria #5 (above) were represented in the students' drawings in this study.

Interestingly, many students represented their scientist as either partially bald, or having the "Einstein look." Not surprising was the fact that most students illustrated their scientist working in a laboratory, and mixing chemicals in test-tubes or flasks, indicating that their current perception of scientists' working were only in laboratories. One student drew a scientist working in a laboratory at night, which indicated the long hours of lab work done by scientists. Only one male student represented his scientist correlated to a recent animated movie signifying the influence that movies have on kids' perception.

All male students drew their scientists as male characters, however females drew both male and female scientists, especially the students in Ms. May's class. Although many female students drew the stereotypical "Einstein" character mixing chemicals in a laboratory, other

female students drew younger, more modernly attired female scientists. Consequently, these vibrant representations came from students in Ms. May's class.

Water Monitoring Informal Science Activity

The two 7th grade life science teachers and I initially met to discuss ways to introduce Module 4 of the proposed water monitoring curriculum in an informal science setting (i.e. the pond). We agreed that students should be given brief instructions about their tasks and why this method of water monitoring was one way to determine the "health" of the school's pond. At the pond, each student group received instructions and aquatic macroinvertebrate identification forms. Many students stayed on the edge of the pond to collect their water samples, and most groups required assistance with macroinvertebrate identification. Mr. Clay's four 7th grade classes caught a wide range of vertebrates (fishes, tadpoles, frogs), which provided student interactions within each group. Macroinvertebrate identification presented some challenge to student groups, however each class recorded at least three types of macroinvertebrates.

At the conclusion of the macroinvertebrate water monitoring activity, students were asked to write short responses relative to what they liked and disliked about the activity the very next day. A few students from Mr. Clay's 3rd period class stated:

I think it was a good lesson because I got to learn that you can do science outside too...I got to learn how to tell if the water is polluted or not by the things living in it. I liked it because we got to look at different bugs that live in the water...it was interesting to see all the different species living in the pond...I really enjoyed finding organisms and vertebrates in the pond...I really liked it, because we got to go outside on the nature trail and to the pond, and we got to learn about some living things.

Students in the 4th period class related similar comments as mention above, however students expressed their attitude towards being outdoors relative to indoor classroom activities as mentioned in the following:

We didn't have to do class work, and we got to stay outside. We got to just see neat things in the water...I liked going outside yesterday because we got to get out the classroom and go outside...I liked the lesson because it was something else other than sitting down in a desk all day...I liked that we got to go outside with the water and nature...I liked it b/c we got to get out of the classroom and enjoy looking at different things in the water...

Students also noted that they needed more equipment for each group. Students in all classes noted:

The lesson was fun, we could use better equipment...I really didn't enjoy the lesson because no one wanted to let us use a net, so it was hard to find anything...I think they can improve period 6 on the nets, because there were only 4 and there were only 7 groups...what I didn't like is their wasn't enough equipment down there for everybody or the groups plus some people wouldn't share the equipment.

Although most students in Mr. Clay's life science classes enjoyed the informal science activity, there were other statements by students that highlighted their interests. For example, some students stated:

You can learn more from hands on experiments rather than reading it out of a book. I think it would make science better to go outside more instead of reading about it...It was a great hands-on experience and I would love to do it again in the future...I liked that we

actually got to go outside and look for the bugs instead of you just getting a sample and bringing it to the class...I like the fact that we got to go outside but learn at the same time. I think that if we did an activity with everything we did then it would make science, would be much enthusiastic or funny, then I might want to learn about science.

Interestingly, students also expressed positive interests towards the educators assisting them with the informal science activity.

Students expressed:

If we needed help with something, and they were really helpful. I learned a lot from them and I think they should be teachers...They are good scientists and good at teaching me the types of living things in the water...They were great scientist, they showed me different types of animals...The demonstration was very well taught. They interacted with the students very well, and they showed very good examples. They explained the assignment and answered all my questions...They helped us through a lot of it and they taught us a lot about different animals...I liked it because we got to look at different bugs that live in the water and they let us use tools to make them look bigger and they helped us identify what type of bugs they were...

Students from Ms. May's 3rd and 4th period reported similar responses as Mr. Click's classes about what they experienced.

Students reported:

Getting to go outside and discover creatures that I've never seen before...getting to go outside and finding all kinds of bugs in the water...going outside and catching a lot of

weird things in the water...my favorite part was looking for different kinds of animals...we got to take out things from the out of the pond and examine them...I liked collecting samples of the water and looking at the species...my fave part of the lab was getting to catch the fish and getting to name them and discover all the different types of creatures...My favorite part of the lab was figuring out the names of the bugs because I didn't know the names of the bugs.

When students were asked what they learnt the most, they replied:

I learned what a mayfly looks like...invertebrates don't have spines...There are a lot of things that we see that we don't recognize, small things, until we really pay attention...I learned that there are many creatures that can live in a pond...I learned about some new species...there are more invertebrates than I thought lived in a pond...a dragonfly nymph starts the cycle of a dragonfly as they grow bigger and bigger...I did not know that little things like bloodworms live in that pond...I got to learn about a lot of creatures I've never seen before...I learned new species like the bloodworm and dragonfly.

Students expressed surprise over what they found in the pond as described below:

...There is a lot of weird things in the water...there are a lot of small animals than I thought...there are millions of different species in a tiny pond...I learned the name of a bunch of creatures...there are many different living/non-living things in very different places...There are many creatures that can live in ponds.

Overall, students enjoyed the informal science macroinvertebrate water monitoring activity, because most students cited their enjoyment of being outside, learning about macroinvertebrates and vertebrates, and learning from the teachers present. They expressed

interest in doing more classes outdoors, but asserted that they needed more equipment. Students maintained an overall positive attitude for the experience, and their remarks suggested that their perspectives were geared to having more activities like this implemented in the future.

Quantitative

Science Interest Survey

Family Encouragement. For the 6 classes, each with a mean average of approximately 23 students per class, overall students responded in disagreement 22.88 ± 8.13 (Mean \pm (SD)) of the time that family members were interested in science (Overall, Table 4). Students responded an average of 9.67 ± 1.75 times in disagreement that their family was not as interested in their science careers (Item 7, Table 4). Consequently, an average response of 7.00 ± 2.19 students per class disagreed that their family members were interested in science courses (Item 10).

Peer Attitude. Students disagreed ($10.00 + 1.90$, Mean \pm SD) per class that their friends did not like science (Item 2, Table 4). In fact, male students disagreed (6.67 ± 2.50) more than female students (3.83 ± 1.47) relative to their peers viewing science as nerdy (Item 9, Table 4). Furthermore, an average of 5.83 ± 1.83 students per class agreed that their friends do not like to watch science programs on television (Item 12, Table 4).

Teacher Influence. Overall, male and female 7th grade life science students strongly agreed an average of 15.50 ± 4.09 students per class (Mean \pm SD) that teachers encouraged them to do their best (Item 3, Table 4). Students agreed an average of 9.33 ± 2.50 students per class that past science teachers had encouraged them to learn about science (Item 8, Table 4). Students agreed that their past science teachers were enthusiastic about science an average of 8.83 ± 4.87 per class (Item 18, Table 4).

