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Investigating student attitudes and achievements in an environmental place-based inquiry in secondary classrooms

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Student attitudes toward science and content achievements were examined in three secondary Biology I classrooms using an environmentally place-based curriculum as well as a traditional curriculum. Student attitudes were measured using Likert-scale science attitude surveys administered at the beginning of the school year and once again following completion of weeklong ecology curricula. Content achievements were assessed on a pre- and post-test as well as an end-of-unit test. The quantitative results show some attitude measures are correlated with ability-group tracking, and that little change in science attitudes occurred during the course of the study for the three groups. Results also indicate that overall test scores on an end-of-unit test were not significantly different between the inquiry-based and traditional curricula. Qualitative analysis of the pre- and post-tests show growth in ecology knowledge for all three classrooms, with the Inquiry-Based Academic Class achieving the greatest gains. The results warrant an exploration of curricula that use place-based inquiry as a teaching tool and learning goal by educators interested in student content achievements and keeping science attitudes from decreasing while fostering critical thinking skills.

Key words: environmental education, place-based education, inquiry, standardized testing

Introduction

What happens to a child when they are separated from nature, their place, as some kind of alienated other? When at best they view themselves an infrequent or reluctant visitor, or, at worst, as an intruder? What connections to the local environment can that child make if little time is actually spent *in* it? There is evidence that these children tend to suffer more from obesity, depression, apathy towards nature, and Attention-Deficit Disorder (Louv, 2005). Conversely, research has shown that out-of-doors experiences have positive effects on student emotions and attention (Berman, Jonides, & Kaplan, 2008; Taylor, Kuo, & Sullivan, 2001; Kaplan, 1995). Children (and adults) *need* nature, we need to be attached to place. But in an era where achievement on high-stakes testing and adoption of standards-based reforms means “no child left behind,” what are the implications for educators who leave no child inside?

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Literature Review

It is helpful to review what may be considered a "traditional" classroom that uses conventional methods of instruction. Whereas an inquiry-based curriculum would begin with the assumption that students construct knowledge and meaning from their experiences, a traditional classroom operates with the belief that knowledge is outside of the student, objective, and can be transmitted from teacher to student (Dewey, 1997; Friere, 1970). An emphasis is placed on content knowledge, memorization of terms and procedures, and performance on high-stakes standardized assessment tests (Stigler & Hiebert, 1999). Even lab experiences, supposedly a chance for students to experience scientific methods in action, often emphasize procedures and content acquisition (Singer, Hilton, & Schweingruber, 2006). The teacher proposes scientific problems and questions, and provides authoritative direction on how to solve and answer those problems and questions as well as present data and findings.

Studies completed by Hudson, McMahon, and Overstreet (2002) and Weiss, Pasley, Smith, Banilower, and Heck (2003) suggest classrooms still do not actively incorporate inquiry into the curriculum as either a pedagogical method or a learning goal, and traditional classrooms remain the norm. The *National Science Education Standards* (*NSES*) (National Research Council [NRC], 1996) learning goals for inquiry are often not met in such traditional classrooms. Furthermore, students still struggle to meet the national goals for content (Stigler & Hiebert, 1999).

Groups such as the NRC (1996, 2000), National Science Teachers Association (NSTA) (2004) and the American Association for the Advancement of Science (AAAS) (1990) have identified inquiry as an important goal of science education. The science education community generally agrees that the incorporation of inquiry-based learning should be a goal of educators, and many researchers have found more positive results when using inquiry-based instruction as opposed to traditional instruction (Colburn, 2006; Geier et al., 2008; Wilson, Taylor, Kowalski, & Carlson, 2010). However, there is disagreement on exactly what constitutes inquiry and how to measure the level, amount, or type of inquiry implemented in a lesson or curriculum (Anderson, 2002; Dolan & Grady, 2010; Wilson et al., 2010), and educators confuse inquiry as a goal of education and inquiry as a tool to teach (Colburn, 2006).

Inquiry may be considered a constructivist model of thought that explains how phenomena are investigated by students in the building of knowledge (Minner, Levy, & Century, 2010). It holds similarities with how the NRC (2000) describes scientific inquiry in that students generate or have interest in a scientifically oriented question, gather and use evidence to form and evaluate explanations or hypotheses to these questions, and communicate and justify their explanations in the context of general scientific understanding. As an instructional method, inquiry is somewhat more varied, due to the amount of teacher guidance during instruction and student "hands-on" involvement and responsibility for learning (Minner et al., 2010). Lower levels of teacher involvement and higher levels of student hands-on involvement and responsibility for learning will be defined as "inquiry pedagogy." Teacher involvement has been defined in terms such as "guided inquiry" and "open inquiry," among others (Colburn, 2006). Open inquiry would consist of very little teacher direction in defining problems for students, whereas guided inquiry may provide more direction from the teacher.