Informal Science Learning. Students strongly disagreed that they were not interest in visiting museums or science centers by an average of 11.17 ± 4.12 students per class (Item 4, Table 4), and showed a positive attitude for science-related field trips resulting from these visits (Item 6, Table 4). Additionally, 23.00 ± 10.41 students per class revealed that they are in agreement about wanting to learn more science after a trip to the museum (Item 11, Table 4). There was no noticeable difference between positive or negative interests towards museum and science center visits, student field tips, or a sense for learning science after a visit to the museum (i.e. items 4, 6, and 11 respectively, Table 4) amongst male and female students.

Science Classroom Experience. Almost all students in each of the 6 classes agreed (10.33 ± 1.75 , Mean \pm SD) or strongly agreed (9.33 ± 2.58) that their science topics were important (Item 5, Table 4). Students per class strongly agreed (9.33 ± 3.01) and agreed (8.50 ± 2.74) that their science classroom had interesting equipment (Item 16, Table 4). More male students per class disagreed (4.67 ± 3.14 students per class) than female students (1.17 ± 1.16 students per class) that the classroom science equipment was not utilized (Item 17, Table 4).

Table 4.

Overall responses by 7th grade Life Science students (n=135, males = 78, females = 57, 6 classes) on the Student Science Interest survey.

Item	Response Frequencies for Overall Sample Mean \pm (SD)	Response Frequencies for Male Students Mean \pm (SD)	Response Frequencies for Female Students Mean \pm (SD)
Family Encouragement Overall			
Disagree	$22.88 \pm (8.13)$	$27.50 \pm (4.04)$	$18.25 \pm (8.99)$
Agree	$21.90 \pm (5.44)$	$22.25 \pm (4.11)$	$21.5 \pm (7.19)$

Strongly Disagree	11.00 ± (4.41)	13.50 ± (3.70)	8.50 ± (3.87)
Strongly Agree	9.13 ± (4.32)	11.25 ± (4.35)	7.00 ± (3.60)
Item 1			
Agree	7.67 ± (3.14)	3.50 ± (1.38)	4.17 ± (2.04)
Disagree	6.67 ± (1.86)	5.00 ± (1.67)	1.67 ± (1.51)
Strongly Agree	4.50 ± (2.88)	2.67 ± (1.63)	1.83 ± (1.72)
Strongly Disagree	2.50 ± (2.43)	1.33 ± (1.03)	1.17 ± (0.41)
Item 7			
Disagree	9.67 ± (1.75)	4.83 ± (2.14)	4.83 ± (1.94)
Agree	5.33 ± (2.16)	3.50 ± (1.87)	1.83 ± (1.47)
Strongly Disagree	3.50 ± (2.51)	2.17 ± (1.60)	1.33 ± (0.41)
Strongly Agree	2.33 ± (1.97)	1.50 ± (2.34)	0.83 ± (0.75)
Item 10			
Disagree	7.00 ± (2.19)	4.17 ± (2.04)	2.83 ± (1.17)
Agree	5.83 ± (2.48)	2.67 ± (0.82)	3.17 ± (2.23)
Strongly Disagree	5.17 ± (2.14)	3.00 ± (1.41)	2.17 ± (1.17)
Strongly Agree	2.50 ± (1.87)	1.83 ± (1.17)	0.67 ± (0.82)
Item 13			
Agree	8.67 ± (1.37)	4.33 ± (1.63)	4.33 ± (2.25)
Disagree	5.33 ± (3.01)	3.33 ± (1.51)	2.00 ± (1.67)
Strongly Disagree	3.17 ± (1.33)	2.33 ± (1.21)	0.83 ± (0.75)
Strongly Agree	2.17 ± (1.72)	1.00 ± (0.63)	1.17 ± (1.60)
Peer Attitude			
Overall			
Disagree	29.17 ± (7.08)	33.67 ± (6.65)	24.67 ± (4.51)
Agree	16.50 ± (4.97)	20.00 ± (3.460)	13.00 ± (3.61)
Strongly Disagree	12.83 ± (3.60)	13.67 ± (1.53)	12.00 ± (5.29)
Strongly Agree	8.17 ± (3.97)	9.00 ± (3.61)	7.33 ± (4.93)
Item 2			
Disagree	10.00 ± (1.90)	5.33 ± (1.21)	4.67 ± (2.34)
Agree	5.33 ± (2.25)	2.83 ± (0.75)	2.50 ± (1.64)
Strongly Disagree	3.50 ± (1.38)	2.17 ± (1.17)	1.33 ± (1.97)
Strongly Agree	2.16 ± (1.60)	1.67 ± (0.81)	0.50 ± (0.84)
Item 9			
Disagree	10.50 ± (3.21)	6.67 ± (2.50)	3.83 ± (1.47)
Strongly Disagree	5.00 ± (1.67)	2.00 ± (1.41)	3.00 ± (1.67)
Agree	4.17 ± (2.32)	2.67 ± (1.37)	1.50 ± (1.05)
Strongly Agree	1.50 ± (1.38)	0.67 ± (0.81)	0.83 ± (0.75)
Item 12			
Disagree	7.50 ± (1.87)	4.33 ± (2.25)	3.17 ± (1.60)
Agree	5.83 ± (1.83)	3.67 ± (1.03)	2.17 ± (1.60)
Strongly Disagree	4.17 ± (2.71)	2.50 ± (2.26)	1.67 ± (1.21)
Strongly Agree	3.67 ± (2.16)	1.67 ± (2.25)	2.00 ± (1.25)
Teacher Influence			