There is disagreement as to what amount of teacher involvement inquiry should possess. Settlage (2007) argues that a myth has been created about the appropriateness of using open inquiry in the majority of educational settings. He states that there is a lack of evidence of both the effectiveness of open inquiry and that it is even used. Johnston (2008) addresses this argument and tries to clarify the differences between open inquiry as a teaching tool and open inquiry as a learning goal. While Johnston agrees that it may not be appropriate to use open inquiry to get students to remember discrete facts, it is open inquiry, "the process that allows the extraction of explanation from evidence," (p. 12) that should be a central learning goal of science education, "more important than cell features or freefall or any other piece of scientific content" (Johnston, 2008, p. 12).

Hands-on involvement speaks to the amount of experiential exposure students have to the content they are exploring in direct contact using the "tools, data collection techniques, models, and theories of science" (Singer et al., 2006, p. 3). Lab and field experiences contribute opportunities for students to have hands-on involvement. Student responsibility for learning can be seen as linked to how much teacher guidance is given during instruction. Students forming their own questions for study, designing their own studies and determining how to present data and conclusions – and being responsible for seeking assistance when it is needed – characterize curricula in which students have more responsibility for learning (Minner et al., 2010).

Various methods and rubrics have been proposed to measure the amount and type of inquiry implemented in the classroom, along with student and teacher proficiency in understanding and applying those goals (Minner et al., 2010). Multiple studies have been performed to assess the effect that various types of inquiry instruction have had on student achievement, with results showing that guided inquiry is generally more effective than open inquiry (Minner et al., 2010; Pasley, Weiss, Shimkus, & Smith, 2004).

With confusion over what inquiry is, how to implement it, and how well it works, it's little wonder that inquiry has not become more common in today's classrooms. Teachers are seemingly caught between two goals of science education, one that prescribes implementing and evaluating science as inquiry with their students, and one that measures content knowledge, facts, and use of standardized procedures – and they are not sure if these worlds are compatible (Anderson, 2002). Students may even resist inquiry-oriented approaches to teaching due to the vagueness in learning goals it sometimes presents, or just to maintain the classroom status quo (Roehrig & Luft, 2004; Wood, Lawrenz, & Haroldson, 2009).

Making matters even more complicated is that research that examines gains in student achievement through the use of inquiry have not provided consistent and conclusively positive results (Anderson, 2002; Wilson et al., 2010), although this may be a condition caused by lack of inclusion of inquiry in the classroom and unclear definitions for what exactly constitutes inquiry (Wilson et al., 2010). As well intentioned as the goals of inquiry are, it fails to disambiguate the learning goals of students and teachers. But, if science as inquiry is an effective way to teach content, it would seem that additional factors affecting instruction need to be considered. The *NSES* does not situate the issue of inquiry in relation to existing power structures or social contexts (NRC, 1996; Rodriguez, 1997), which is a problem that needs to be addressed, as there is evidence that incorporating place-based approaches into inquiry instruction can improve student achievement (Carleton-Hug & Hug, 2010; Wyner & Desalle, 2010).

The concept of place is broad and can be organized into categories. Karrow and Fazio (2010) suggest three categories: natural, cultural, and ontological. The natural may be described as physical spaces that are occupied (a southern lowland swamp for example), while the cultural conception of place recognizes social constructs of class, gender, race, and power. These are the conceptions of place used by Gruenewald (2003) in advocating for a critical pedagogy of place, a pedagogy that is both "socially and ecologically critical" (p. 9). As further advocated by Karrow and Fazio (2010), the ontological category of place may inform the moral ideals of the natural and cultural categories. The ontological category defines a sense of self or objects coming into being, the sense of experience.

Place-based instruction provides such a lens to put subject matter into context and becomes both a pedagogical approach and a learning outcome (Brooke, 2003). It considers, and places a premium on, the background of the community and history of the learners as well as the learners themselves. Smith (2002) indicates that place-based education has the following common elements:

- students and teachers turn to phenomenon around them;
- students are creators rather than consumers of knowledge;
- students' questions and concerns play a central role in determining what is studied;
- teachers act as guides, co-learners, and brokers of community resources; and
- walls between school and community become more permeable (p. 593)

The elements described above are fully compatible with inquiry learning goals.

At the turn of the 19th century, Dewey and Small (1897) noted how schoolwork should strive not to be devoid of real world meaning, that school should not be some purgatory for another life. Place-based inquiry's specific aim is "to ground learning in local phenomena and students' lived experience" (Smith, 2002, p. 586). Educators have various reasons to incorporate place-based curriculum, valuing that it instills social responsibility and appreciation for community, as well as its academic value (Jennings, Swidler, & Koliba, 2005; Wyner & Desalle, 2010).

Place-based education can be approached from several angles, for example problem-based learning and service-learning. In problem-based learning, educators pose or allow students to define real-world problems to be solved in their local community and work toward solutions to those problems. Service-learning engages students into active service to their communities in reaction to problems. It may introduce students into the civic life of their communities, examine local culture, or include environmental education. The common thread among these and other approaches is that they are all grounded in the community and actively dissolve the traditional school boundaries (Smith, 2002).

Environmental education (EE) merges content and curriculum within an environmental context. This might include an art class centered on creating compositions of local flora and fauna, a civics class that explores conflicting interests in private and public rights by examining cases from the National Forests, or a science lesson on pH that brings students to a local stream to measure that component of water quality. When described in this manner, it becomes apparent that EE is a method of teaching content from multiple subject areas.