Overall			
Strongly Agree	31.13 ± (11.06)	34.75 ± (12.53)	27.50 ± (9.68)
Agree	22.00 ± (7.03)	25.00 ± (7.30)	19.00 ± (6.16)
Disagree	6.75 ± (4.37)	9.00 ± (3.65)	4.5 ± (4.20)
Strongly Disagree	4.88 ± (1.96)	5.25 ± (2.63)	4.5 ± (1.29)
Item 3			
Strongly Agree	15.50 ± (4.09)	8.67 ± (3.01)	6.83 ± (3.54)
Agree	4.67 ± (2.81)	2.83 ± (2.23)	1.83 ± (1.47)
Strongly Disagree	0.83 ± (1.17)	0.50 ± (0.84)	0.33 ± (0.52)
Disagree	0.17 ± (0.41)	1.67 ± (0.40)	0.00 ± (0.00)
Item 8			
Agree	9.33 ± (2.50)	5.17 ± (3.31)	4.17 ± (1.60)
Strongly Agree	8.50 ± (3.21)	5.00 ± (2.19)	3.50 ± (1.76)
Strongly Disagree	2.00 ± (0.63)	0.83 ± (0.98)	1.17 ± (0.75)
Disagree	1.50 ± (1.22)	1.17 ± (0.98)	0.33 ± (0.52)
Item 14			
Agree	6.83 ± (3.31)	4.50 ± (2.07)	2.83 ± (1.47)
Strongly Agree	7.33 ± (2.58)	3.33 ± (1.97)	3.50 ± (2.43)
Disagree	3.33 ± (1.86)	1.83 ± (1.47)	1.50 ± (1.51)
Strongly Disagree	2.16 ± (1.17)	1.50 ± (0.55)	0.67 ± (0.82)
Item 18			
Strongly Agree	8.83 ± (4.87)	5.33 ± (2.53)	3.50 ± (2.59)
Agree	6.33 ± (1.97)	3.33 ± (2.25)	3.00 ± (1.27)
Disagree	3.16 ± (1.94)	2.00 ± (1.09)	1.17 ± (1.16)
Strongly Disagree	1.33 ± (0.82)	0.50 ± (0.55)	0.83 ± (0.75)
Informal Science Learning			
Overall			
Agree	23.00 ± (10.41)	26.00 ± (12.29)	20.00 ± (9.64)
Strongly Agree	18.33 ± (8.87)	22.33 ± (9.07)	14.33 ± (8.14)
Strongly Disagree	15.83 ± (14.66)	17.66 ± (17.62)	14.00 ± (14.73)
Disagree	9.33 ± (3.44)	10.00 ± (4.36)	8.66 ± (3.05)
Item 4			
Strongly Disagree	11.17 ± (4.12)	6.33 ± (2.42)	4.83 ± (2.79)
Disagree	4.16 ± (2.23)	2.16 ± (1.47)	2.00 ± (1.41)
Agree	3.17 ± (1.72)	1.83 ± (1.17)	1.33 ± (1.03)
Strongly Agree	2.67 ± (0.82)	1.83 ± (0.41)	0.83 ± (0.75)
Item 6			
Agree	9.33 ± (1.97)	5.50 ± (1.64)	3.83 ± (0.98)
Strongly Agree	7.17 ± (2.14)	4.00 ± (0.89)	3.17 ± (2.32)
Disagree	2.50 ± (1.38)	1.33 ± (1.75)	1.17 ± (0.75)
Strongly Disagree	2.33 ± (1.21)	1.33 ± (0.52)	1.00 ± (1.09)
Item 11			
Agree	23.00 ± (10.41)	4.83 ± (2.31)	4.17 ± (2.64)
Strongly Agree	18.33 ± (8.87)	4.50 ± (1.87)	2.83 ± (2.79)

Strongly Disagree	15.83 ± (14.66)	1.17 ± (0.75)	1.00 ± (0.89)
Disagree	9.33 ± (3.44)	1.17 ± (0.75)	1.00 ± (1.09)
Science Classroom Experience Overall			
Agree	22.13 ± (9.37)	24.75 ± (10.63)	19.50 ± (8.58)
Strongly Agree	18.38 ± (12.60)	20.50 ± (13.38)	16.25 ± (13.40)
Disagree	13.13 ± (11.68)	16.50 ± (14.01)	9.75 ± (9.57)
Strongly Disagree	9.13 ± (8.77)	9.50 ± (8.70)	8.75 ± (10.12)
Item 5			
Agree	10.33 ± (1.75)	5.83 ± (1.72)	4.50 ± (2.07)
Strongly Agree	9.33 ± (2.58)	5.00 ± (1.79)	4.33 ± (1.63)
Strongly Disagree	0.83 ± (0.52)	0.83 ± (0.41)	0.00 ± (0.00)
Disagree	0.50 ± (0.84)	0.33 ± (0.52)	0.16 ± (0.41)
Item 15			
Disagree	7.50 ± (1.97)	4.67 ± (1.63)	2.83 ± (1.17)
Strongly Disagree	5.67 ± (1.37)	3.16 ± (0.41)	2.50 ± (1.38)
Agree	3.83 ± (3.55)	2.16 ± (2.14)	1.67 ± (1.51)
Strongly Agree	2.67 ± (2.42)	1.17 ± (1.47)	1.50 ± (1.64)
Item 16			
Strongly Agree	9.33 ± (3.01)	5.00 ± (1.10)	4.33 ± (3.27)
Agree	8.50 ± (2.74)	4.67 ± (2.50)	3.83 ± (0.98)
Disagree	1.50 ± (1.05)	1.17 ± (1.17)	0.33 ± (0.82)
Strongly Disagree	0.17 ± (0.41)	0.17 ± (0.41)	0.00 ± (0.00)
Item 17			
Disagree	7.33 ± (4.23)	4.67 ± (3.14)	1.17 ± (1.16)
Agree	5.33 ± (3.20)	3.00 ± (1.55)	3.00 ± (1.26)
Strongly Disagree	4.67 ± (2.73)	1.67 ± (1.63)	0.83 ± (0.75)
Strongly Agree	1.83 ± (1.83)	1.67 ± (1.86)	3.50 ± (2.59)

Environmental Literacy and Stewardship Quizzes

Of the total 135 7th grade Life Science student participants, prior to the implementation of the water monitoring activity, there overall score (total score = 10) on the Environmental Literacy Knowledge (ELK) quiz was 3.19 ± 1.71 (Mean \pm S.D.), and the overall score (total score = 10) for the Stewardship Knowledge (SK) quiz was 5.03 ± 1.71 (Table 5). At the

conclusion of the activity, results of post student mean score for the ELK quiz was 3.59 ± 1.83 , and SK 5.29 ± 1.61 (Table 5).

The overall mean scores (out of 20) for 135 7th grade Life Science students improved from 8.21 ± 2.70 (Mean \pm SD) to 8.87 ± 2.73 (Table 5) after completing the outdoor activity related to the informal science-based curriculum. Students scored significantly higher on the overall quiz (T-Test = 2.581, $p = 0.01$, Table 5). Although students scored significantly higher on the Environmental Literacy Knowledge quiz (T-Test = 2.513, $p = 0.01$, Table 5), there was no significant difference in their overall Stewardship Knowledge scores (T-Test = 1.398, $p = 0.16$, Table 5).

A total of 78 male students had a mean score of 3.22 ± 1.73 (Mean \pm SD) for ELK and 5.01 ± 1.81 for SK quizzes prior to the implementation of the outdoor water monitoring activity (Table 6). Their mean score increased for both quizzes after the conclusion of the activities at 3.50 ± 1.76 and 5.40 ± 1.69 respectively (Table 6). However, there were no significant difference SK male student scores after the conclusion of the activity.

A total of 57 female students participated in the knowledge assessment for ELK and SK. Their initial mean score prior to completion of the activity were 3.14 ± 1.68 for the ELK quiz and 5.05 ± 1.59 for the SK quiz (Table 6). On completion of the activity, scores for the ELK and SK quizzes were 3.70 ± 1.94 and 5.14 ± 1.49 respectively (Table 6). There was a significant increase for female ELK scores (T-Test = 2.129, $p = 0.04$, Table 6), but not for SK scores.

Although there was a significant difference between pre-post ELK and SK scores (ANOVA, $F = 6.84$, $p = 0.01$, Table 6), there were no significant differences in gender, neither between gender and time (pre-post) interactions.

Table 5.

Overall responses by 7th grade life science male (N = 78) and female (N = 57) students on the environmental literacy knowledge (ELK) and stewardship knowledge (SK) quiz.

Variable	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	T-test (p)
Overall	8.21 ± 2.70	8.87 ± 2.73	2.581 (0.01)*
ELK	3.19 ± 1.71	3.59 ± 1.83	2.513 (0.01)*
SK	5.03 ± 1.71	5.29 ± 1.61	1.398 (0.16)
Male Students	8.23 ± 2.63	8.90 ± 2.83	2.093 (0.04)*
ELK	3.22 ± 1.73	3.50 ± 1.76	1.430 (0.16)
SK	5.01 ± 1.81	5.40 ± 1.69	1.557 (0.12)
Female Students	8.19 ± 2.82	8.84 ± 2.61	1.535 (0.13)
ELK	3.14 ± 1.68	3.70 ± 1.94	2.129 (0.04)*
SK	5.05 ± 1.59	5.14 ± 1.49	0.312 (0.76)

Table 6.

Illustration of the influence of gender on pre-post knowledge quizzes.

Sources of Variation	df	F	P
<u>Between Subjects</u>			
Gender (ELK)	1	0.06	0.81
Gender (SK)	1	0.24	0.62
<u>Within Subjects</u>			
Time (ELK pre-post)	1	6.84	0.01*
Time × Gender	1	0.75	0.39
Time (SK pre-post)	1	1.58	0.21
Time × Gender	1	0.62	0.43

Overall Evaluation of the Curriculum

Both 7th grade Life Science teachers rated the individual sections of the curriculum with an average score of 4.5 out of 5, which represented good to excellent. Scores identified each section of the curriculum that included: the introduction, water quantity, quality, and sustainability, biological monitoring, and chemical monitoring. Additionally, both teachers also rated the curriculum with a score of 4.5 out of 5 in terms of what was covered in the curriculum. For instance, teachers scored a 4 or 5 in terms of their expectations of the curriculum, how the activities fit into the classroom curriculum, if the curriculum was clear and easy to follow, and if the activities in the curriculum maintained students' interest. Overall, teachers scored individual sections and the entire curriculum with a 90-95% approval (Table 7).

Table 7.

Illustration of teacher evaluation of the curriculum.

Teacher	Rate Individual sections of the curriculum	Rate the curriculum as a whole
Mr. Clay	90%	95%
Ms. May	95%	95%

Report Card

Students slightly improved from 23% to 30% passing (i.e. students with A, B, C, and D) on their "Report cards" on the environmental literacy knowledge quiz, and 64% to 74% pass on the stewardship quizzes after they concluded the informal science related water monitoring activity (Table 8). Only 3 students scored an A grade on the stewardship knowledge quiz prior to

the implementation of the curriculum, however there were no more A-grades for the other quizzes. Although A grades decreased, other grades, such as B, C, and D increased, as well as less student failing grades for ELK and SK (77% to 70% and 36% to 26% respectively, see Table 8).

Table 8.

Report card showing student result on the Environmental Literacy Knowledge (ELK) and Stewardship Knowledge (SK) quizzes before and after the implementation of the curriculum.

Grades	ELK (Before)	ELK (After)	SK (Before)	SK (After)
A	0	0	3	0
B	0	1	7	9
C	4	8	11	21
D	27	31	66	70
F	104 (77%)	95 (70%)	48 (36%)	35 (26%)
% Improved		56 (41%)		63 (47%)
Total	135	135	135	135

Chapter 5: Discussion and Implications

Overview

Chapter 1 provided a statement of the problem for this case study research, which focused on the interests and perspectives of 7th grade Life Science students and teachers relative to expanding environmental literacy and stewardship using informal science activities, related to a water monitoring curriculum. Chapter 1 also highlighted the ongoing problems in science education, with a specific concentration on a need to expand environmental literacy in rural areas. A subjectivity statement, role of the researcher, the role of informal science education, strategies for using an informal science education based curriculum, science attitudes, significance of the study, background information on environmental literacy and the field of science education, which included definition of the terms, science literacy were provided as well. Chapter 1 also focused on provided a theoretical framework for the study, information on constructivism from a teacher's view on science, and the role of misconceptions and how students understand concepts.

Chapter 2 presented a literature review of a wide range of topics under the umbrella of science literacy, such as environmental literacy and stewardship, informal science education, rural science education, citizen science and water stewardship in rural science, citizen science and water monitoring, and public participation in scientific research.

Chapter 3 presented the research design, methods and strategies used to answer the four research questions of the study. The research strategies highlighted in chapter 3 resulted from a mixed method research design and illustrated qualitative and quantitative aspects of the study.

The limitations to the study, data collection and analysis procedures, the researcher's role in the study, reliability and validity were highlighted in this chapter.

Chapter 4 presented the findings of the case study. The case outline, qualitative and quantitative results were presented in this chapter. The qualitative section highlighted the teacher classroom observations, teacher outdoor observations, and findings from the interviews, teacher questionnaire, student artifacts, and the water monitoring informal science activity. The quantitative section illustrated findings of the student science interest survey, the environmental literacy and stewardship pre and post knowledge quizzes, an overall evaluation of the curriculum, and a student report card.

The purpose of this study was to examine the case study of two life science teachers at a rural school in the southeastern part of the United States and their interests and perspectives on using informal science education to increase environmental literacy and stewardship among their students. The following research questions were used to obtain the purpose of this study:

- (1) How does implementation of a water monitoring curriculum impact 7th grade life science teacher interests and perspectives towards environmental literacy and stewardship in the classroom?
- (2) How does implementation of the curriculum impact 7th grade life science students' interests towards environmental literacy and stewardship?
- (3) What are 7th grade life science students' interests towards science in a rural middle school?
- (4) How has past informal science activities in the lives of two 7th grade life science teachers influenced interests and perspectives towards teaching science?

The participants of this study were purposely selected from a rural middle school located in southern Alabama, which served approximately 730 students (5-8 grade) at the time of this study. Of the 188 7th grade students currently at the school at the time of the study, a total of 135 students (78 males, 57 females) had parental consent to take part in this study. Both 7th grade Life Science teachers (1 male, 1 female) consented to be participants of this study for the fall semester.

A mixed method research design was used to answer the research questions mentioned above, and required both qualitative and quantitative strategies to examine and determine a deeper meaning of the interests and perspectives towards environmental literacy and stewardship of the participants of this study. Instruments used for the teachers, such as the questionnaire were adapted from (Jordan *et al.* 2011; Overdeest, Orr, & Stepenuck, 2004), semi-structured interviews (King, Shumow, & Lietz, 1999), and an evaluation form from Georgia Adopt-A-Stream (2009). Student pre/post measurements were adapted from environmental literacy and stewardship knowledge quizzes (Coyle, 2005; Overdeest, Orr, & Stepenuck, 2004). The student science interest survey was adapted from Lamb, Annetta, Meldrum, & Vallett (2011).

Discussion

Qualitative

Dynamic Teaching in the Rural Science classroom. In answering the first question on how two 7th grade life science teachers' interests and perspectives on informal science education and its potential use in their classrooms, it was first important to determine their current interests and perspectives prior to the implementation of the curriculum. This study focused on how each teacher viewed informal science, and if they would utilize a water monitoring curriculum as a

source of informal science education, which can be used as a resource to increase environmental literacy and stewardship.

One of the main goals of this study was to examine the daily schedule of two life science teachers prior to and after they introduced the curriculum. Although the overall daily activities of the school environment displayed stringent protocols for maintaining student class schedules, each life science teacher invariably found ample time within their allotted classroom period to add activities that initiated science inquiry. Activities done at the teachers' planning period shared similarities as well as differences throughout the week. For instance, the two life science teachers at the school met at least once a week to discuss ideas and resources on the topic being taught for the upcoming week. In fact, these two life science teachers taught the same topics in class during each week.