Like inquiry and place-based education, EE has dual purposes as a teaching method and a learning goal. The learning goals of EE fall into two categories, content knowledge and behavioral change, and were laid out by the Belgrade Charter (UNESCO-UNEP, 1976), which states:

> The goal of environmental education is to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones. (p. 1-2)

The Tbilisi Declaration and other organizations and authors have elaborated and expanded on this goal (NAAEE, 2004; UNESCO-UNEP, 1978). Evaluation of EE programs often have focused on examining changes in behavior and knowledge as it relates to the environment, congruent with the goals of EE, but missing the link to other content standards (Carleton-Hug & Hug, 2010). Those studies that have focused on content acquisition generally show positive results (Endreny, 2010; Wyner & Desalle, 2010). However, many educators view

EE not as a concept interwoven in science education content, but a supplement to it (Steele, 2011).

Educators face many challenges in meeting standards-based assessments for their classes. These challenges have, at times, led to practices that are questioned as "teaching to the test" (Jennings et al., 2005). There is also concern that a standardized curriculum's goal is to produce students who are able to compete nationally and globally at the expense of local industry and concerns (Gibbs & Howley, 2001; Kannapel & DeYoung, 1999). Furthermore, the standards-based reforms solidified in No Child Left Behind (NCLB) may not be increasing student achievement (Wood, Lawrenz, Huffman, & Schultz, 2006). Meeting standards for content learning is a reality, but it becomes obvious that educators cannot solely rely on standards-based reforms such as NCLB to meet the needs of their students and community. Although incorporating science as inquiry has been shown as an effective way to teach content (Wilson et al., 2010), results have been inconclusive at times, warranting further refinement in the classroom.

Attitudes toward science formed by the 10th grade are reliable predictors of the future amount and type of science courses students will take while still in school, and are most influenced by the school and, in particular, class environment (Simpson & Oliver, 1990). It is therefore apparent that some consideration of the effects a lesson has on attitudes toward science should be given when designing curriculum. Sharing responsibility for learning, creating a sense of community, and inclusion of salient, real-world issues are several methods for achieving this goal (Tobin, 2006).

Purpose

This study examined student achievements when participating in either traditional or environmental place-based inquiry programs. Student attitudes toward content and pedagogy were also explored. Specific research questions were:

1. What difference in achievement, if any, will a place-based inquiry curriculum have compared to that of a more traditional curriculum?
2. Will the differences in achievement change or remain the same depending on whether a student is in an honor's or regular course?
3. What effect, if any, will these two curricula have on student attitudes toward science, and what interaction does this have with student tracking? For example, what are students' definitions of science? How do they feel people best learn science? What is the goal of learning science?

Methods

Three aspects of students' attitudes toward science were identified: science as content, science as inquiry, and inquiry pedagogy. Specifically, these attitudes were examined in both the context of a "traditional" classroom setting and one that uses the science-as-inquiry, environmental place-based approaches as described by the NRC (1996, 2000), the NAAEE (2004), and Smith (2002). The first of these characteristics was *science as content*. This characteristic examined positive and negative student attitudes toward content and "factual knowledge." The second characteristic measured was *science as inquiry*. This characteristic explored students' attitudes toward defining science as a process of inquiry. The final characteristic was *pedagogy*, or method of instruction. Pedagogical attitudes relate to method of instruction, and used inquiry or traditional "transmission" as models to examine. It was important to explore these attitudes, as there is evidence that they decline over time and through the course of a year (Simpson & Oliver, 1990), which should make any observed positive or even neutral changes in attitude with high school students during this study a significant concern for educators to consider when designing curriculum.

Although a more positive attitude toward science may be associated with improved student achievement (Simpson & Oliver, 1990), it was also important to measure what effect that traditional and place-based inquiry has directly on student achievement as well. Although student achievement may carry different meanings to students, parents, educators, professional communities, and other stakeholders, in this study, student achievement was measured by content competency and inquiry competency on a pre- and post-test, and through student work artifacts created during the curriculum. Of particular interest was comparing students' science achievement scores on a high-stakes-style test when participating in either a traditional or environmental place-based inquiry curriculum. Content competency was designed to mimic the style of questioning and content that would be expected in standardized testing, while inquiry competency used the *NSES* guidelines on inquiry as a framework to evaluate students' familiarity and understanding of inquiry (NRC, 2000). Together, these assessments served to provide some measure of the students' ability to acquire the content being taught, as well as provide a measurement of acquisition of the *NSES* (NRC, 1996) and goals for inquiry addressed in *Inquiry and the National Science Education Standards* (NRC, 2000).

Participants and Context

The participants in this study were a group of ninth-grade Biology I students and their teacher in the suburbs of a large urban area in south Louisiana. The school's student population was 87% White, 11% African American, 2% Hispanic, and less than 1% each Native American and Asian, with an average expenditure of $8,000 per student (National Center for Education Statistics [NCES], 2008-2009). At this school, 28% of the students are eligible for free or reduced lunch (NCES, 2008-2009). The three classes for this research project were selected for convenience due to the first author's role as a preservice teacher in them. The demographics of the three classes differed from the school in that there were no African American students. Two of the classes were considered honors programs, while the other was labeled by the school as "academic." Participation in the honor's program depended on a student having either a 3.5 grade point average in previous science coursework, an "Advanced" or "Mastery" score on the science instrument of the Louisiana Educational Assessment Program (LEAP) standardized test, or an Explore Science score of 19. The depth and breadth of the subject matter covered in the academic and honors classes were largely similar during observations preceding the study. The Traditional Honors Class (THC) (n = 31) participated in the traditional curriculum, while the Inquiry-Based Honors Class (IHC) (n = 22) and the Inquiry-Based Academic Class (IAC) (n = 23) participated in the inquiry-based curriculum. In this way, any impact of the curriculum could be ascertained while providing additional insight into how the inquiry-based curriculum may affect students based on academic tracking.

Participants were informed of this study at the beginning of their school year. The description included the study's scope and intent, as well as a brief overview of what students could expect in terms of the curriculum that would be covered. Parental consent forms and student assent forms were handed out in-class to all students (n = 77), and were generally collected within a period of two weeks. All but one student was able to provide parental consent and assent, resulting in a response rate of 98.7%.

The Curriculum

Two ecology curricula were implemented during the course of this study. Ecology was chosen as the research unit because of the rich opportunities for environmentally place-based lessons, with major foci of topics including “populations and ecosystems” and “science and the environment” (Picard, 2004). The mentor teacher was an invaluable resource in examining the two curricula for similarities in learning objectives. It should be noted that these learning objectives related not only to content, but also to the science-as-inquiry goals laid out in the Louisiana science Grade Level Expectations (GLEs).

One curriculum, designed by the first author, was an inquiry-based unit that had students assume the role of an environmental consultant who had to provide a management recommendation for a local watershed. The curriculum was designed to take place both inside and outside the classroom, have an environmental focus, and considered understanding “inquiry” to be an equally important goal of the unit. Inside the classroom, guided notes were given that contained the terms and concepts students would need mastery of to complete their recommendation. Students used these notes to guide them in completing projects inside and outside of the classroom. For example, in order to arrive at an estimation of primary productivity biomass, students spent time outside the classroom in a local forest edge gathering biometric data and then utilized this data in their project. The data from these projects then became part of a portfolio that was used to explain their management decisions. At the end of the unit, students submitted their portfolio with a professionally written management decision for their ecosystem.

“Alligator Bayou” was the ecosystem chosen due to its proximity to the participants’ school and because of the “real life” salience that the issues surrounding the bayou provided. Controversy had surrounded this area with various stakeholders that included county leadership, private landowners, wetland mitigation brokers, and an ecotourism industry competing with their various goals for the bayou. The central question students needed to answer was “Should Alligator Bayou be drained, left ‘as-is,’ or be dredged?” The students were required to justify their recommendation in a report that detailed the various components of the Alligator Bayou ecosystem, how these components would be affected by their management decision, and how this compared to the other management options. Having the students examine a researchable problem that affects their community using data met the criteria for place-based inquiry (Smith, 2002). The first author assumed lead responsibility for teaching this unit. Despite being separated based on ability tracking, both the IHC and IAC were taught similarly by the first author. This allowed comparison of students based on tracking ability.

The other curriculum was designed by the mentor teacher and had been used in the classroom during previous years. In the traditional classroom model, the curriculum was designed to primarily take place in the classroom and considered content to be the primary goal of the unit. Example activities from this curriculum include building a Louisiana food web, viewing “The Lorax” on film and completing a video guide associated with the film, guided notes, and a hands-on activity that explored population dynamics. Using Smith’s (2002) guidelines, one of these lessons was considered place-based (creating a Louisiana food web). The guided notes were similar between the two treatments except that the inquiry-based group was primarily shown examples of concepts that were local in nature. To illustrate, the Traditional Honor’s Class (THC) was shown a picture of a bird picking insects off of a rhinoceros as an example of a mutualism, while the Inquiry-Based Honors and Academic Classes were shown a picture of a local native species, the eastern grey squirrel, eating and storing acorns. Using examples that are geographically local help to make a lesson more place-based (Smith, 2002).

The traditional unit did not reflect a high level of inquiry when scored using the simplified inquiry scale developed by Author (2005). The mentor teacher assumed lead responsibility for teaching this unit, with the first author being responsible for a couple of lessons. The decision was made to have the teacher most familiar with their respective curricula responsible for its execution due to time constraints that precluded the mentor teacher and first author being trained in both curricula.

Both curricula were designed to meet the content learning objectives contained within Louisiana's science GLEs (Appendix A) and were also designed to align with the school districts' mandated pacing guide and comprehensive curriculum. However, the two curricula differed in the science as inquiry GLEs (see Table 1) that were expected to be addressed. Significant to note is that, although Louisiana science GLEs want students to know that scientific investigations can take multiple forms (SI.2), many of the science as inquiry GLEs are only concerned with experimental procedures, and therefore were not technically addressed by the inquiry-based curriculum (SI.3, SI.4, SI.9, SI10). The inquiry-based curriculum also differed in assigning a higher value to guided and open inquiry as a teaching tool and central learning goal of the unit.