Both Mr. Clay and Ms. May heavily relied on interactive science inquiry-based lessons. However, students seemed to do just as well with in-class and out of class assignments related to science topics, such as cell types, photosynthesis, respiration, and genetics. Each teacher used creative methods, which allowed students to attain knowledge from certain challenging science topics. These methods either involved collaboration amongst teachers themselves or individuality where necessary. Hence, the two teachers in this study had excellent backgrounds in science literacy, which was an excellent pre-requisite for environmental literacy and stewardship. One valuable intervention recently started at the school was the use of smart devices (smart phones, iPads, Kindle, tablets, etc.) to assist students with academic enrichment. For instance, Mr. Clay and Ms. May encouraged students with these devices to use them to research a science topic that interests them. This study sought to encourage informal science education using outdoor activities related to water monitoring, which is a resource not readily available for

either teacher in this study. However, the use of smart phones by students to explore science topics that interest them, which are not readily available to them was noteworthy to witness at this rural middle school.

Mr. Clay and Ms. May followed a similar pattern in terms of utilizing their hour-long classes. For instance, they typically began class with student readings prior to presentation of the topic. These topics usually required some form of in-class inquiry-based activity. However, out-of-class assignments also assisted with the introduction of the science topic. In the case of Mr. May, his 4 classes followed a similar protocol of class presentations, which he rarely veered away from. Although Ms. May only had two 7th grade life science classes, these classes followed a similar monotonous plan similar to Mr. Clay.

The classroom observations identified key factors that represented the teaching styles and interests of each teacher. For instance, the spacious classroom allowed Mr. Clay room to be mobile throughout the classroom. The outdoor activities presented in this study was keenly investigated by Mr. Clay prior to its implementation, because his interest in having more outdoor learning experiences for his students was evident during informal conversations with him during the initial teacher conference. This study focused on teachers' interest in using informal science, and the initial interest by Mr. Clay highlighted a positive attitude for informal science education.

Ms. May had a smaller class than Mr. Clay, however she had access to another spacious classroom to be used as a laboratory. In this classroom, she displayed a fish tank, a few preserved animals in jars, and science posters on the walls. Ms. May was keen and excitingly expressed her interest in using the informal science activities from the curriculum in this study. Overall, the initial interest level to use informal science activities from all key members at the rural school,

that is, the principal and both life science teachers was positively received prior to the implementation of the curriculum.

The two teachers in this study informally discussed ways to use the informal science curriculum in this study, because they viewed the water monitoring modules as one way they could initiate student inquiry relative to issues with water quality, quantity, and sustainability. Furthermore, teachers envisioned that students could gain increased environmental knowledge of water in the state of Alabama using informal science. Ultimately, teachers' past experiences with informal science learning at various out-of-school environments allowed them to view the curriculum as a positive asset for their future classes prior to its implementation.

This study demonstrates that teachers would be very interested in adding informal science activities, such as macroinvertebrate water monitoring to their life science course protocol. The outdoor activity exposes students to learning science in an informal setting. Although teachers can add to student misconceptions through teaching concepts that can be confusing (Thompson & Logue, 2006), they can alleviate many misconceptions of how students perceived scientists and science as displayed from their initial drawings. This study added another teaching resource to enhance informal science learning in a rural area.

A questionnaire was introduced to initially gather background information on environmental literacy and stewardship about each teacher. In terms of environmental literacy, it was not surprising to note that the younger inexperienced teacher of the two (i.e. Ms. May) scored lower on key environmental issues, such as non-point source pollution, wasting water, water quality, and water monitoring programs, compared to the more experienced science teacher. However, it was important to note that this teacher (Mr. Clay) took a water monitoring

course in the past, therefore key terms, such as non-point source pollution and alteration of stream habitat were not uncommon phrases to him.

Mr. Clay and Ms. May expressed interest in using the outdoor classroom located within close vicinity of their classrooms, thus showing support for informal science education.

Awareness of the small pond located near the outdoor classroom sparked early interest for the water monitoring curriculum being implemented from the two teachers in this study. Hence, their interests were positive prior to the implementation of the curriculum. This study noted that both teachers received training in the past and currently takes part in informal science monitoring programs. For instance, Mr. Clay does water monitoring from past training with the Alabama Water Watch Program in a water monitoring program. Ms. May is currently a monitor with the Project Bird Feeder Watch program.

Student are Interested in Informal Science. In order to determine student interests and perspectives for the implementation of an informal science-based curriculum related to water monitoring, student interests about science, environmental literacy, and stewardship was a key factor. For instance, most student comments about the topic of what is the meaning of science to them focused on the current topic being taught in class. Hence, most students stated that science was about living plants and animals, which incidentally was the topic was being taught in class during the first classroom observations done August 27th – September 27th 2013. However, this study reported that there were students who indicated that science was a diversity of life, ecology, human anatomy, chemistry, and astronomy, which are all advanced classes that they may take in high school. This may suggest the presence of an older sibling, because it is likely that an older sibling may have an influence on their younger counterpart.

Although this study did not focus on gender issues (Sonnert, 1995), gender related responses may be viewed in relation to students having a female life science teacher. In Ms. May's class, females generally had more to say about what science meant to them than males. Although 7th grade classes have a male and female teacher, no distinction could be made relative to the effect of the teachers' gender on their students.

The Draw A Scientist test was added in this study to provide a deeper meaning of how students viewed science and scientists who performed scientific experiments. Not surprising, most students showed similar patterns as past research of how students perceive scientists (Chambers, 1983; Mead & Metraux, 1975). For instance, they mostly drew older white male scientists dressed in lab coats, wearing glasses, mixing chemicals, and performing secret indoor experiments. The typical "Einstein look" was easily the favorite student representation of a scientist. This feature in their drawings highlighted the fact that students do not think science could be done outdoors, which has been a characteristic since this particular test was done nearly sixty years ago (Chambers, 1983; Finson, 2002). Hence, the addition of informal science activities in this study inspired students to view scientists beyond the current trends was agreed to be appropriate for teachers and students.

As in past research, only girls drew female scientists (Chambers, 1983), however this study showed that there were more female students that drew female scientists in Ms. May's class relative to females in Mr. Clay's class and this may definitely be attributed to students having a female science teacher compared to a male teacher. Although students drew female scientists mixing chemicals in a laboratory, most of the female students in Ms. May's class drew students dressed in modern clothing rather than the customary drab laboratory clothing. Student drawings had more happy expressions, which may suggest an intimate connection with the

students' personality and the drawing. Past research by done by Carlone (2003) highlighted female students as mostly viewing themselves as not a "science person." However, this study essentially illustrated a female interest in science as illustrated by student drawings. Moreover, student interests provided an insight into their positive perspectives towards science.

Unfortunately, there was still the notion with male students that they do not perceive females as being scientists, because males did not draw female scientists. The gender issues seen from these displays are not different from those seen at any academic level (Finson, 2002). This study showed that from an early age (i.e. 7th grade) males fail to represent females in science, and almost always illustrated their perception of a scientist as working in the laboratory doing some secretive chemical experiment that involved explosives.