Table 1. *Louisiana State Science as Inquiry GLEs and Benchmarks Addressed by Group*

GLE #	GLE Text	Benchmarks	Group	
			THC	IHC
SI 1	Write a testable question or hypothesis when given a topic	(SI-H-A1)		
SI 2	Describe how investigations can be observation, description, literature survey, classification, or experimentation	(SI-H-A2)		X
SI 3	Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls	(SI-H-A2)		
SI 4	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately	(SI-H-A2)	X	
SI 5	Utilize mathematics, organizational tools, and graphing skills to solve problems	(SI-H-A3)	X	X
SI 6	Use technology when appropriate to enhance laboratory investigations and presentations of findings	(SI-H-A3)		X
SI 7	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations)	(SI-H-A4)	X	X
SI 9	Write and defend a conclusion based on logical analysis of experimental data	(SI-H-A6) (SI-H-A2)	X	
SI 10	Given a description of an experiment, identify appropriate safety measures	(SI-H-A7)		
SI 12	Cite evidence that scientific investigations are conducted for many different reasons	(SI-H-B2)		X
SI 15	Analyze the conclusion from an investigation by using data to determine its validity	(SI-H-B4)		X

Data Collection

A variety of data sources included classroom observations/lesson plans, student artifacts, Likert-based surveys, unit test, and an open-ended assessment. A major student artifact that was collected during this study was students' completed Alligator Bayou projects. The project amounted to nearly two-thirds of the student grade during this unit, and provided invaluable insight into student achievement.

A Likert-based survey was administered at the beginning of the school year to develop baseline data on participants' attitudes toward science (Appendix B). The survey measured attitudes about inquiry pedagogy, science as inquiry goals in science education, traditional classroom strategies, self-perception of science aptitude, and student responsibility for learning. After participating in the investigation this survey was re-administered to see if attitudes changed, remained unchanged, or were reinforced.

One goal of this research project was to determine if an inquiry-based unit would produce similar or greater student achievement on high-stakes-style tests. In Louisiana, End-of-Course tests (EOCs) are standardized tests slated to become a major criterion by which student achievement and teacher effectiveness is evaluated. EOC-style sample tests and questions were used for the end of unit test administered to all three classes. Only one question, number 30, was considered an assessment of student inquiry skills. Although only having one inquiry-related question was undesirable from a research perspective, it also raises several new research questions that could be addressed in the future. Some of these will be addressed in the discussion section.

A two-question open-ended pre-test (Appendix C) was designed and administered to measure students' knowledge of ecology. It was hoped that the assessment would not only give insight into previous vs. gained content knowledge, but also reveal how participants constructed ecological knowledge during the course of the unit. A post-test that was identical to the one administered at the beginning of the unit was given again after the unit's completion.

Data Analysis

Participant mean responses to the attitude surveys were analyzed quantitatively through a variety of statistical measures with SPSS. Survey items were grouped into measurement categories before running the statistical tests. Mean attitude scores between the THC (n = 31) and IHC (n = 22), and the IHC (n = 22) and IAC (n = 21) that were obtained prior to the beginning of the treatment were examined using independent t-tests. Main effects of the time between the first survey and the final one (Pre_vs_Post), the treatment (Treatment), and the interaction effect of the two (Pre_vs_Post x Treatment) were explored using a split plot factorial ANOVA. Additional information about how the IAC course responded to the treatment was gathered through the use of a paired t-test.

Differences on the unit test between the THC (n = 31) and IHC (n = 22), and the IHC (n = 22) and IAC (n = 23) test scores were examined through independent t-tests. Questions also were grouped by GLE content strand to ascertain if the treatment produced any significant difference in mean achievement in these individual strands. Additionally, the short answer questions were examined separately from the multiple-choice portion of the test in order to determine if the format of the question interacted with the treatment or academic tracking of the participants.

The open-ended pre- and post-test assessments were analyzed using a combination of qualitative and quantitative techniques. The constant comparative method (Boeije, 2002; Corbin & Strauss, 1990) was used to analyze student responses qualitatively. For this analysis, student responses were entered into text documents and loaded into TAMS Analyzer. This program was then used to code data and to develop, segregate, and link themes. Prior to data analysis, several themes were identified that would be considered expected responses to the questions. The responses were then analyzed for the presence of these themes. Changes in frequencies of these previously and newly detected themes were measured using descriptive statistics in order to ascertain if any change in content knowledge had occurred, or if new themes had emerged.

Results

Attitude Survey

Prior to beginning the study, it was assumed that both the THC and IHC would report similar attitude scores on their survey. Classroom observations and lesson plan analysis indicated that both classrooms had received similar curriculum and pedagogical treatment prior to the study. Additionally, an independent *t*-test on the pre-treatment means also showed no significant difference between the two groups. The pre-treatment and post-treatment mean attitude scores for the THC and IHC are reported in Table 2.

Table 2. *Pre and Post Test Science Attitude Means in the Honors Groups*

Attitude Measure	Pre-Test Means (*SD*)		Post-Test Means (*SD*)	
	THC	IHC	THC	IHC
Positive Inquiry	3.82 (0.502)	3.86 (0.537)	3.87 (0.520)	3.94 (0.466)
Positive Traditional	3.41 (0.445)	3.46 (0.489)	3.23 (0.462)	3.53 (0.477)
Positive Class Experience	3.46 (0.529)	3.40 (0.701)	3.47 (0.752)	3.39 (0.808)
Self-View of Science Ability	3.58 (1.004)	3.47 (0.974)	3.69 (0.989)	3.64 (1.049)
Nature of Science	3.67 (0.653)	3.93 (0.761)	3.87 (0.577)	3.86 (0.819)
Negative Inquiry	2.90 (0.917)	2.93 (0.776)	2.60 (0.811)	3.09 (0.734)
Negative Traditional	2.74 (0.717)	2.68 (0.810)	3.11 (0.738)	2.80 (0.826)
Self-Directed Response	3.13 (1.408)	3.77 (1.270)	3.35 (1.142)	3.82 (1.140)
Positive Place-Based	3.81 (0.910)	4.05 (0.899)	3.74 (1.237)	3.91 (0.971)
Negative Place-Based	2.42 (0.958)	2.55 (0.912)	2.58 (1.234)	2.68 (1.129)

A split-plot factorial ANOVA showed a significant difference ($F_{Pre\_vs\_Post}(1, 51) = 4.824$, $p = .033$) between pre- and post-treatment means that measured students' negative feelings toward traditional instruction within each group. While both treatments reported an increase in negative feelings toward traditional classrooms, negative feelings in the THC grew more significantly. There was also a significant difference ($F_{Pre\_vs\_Post}(1, 51) = 4.985$, $p = .030$) in mean scores reporting students' negative feelings about inquiry instruction, with the THC mean scores decreasing, and the IHC mean scores increasing.

Paired *t*-tests were performed on the mean attitude scores from the IAC to determine if any changes had occurred after participation in the inquiry-based curriculum. No significant difference in any attitude measure was found within this group pre- to post-test.

This study also explored if differences in science attitudes existed between the IHC and IAC groups based on academic tracking, and what interaction this tracking would have with the inquiry-based curriculum. An independent *t*-test confirmed that there were pre-instructional differences in some of the mean attitude scores measures (Positive Inquiry, p = .005; Positive Class, p = .031; Self-View of Science Ability, p = .010) between these two groups. The measures that returned significant differences showed less positive feelings about inquiry instruction, classroom experience, and view of science ability in the IAC. These results are summarized in Table 3.

Table 3. *Independent t-test Results from the Inquiry-Based Groups*

Attitude Measure	*t*-test for Equality of Means			Pre Test Mean Scores		Post Test Mean Scores	
	p	Mean Difference	Std. Error Difference	IHC	IAC	IHC	IAC
Positive Inquiry	.005	.40711	.13703	3.863	3.031	3.943	3.542
Positive Traditional	.177	.18824	.13711	3.454	2.833	3.528	3.155
Positive Class	.031	.39773	.17880	3.397	2.583	3.386	3.000
Self-View of Science Ability	.010	.75955	.28031	3.469	2.402	3.636	2.730
Nature of Science Knowledge	.102	.36660	.21952	3.931	3.125	3.864	3.643
Negative Inquiry	.499	-.15514	.22727	2.931	2.666	3.091	3.095
Negative Traditional	.364	-.20949	.22853	2.681	2.562	2.795	3.262
Self-Directed Response	.193	.51186	.38669	3.772	2.791	3.818	3.476
Positive Place Based	.190	.39328	.29533	4.045	3.166	3.909	3.714
Negative Place Based	.451	.19763	.25995	2.545	2.083	2.682	2.905

A split-plot factorial ANOVA (Table 4) confirmed the pre-test between group differences that were discovered through the independent *t*-tests, and also indicated that these differences remained in the pre- and post-test within the groups.

Table 4. *Significant Split-plot Factorial ANOVA Results from the Inquiry-Based Groups*

Between-Subjects Effects				
Source	Measure	df	F	*p*
TRACK	Pos_Inquiry	1	10.645	.002
	Pos_Class	1	6.330	.016
	Pos_SVS	1	9.184	.004

End-of-Unit Test

This study also tested the hypothesis that focusing on inquiry as a learning goal would produce equal or greater achievement results on high-stakes-style testing. A summary of the students' test results sorted by learning goal is located in Table 5. Separate ANOVA procedures were used to explore these achievements in the THC and IHC, and the IHC and IAC. No significant difference was found in the mean class scores between the THC and IHC. However, the THC did have a higher score on Louisiana state GLE ES.2 (p = .032). Significant differences were found in the achievement scores between the IHC and IAC on LS.23 (p = .012) and the multiple-choice porti-on of LS.24 (p = .043). The IAC scored lower in each of these categories. Short answer questions received higher scores than multiple choice format questions. Although multiple choice and short answer responses on tests may measure different cognitive abilities, there is little evidence that question format has a significant effect on overall test item scores (Frederiksen, 1984). Perhaps the rubric for scoring the short answer questions, which is more open and subject to interpretation than the answers to a multiple-choice question, is involved in the higher scores. The scoring rubric that the mentor teacher used to score these questions is included in Appendix D.