Students in both classes commented on being ecstatic about learning outdoors and these comments suggested a genuine enjoyment for learning in an informal science setting. Both teachers mentioned the outdoor activity, which was greeted with curious questions from the 7th grade life science students. Although all the students knew of the pond's existence within the vicinity of the school compound, many students demonstrated surprise when they caught fishes, tadpoles, and various macroinvertebrates in their dip nets. This study demonstrated that students became increasingly curious about the pond's biodiversity.

Not surprising, students voiced their concerns about learning in the classroom all day, and expressed their enjoyment for learning outside. Students deemed the outdoor experience as mostly enjoyable and exciting. They expressed words like "discovered" "fun" "hands-on" which showed positive interests towards the informal science activity.

It was evident from informal comments during the macroinvertebrate outdoor activity that students were concerned about the lack of equipment. This stemmed from the lack of a dip net for each group. Students who had more possession of the nets caught more interesting animals, because they had more time to do so. This showed that the limiting factor for this activity was time. It took at least 15 mins. for students to arrive at the site, receive instructions and gather their equipment. Another 10 mins. was allotted for their timely return to the next class, which left a total of 35 mins. for the activity. In conclusion, students experienced an informal science activity, which increased interest in outdoor science, and also added information about equipment and time issues that teachers can consider for future outdoor lessons.

Interviews

Teacher Interests and Perspectives of Informal Science Education Prior to the Implementation of the Curriculum. In answering the fourth research question on how teachers' past informal science experiences influenced their interests and perspectives towards informal science education, analysis revealed two emergent themes. These themes were as follows: (a) parent provides the initial informal science interest, and (b) past informal science experiences connecting with a science perspective.

Mr. Clay's interview revealed that at the beginning, or during the childhood years, the influence of a parent was paramount in providing the initial exposure to informal science. In fact, the effect of the exposure of animals in a Veterinarian environment from his father led Mr. Clay to pursue a degree in the Animal Sciences. The close relationship between a father and son developed from the son spending a lot of time assisting his dad at work from an early age. The

presence of injured or sick animals provided a foundation for inquisitive questions. The patience shown from Mr. Clay's dad who was willing to allow his son to spend time with him at his workplace was an important junction in highlighting informal science experience at an early age.

The informal science activities accomplished during his childhood years developed into a love for animals. For instance, he completed many tasks on the farm that influenced his pursuance of an academic degree based on animal sciences. Moreover, the combination of life at the Veterinarian laboratory with his dad, and life on the farm with his family guided his future career choice to pursue a degree in Animal sciences.

The interview identified his decision to follow teaching, which changed his overall interest from learning about animals, to teaching kids. This decision was made during his teenage years and became his career. Why make this decision to switch careers? Mr. Clay remarked, "I realized that I love people more than I love animals." Although he was very interested in animals, I think it was the relationship with his dad that sparked the foundation of teaching in science. The manner in which his dad communicated with him, and the way he was taught may have influenced Mr. Clay to pursue teaching as a profession.

Mr. Clay acknowledged that he continually relied on his family for ideas about teaching. For instance, he was adamant on sharing an experience about the way his brother patiently explained concepts to his niece. This has led him to follow a similar tactic when explaining a concept to his own son, and this is testament that a parent can transfer an interest to the next generation.

Based on the interview data, a similar theme to that reported for Mr. Clay was seen for the influence Ms. May's dad had on the way she currently teaches science. There were many

exposures to informal science learning settings, such as mud bogging and museums early in her childhood. These activities required her to get physically close to nature, hence the teaching philosophy of, “hands on, minds on, knees on.” There was great admiration for her dad whom exposed her to many informal science activities, such as bee keeping and bird watching. These activities continually maintained her interest in using the outdoors to teach science. This was an excellent trait since we spend less than 5% of our lives learning in the classroom.

Informal Science Curriculum Review. Mr. Clay’s review of the curriculum allowed him to comment on the separate modules, which provided his specific perspectives for each topic. His experience with completing a course in water monitoring was evident from his positive attitude towards Module 4, “*Stream Critters as Pollution Indicators.*” Additionally, he expressed positive interest for water stewardship mentioned in one of Module 1’s activities, where he noted the importance of having knowledge of watersheds and water quantity.

During the macroinvertebrate activity, it was evident that Mr. Clay was comfortable with the activity, because he patiently answered many student questions related to macroinvertebrates and water monitoring. Each of his four classes were provided with instructions and worked in small groups of four students with Mr. Clay moving from one group to the next asking and answering questions. At the completion of the activity, Mr. Clay was adamant on using the activity each semester with his class. In my opinion, the defining moment that illustrated a positive perspective was indicated during his 5th period class when he expressed that he had 9 students with disabilities, but he couldn’t tell who they were during the outdoor activity. He exclaimed, “They all look the same” with a smile and demonstrated deep admiration with his statement.

Although topics such as, watershed, build a critter, and water chemistry were of concern to Mr. Clay in terms of implementing into the class, it was not viewed as a negative attitude. In fact, Mr. Clay stated, “Time is an issue” to highlight the difficulty with preparing and introducing these aforementioned topics. Overall, his attitude towards using the macroinvertebrate water monitoring module was positive, and his perspective was that this activity was important and relatively easy to prepare for, therefore it would be incorporated as a “mainstay” topic in his future classes.

Unlike Mr. Clay’s class, Ms. May seemed more ambient to try all parts of the curriculum. After her review of the curriculum, she expressed interest to incorporate almost all the topics, which Mr. Clay declined on doing. For instance, she was keen on building a watershed in class, and definitely wanted students to build a critter. Surprisingly, she wanted to introduce reading scientific articles in her class, which was something Mr. Clay thought would be inappropriate as the reading assignment was extremely difficult for 7th grade students. Ms. May was definitely in favor of the macroinvertebrate activity, but expressed concern with species identification during the activity.

Ms. May was very organized throughout the implementation of the macroinvertebrate water monitoring activity. She organized student groups and maintained order by providing students with ample instructions on the protocol for the lesson. Like Mr. Clay, she too was bombarded by questions from her students, but she maintained poise and control. When she wasn’t sure about a question, she asked for assistance or told students to look it up on Google.

Her overall evaluation of the curriculum illustrated a positive perspective, and showed her interests for the addition of many activities within the curriculum that were beneficial to her

students to phased into her current teaching curriculum. She expressed a continual collaboration with Mr. Clay to continue the water monitoring using the pond at the back of the school. Additionally, she seemed very adamant on having students build a critter in class, and to take part in building a watershed as a classroom demonstration.

Quantitative

Science Interest Survey. The five subscales of the survey revealed various student perspectives for family encouragement, peer attitude, teacher influence, informal science learning, and classroom experience. These were necessary to determine how rural students in 7th grade life science perceived science. For instance, although parents were somewhat interested in science, they discouraged their children from pursuing science related careers. Even more so, parents discouraged males more often than females, which indicated a lack of support from parents who undoubtedly have a main role in directing career paths.