Table 5. *End-of-Unit Test Results by Treatment Groups*

GLE Tested	**Question Format**		**Class Averages**		
			THC	**IHC**	**IAC**
LS.23	MC		60.48	57.95	38.04
LS.24	MC		58.06	77.27	47.83
LS.24		SA	96.77	95.45	100.00
LS.25	MC		52.26	56.36	45.22
LS.26	MC		61.29	68.18	63.04
LS.26		SA	83.06	89.77	86.96
LS.27	MC		74.19	82.95	75.00
LS.28	MC		80.65	68.18	45.65
LS.29	MC		96.77	86.36	73.91
LS.31	MC		95.16	93.18	84.78
LS.35	MC		59.14	59.09	62.32
LS.36	MC		83.33	78.03	81.88
LS.36		SA	93.55	95.45	95.65
SI.4	MC		70.97	72.73	73.91
ES.2		SA	96.77	84.09	91.30
TOTAL LS.24			83.87	89.39	82.61
TOTAL LS.26			75.81	82.58	78.99
TOTAL LS.36			85.89	82.39	85.33
MC Average			70.24	70.53	62.55
SA Average			90.65	90.91	92.17
Total Test Average			75.22	75.50	69.78

Note. MC = Multiple Choice, SA = Short Answer

Multivariate analysis (MANOVA) was used to explore the interactions of the treatment and tracking on the students. These results are summarized in Table 6. Both inquiry-based groups had lower mean scores on GLE ES.2 (p = .028) than the traditional group. A greater number of significant differences were found between the scores of the IAC and the two honors groups. Where a significant difference was found, the score of the IAC were lower for all of these measures.

Open-Ended Assessment

The open-ended pre- and post-test assessments asked for students to respond to the potential consequences of building a development in a managed pine and hardwood plantation, which historically was a fire-maintained longleaf pine savannah. The development would halt all commercial logging activities in the area. Students were also asked for solutions to the potential consequences that might mitigate any environmental impacts, while still allowing for development. A "No Solution" response was coded when the student indicated that they did not feel there was any way for development to progress while at the same time mitigating environmental impacts. For example, James states "... if you're building something in an ecosystem there is no way of improving the ecosystem because of pollution and other things."

Table 6. *Significant Between Subjects (Tracking Group) MANOVA Results for End-of-Unit Test*

GLE Assessed	df	F	*p*
MC_LS.28	1	4.138	.046
MC_LS.23	1	5.536	.021
MC_LS.24	1	4.150	.045
MC_StuAvg	1	4.094	.047

Pre-Test

Several interesting themes became apparent when reviewing the students' pre-test. The first of these is the traditional classroom's overwhelming majority of expected responses for both consequences and solutions during the pre-test as indicated in Table 7. This majority held across every category of expected responses except for the "Change Site" expected solution.

Table 7. *Frequency of Expected Responses*

	Expected Responses	Pre Test			Post Test		
		THC	IHC	IAC	THC	IHC	IAC
Consequences	More Trees	7	0	1	4	1	5
	More Fires	2	0	0	1	2	1
	Pollution	4	4	1	13	11	4
	Wildlife Affected	4	1	1	9	8	6
Solutions	Change Site	2	6	2	9	9	3
	Reduce Pollution	2	2	1	3	4	3
	Harvest Trees	9	3	2	1	0	0
	Controlled Fires	1	0	0	0	0	1
	No Solution	2	1	1	0	3	1

Another theme is the THC's utilization of responses that address the development consequences of this ecosystem with what will happen with the trees. Namely, because of the development there will be more trees, and a potential solution to this problem is to allow logging. Ashley gives an example of a well-thought and appropriate response for a consequence when she states, "As a result of the building development the trees would overgrow and burn more often causing forest fires and the hardwood would die out leaving pine trees." Her potential solution also directly addresses the problems she sees: "Controlled logging and controlled forest fires would increase wood harvesting and increase productivity, while helping make room for more pine trees."

Other students provided seemingly contradictory statements that at one time suggest the development will destroy the ecosystem but also preserve it. Rebecca states, "It will destroy what is left of the forest in that land and make loggers move to a different area, causing even more forests to be destroyed." Her solution, "Allow logging…?," indicates she is not quite certain of the consequences of the development, and therefore not certain of what solutions may be available, but it somehow involves trees. And still other students, such as Sally, provide responses that do not seem to match one another. Sally writes about the consequences of the development: "The creek can get backed up and not smoothly flow like usual." A given solution states, "He can keep the logging to help make money." There is also evidence that these students are making connections between the consequences that having more trees in an ecosystem may have, such as more fires, or harm coming to wildlife.