There was support for peer interest in science because if students are to choose science-related elective courses in the future, peer interest tends to allow a selection of the same courses. That is, friends choose the same classes. There was no doubt that students regarded teachers' encouragement as a key component to gaining science interest, because students strongly agreed (95%) that their teachers were very influential and enthusiastic about science. The interests of teachers transfer to their students, hence positive interests displayed by teachers inevitably transferred to their students. Andrzejewski and Davis (2008) stated, "Students who feel supported by their teachers have higher school self-esteem, are eager to please their teachers, and therefore, experience greater motivation for learning...students who feel connected to their

teachers are more likely to seek help when it is needed to understand content or complete a learning task.”

Students maintained that science related field trips were very important to attaining important scientific facts. This showed an interest to learn science at traditional informal science settings, such as museums, zoos, and nature parks. Students also agreed that the science taught in the classroom was very important for them to obtain as their knowledge would be meaningful in the real world. In general, students showed positive interests for science and they reflected the influence showed by their respective teachers. It was worth mentioning that female students generally demonstrated more positive attitude for science, and this is something not often seen at this level.

Knowledge Quizzes. Students showed a significant increase in their environmental literacy knowledge (ELK) scores after the implementation of the informal science related curriculum, but there was no significant change in their stewardship knowledge (SK) scores. The study seemed to highlight a higher achievement for environmental literacy rather than stewardship, and this may be one flaw with implementing the curriculum in less than a week. Female students scored significantly higher on their ELK scores, but not on their SK scores. Although male students scored higher on each knowledge quiz (ELK and SK), their scores were not significant.

There was only a small percentage increase for students completing the ELK quiz, which had a 7% passing grade on their Report Card (i.e. students scoring an A = 9-10, B = 8, C = 7). Interestingly, Coyle (2005) reported a 12% passing grade for adults, hence showing a continued trend for what both adults and students think they know concerning environmental knowledge.

Implications

Louv (2005) remarked on the nature-deficit disorder, which alienates a person from nature, and can be correlated to a form of environmental illiteracy. There is a misconception that the average American learns everything in the classroom, however we actually spend less than 5% of our lives in the classroom (Falk & Dierking, 2010a; Dierking and Falk, 2003). We learn more at various traditional informal science venues, such as zoos, nature centers, and museums (Falk 2002). Past research by Falk (2001, 2002) revealed that many people displayed free-choice learning at these informal science settings. This study provided documentation of free-choice learning at a rural middle school where students and teachers completed an outdoor activity based on water monitoring.

This study provides information on the process of the implementation of an informal science-based curriculum related to water monitoring. The process of applying informal science to rural schools may seem unrealistic however rural areas of Alabama may be apt for the introduction of a water monitoring curriculum. The state of Alabama has the most navigable waterways (~77,000 miles) in the United States, which illustrates a high probability that one can find a stream, pond, or river within two miles of their location in the state (Deutsch, Ruiz-Córdova, & Duncan, 2010). Additionally, about 8% of the freshwater in the United States is located or flows through Alabama, and it's the most biodiverse state with respect to turtles, mussels, clams, and snails, but it also has the highest number of organisms on the endangered species list (Alabama Water Watch, 2012). The application of a water monitoring based curriculum presents a unique resource for life science teachers, and can be used to expand environmental literacy. Rural areas make the implementation of the curriculum a prime target since these areas possess many streams that traverse the terrain.

The interests and perceptions of students and teachers are important in science, because their decisions determine who stays in the science pipeline (Brown, 2000; Russell & Atwater, 2005). Ultimately, it is the teacher's behavior that transfers to students (Chamany, Allen, & Tanner, 2008). Additionally, their instructional strategies will inevitably drive student motivation (Russell, 2014). Students who are interested in science and display positive interests will be significantly more motivated to pay attention to science content (Farmer, Waldrop, & Rotella, 1999). The positive interests displayed by the 7th grade life science teachers in this study showed that their support for the informal science curriculum can assist in students' improvement in expanding environmental literacy. This was beneficial to students and teachers because all participants acknowledged that they gained knowledge as a result of the implementation of the curriculum.

For instance, both teachers supported the use of the curriculum, and did not proceed with negative interests. Although most of the curriculum's modules were designed to be used at various stages of the Alabama Course of Study Objectives, both teachers agreed to use various content and activities illustrated within the curriculum. For example, both teachers agreed that the "*Stream Critters as Pollution Indicators*" which was the macroinvertebrate water monitoring activity was the best activity. Students were able to determine the health of their school pond from the type of macroinvertebrates found in it. Many students had not realized that their school pond contained these organisms.

Consequently, this study showed that rural students engaged in outdoor informal science in a positive way. In fact, students improved on environmental literacy knowledge assessments. However, students had "Report cards" lower than the average American adult (as described in Coyle, 2005), but showed improvement on both post knowledge assessments. This study also

showed that students had no change relative to water stewardship. The lack of foundation knowledge in water stewardship illustrated a common fact within many areas in the state where not many people are aware of issues related to water quantity, quality, and sustainability.

Ultimately, this research can spark interest in citizen science at the rural school. Citizen science provides an opportunity for members of the public (including students) to contribute to scientific research (Bonney et al., 2009). Currently, global focus on citizen science projects focus on environmental and biodiverse monitoring. Both teachers have expressed that the outdoor macroinvertebrate activity would be a mainstay in their classroom curriculum. This is an essential step, because teachers can provide data collected from the pond to the Alabama Water Watch Program. This program can add the rural school as a part of their water monitoring hotspots, which can add data to their ongoing water monitoring scientific project.

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Instruments

Appendix 1. Foundational knowledge questionnaire to determine pre and post knowledge interest changes for environmental literacy, stewardship, and informal science during the project. Subscales of this questionnaire were represented as adaptations from Jordan *et al.* (2011) for Environmental literacy, and Overdeest, Orr, & Stepenuck (2004) for Stewardship. Circle the response that is appropriate to you: **1 = Not at all, 2 = slight extent, 3 = moderate extent, 4 = considerable extent, 5 = A great extent.**

Questions	Responses				
Environmental literacy					
1. To what extent are you knowledgeable about environmental science?	1	2	3	4	5
2. To what extent do you understand non-point source water pollution?	1	2	3	4	5
3. To what extent do you feel that you can make a difference about protecting the environment?	1	2	3	4	5
4. To what extent do you feel like you waste water?	1	2	3	4	5
5. To what extent are you knowledgeable about alteration of stream habitat?	1	2	3	4	5
6. To what extent are you knowledgeable about	1	2	3	4	5

laws that protect water quality?

7. To what extent are you aware of water monitoring programs? 1 2 3 4 5

8. To what extent have your behavior about water quality changed within the last 6 months? 1 2 3 4 5

Stewardship

1. How likely are you to turn off the faucet when brushing your teeth? 1 2 3 4 5

2. How often do you drink water from the faucet? 1 2 3 4 5

3. Do you recycle plastic containers? 1 2 3 4 5

4. How likely are you to have at least one water filter at your home? 1 2 3 4 5

5. How often do you watch nature programs on TV? 1 2 3 4 5

6. How often do you use the internet to search for information on Alabama's rivers and streams within the last 6 months? 1 2 3 4 5

7. How often do you think about current issues in global climate change? 1 2 3 4 5

8. How often do you think about how water is made clean at water treatment plants?	1	2	3	4	5
9. How likely are you interested in taking a water monitoring course if available?	1	2	3	4	5
10. How often do you think about water pollution?	1	2	3	4	5
11. How often do you spend gardening?	1	2	3	4	5
12. How often do you spend hiking, fishing, walking in the woods?	1	2	3	4	5

Appendix 2. Science survey used in this study to determine students' interests towards science in rural areas. This survey was developed and used by Lamb, Annetta, Meldrum, & Vallett (2011).

Circle the response that is appropriate to you: **1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.**

Question	Responses			
1. In the past, my family encouraged me to study science.	1	2	3	4
2. My friends do not like science.	1	2	3	4
3. Other teachers encourage me to do my best.	1	2	3	4
4. I do not enjoy visiting museums and science centers.	1	2	3	4
5. The topics taught in my science class are important	1	2	3	4

in the real world.

6. Visiting science museums and exhibits make me 1 2 3 4

consider student field trips.

7. People in my family are not interested in science. 1 2 3 4

8. In the past, my science teachers encouraged me to learn 1 2 3 4

about science.

9. My friends view science as nerdy. 1 2 3 4

10. My family is enthusiastic about my science career. 1 2 3 4

11. Visiting science museums and exhibits makes me 1 2 3 4

want to learn more about science topics.

12. My friends do not like to watch science programs 1 2 3 4

on TV.

13. My family is interested in the science courses I take. 1 2 3 4

14. In the past, my science teacher made science interesting. 1 2 3 4

15. In the past, the topics taught in my science class were boring. 1 2 3 4

16. My science classroom has interesting equipment. 1 2 3 4

17. We do not use most of the equipment in our 1 2 3 4

science classroom.

18. In the past, my science teachers were enthusiastic about science. 1 2 3 4

Appendix 3. Interview questions used to determine teacher's past lived informal science experiences and how these influence current interests and perspectives towards teaching science. Interview question format has been adapted from King, Shumow, & Lietz (1999).

Semi-Structured Interview Questions

1. Background information

A. Where did you go to college and when did you graduate?

B. What was your degree?

C. How many years have you been teaching?

D. How many years have you been teaching this grade?

2. How would you describe your role as a teacher of science?

3. Did you go on school/family field trips throughout your academic career?

A. Elementary, middle, highschool, college

B. Family trips

4. What are some of the experiences that stood out during these trips?

5. Do you participate in any outreach programs where informal science education?

6. A. What is your favorite topic to teach in science? Why do you choose that one?

- B. What is your least favorite topic to teach in science? Why do you choose that one?
- C. How is your teaching in your “favorite” topic different from the teaching in your “least favorite” topic?
7. Do you use informal science to supplement content knowledge learnt in the classroom?
8. A. What do you like most about your current teaching practices in science?
- B. Is there anything you would like to change?
- C. What are some factors “beyond your control” prevent you from teaching science the way you would like to?
9. If you had to explain “inquiry in science” to another teacher, what would you say that it was?
10. A. Science education is often described as “hands on/minds on.” What do these terms mean to you?
- B. How do you apply these ideas to your classroom teaching?
- C. How do these ideas help to develop student learning?
- D. How do you know students have learned this?

Appendix 4. Interview questions used to determine teacher’s interests and perspectives after the completion of the water monitoring curriculum.

1. Do you think the curriculum was successful, and if so, what were some of the factors involved in its success?

2. Were there areas you think should be improved, and what are your recommendations for improvement?
3. Where do you think this curriculum would fit into your teaching schedule, and do you think it is a good fit to supplement certain concepts in science?
4. Do you think your students gained valuable knowledge from the curriculum?
5. Will you incorporate this curriculum into your teaching, if not, please discuss?

Appendix 5. Environmental Literacy Quiz Multiple choice questionnaires adapted from Coyle (2005). True/False questionnaire adapted from Overdeest, Orr, & Stepenuck (2004).

Environmental Literacy Knowledge

1. The world's streams, rivers, and lakes make up what percent of the world's available drinking water?
1%
3%
66%
97%
Don't know
2. In the hydrologic cycle, water returns to the atmosphere through
Evaporation and precipitation
Evaporation and surface runoff
Infiltration and transpiration

Transpiration and evaporation

Don't know

3. The state of Alabama ranks first in the nation in diversity for all of the following freshwater organisms EXCEPT

Mussels

Turtles

Snails

Clams

Don't know

4. Most of the garbage collected from the United States goes into:

Recycling centers

Landfills

Incinerators

Septic systems

Don't know

5. The most common form of water pollution (streams, rivers, oceans) is caused by:

Surface water runoff

Garbage

Sediment

Factory chemicals

Don't know

6. Which of the following is considered hazardous waste:
- Batteries
 - Wal-Mart plastic bags
 - Aluminum cans
 - Used paper towels
 - Don't know
7. A total of 70% of all energy used in the United States comes from which of the following:
- Nuclear power
 - Fossil fuels
 - Hydroelectric power
 - Solar power
 - Don't know
8. Citizen science involves a partnership between which of the following groups:
- Students and citizens
 - Educators and company management
 - Scientists and citizens
 - Politicians and citizens
 - Don't know
9. The main atmospheric gas that is currently responsible for changing trends in the global climate is:
- Methane

Carbon dioxide

Chlorine

Helium

Don't know

10. Ocean acidification is currently being seen as a gradual change in which of the following:

Temperature

Biodiversity

Melting ice caps

pH

Don't know

Stewardship Knowledge

1. Approximately 1% of the Earth's total water supply is actually available drinking water?

a) True b) False

2. Oceans generate 70% of the world's oxygen supply.

a) True b) False

3. There are more plant and animal species on land than in the ocean.

a) True b) False

4. Alabama is first in the nation in freshwater mussel, turtle, crayfish, and snail diversity.

a) True b) False

5. Water pollution causes more deaths in children than famine worldwide.

- a) True b) False
6. The main source of electricity in the U.S. is produced by hydroelectric power.
- a) True b) False
7. Stoneflies, dragon flies, and mayflies require better water quality than bloodworms?
- a) True b) False
8. Sediment increase can cause adverse effects on stream ecology.
- a) True b) False
9. Macroinvertebrate abundance and diversity can give an indication of stream quality.
- a) True b) False
10. Pollutants from a parking lot finding its way to streams and rivers are an example of point source pollution.
- a) True b) False

Appendix 6. Educator’s guide evaluation for the water monitoring curriculum. The evaluation form is adapted from Georgia Adopt-A-Stream (2009). Please rate the following as: **1 = Poor, 2 = Below Average, 3 = Average, 4 = Good, 5 = Excellent.**

Please rate the individual sections of the water monitoring curriculum

Introduction	1	2	3	4	5
Water quantity, quality, and sustainability	1	2	3	4	5
Biological monitoring	1	2	3	4	5

Chemical monitoring	1	2	3	4	5
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Please rate the water monitoring curriculum as a whole

The material covered matched my expectations.	1	2	3	4	5
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The activities fit well into my curriculum.	1	2	3	4	5
---	---	---	---	---	---

The activities were clear and easy to follow.	1	2	3	4	5
---	---	---	---	---	---

The activities maintained the students' interest.	1	2	3	4	5
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General comments

What did you like best about this curriculum?

What did you like least about this curriculum?

What would you like to see improved on this curriculum?