The IHC expressed ecological consequences much more in terms of pollution to the environment, with their construct of pollution being overwhelmingly connected with its impact on Ridgdell Creek. As Jimmy states, "They could pollute the area around the building and the creek next to it." Another significant finding was the sheer lack of responses that fit within the model of expected consequence responses, especially when compared to the THC. Although pollution seems to be a primary concern to these participants, their proposed solutions are mixed in addressing this directly. Often their responses relate back again to Ridgdell Creek. Their proposed method to help reduce the ecological impacts on the creek is to move the development site. Only two participants explicitly connect this action to potentially reducing pollution in the creek. One of the unexpected results for this group was coding that stated *moving nature* would be a possible solution. In particular, moving wildlife to more natural locations was seen as an adequate solution, an indication that theses students were not drawing upon the ecological concept of carrying capacity.

The major underlying theme that describes how participants in the IAC describe the ecological consequences of this scenario did not fit within the authors' model of consequences that would be experienced in the environment. Rather, it is *economic* in nature. These participants addressed the reduction or complete stoppage of logging and lumber production, and the consequences that these actions would have on jobs and profits. One student simply states, "No more lumber and pulpwood will be made there." However, their solutions to this consequence suggests that it is not solely the condition of logging stopping after development begins (as given in the scenario), but rather the removal of trees from such a development that would preclude any further lumber production. The same student goes on to give a conservation-oriented response: "Leave some land for trees to grow to help the ecosystem."

Post-Test

Student post-test results (Table 7) showed an overall increase in expected response frequencies, although the "Harvest Trees" category in expected solutions decreased, and "Controlled Fires" and "No Solution" remained unchanged across groups. The traditional classroom's dominance on expected responses also diminished somewhat. On the pre-test their responses accounted for 57% of all expected responses, while their responses on the post-test accounted for 40% of all expected responses. Furthermore, the two inquiry-based classes account for the majority of responses in several categories now. The IHC showed more responses in "More Fires" in expected consequences, and "Reduce Pollution" and "No Solution" in expected solutions. The IAC had the most frequent responses in "More Trees" in expected consequences and "Controlled Fires" in expected solutions. Responses that addressed pollution as an expected consequence saw the greatest increase in frequency of responses across all groups.

Student responses of potential environmental consequences became more varied on the post-test for the THC. Whereas on the pre-test the majority of responses tried to address what would happen to the trees in the ecosystem, the post-test showed more connections with pollution and effects on wildlife. The interaction of these consequences on various ecosystem components increased as well. An increase in trees was now connected with harming certain species of wildlife. The interaction of pollution on the environment became more varied, with air quality and wildlife now more often to be viewed as being affected, along with Ridgdell Creek. Beyond the interaction with an increase in tree density and pollution, students in this group often credited habitat loss as the major factor that harmed wildlife. Proposed solutions for this group also shifted from a focus of removing excess trees to moving the development site to another location. Moving the proposed development site, especially moving it to the south, was connected with reducing pollution in Ridgdell Creek.

The number and variety of responses from the IHC group increased dramatically on the post-test. Themes revolving around pollution dominate this group's ideas of ecological consequences. These responses often cite Ridgdell Creek as the component of the ecosystem most affected by this pollution. However, these students now also describe relationships where pollution in the creek also harms wildlife. For example, Sean states:

> The building of this development may result in many ecological consequences. One consequence might be a decline in fish populations. Most developments result in pollution in rivers and streams nearby. This can drastically affect certain fish. This could result in a decline in fish eating consumers.

Similar to the THC, moving the development site was often reported as a viable solution to lessening the environmental impacts of the development. These students almost exclusively connected this action with reducing pollution in Ridgdell Creek.

The IAC also saw a dramatic increase in the frequency of expected responses on the post-test. More of these students recognize that an increase of trees may be beneficial to some wildlife species, and that there will likely be an increase in pollution that, similar to the responses of the honors classes, will affect Ridgdell Creek and surrounding wildlife. Another significant finding is the complete absence of the economic consequences that were so dominant during the pre-test. Their proposed solutions most often suggest moving the development site, with the goal of reducing pollution. Outside of the model of expected responses, these students expressed that various conservation efforts would be a significant way to reduce environmental impacts.

While coding student responses on the pre- and post-test, the authors became interested in whether students actually addressed their potential consequences within their solutions, and whether these responses changed during the ecology unit. Michael states:

> It could cause a decrease in forest acreage and cause a lack of home for animals. It will then cause a food chain missing component. It will cause a lack of food for insects then a lack of food for other animals. It might also cause pollution to the creek when they have to cross over it to the proposed site.

His response, "to place the site in a new spot away from the creek and the area. It will not disrupt the food chain and it would not pollute the creek," indicates he is trying to solve the problems he feels might occur in this ecosystem. Students that continued to struggle matching their solutions with their consequences often gave seemingly disjointed responses. For example, one student felt that if everything were "moved in a more efficient way" that it would mediate the harm to trees and other plant life and wildlife. The frequency with which students linked their thoughts remained the same for the IHC pre- to post-test, but increased for the THC and nearly tripled for the IAC.

The nature of these responses also changed. During the pre-test, themes of planting trees to "make up" for lost habitat dominated. In post-test analysis, these themes became more intermingled with moving the development to another location (usually with the qualification that doing so would conserve trees and/or reduce pollution), or working to stop pollution. The language of responses also changed to reflect the course work that students had been engaged in. In other words, many students began to use the language of ecology and ecologists. This language included using concepts like food chains, describing components of the oxygen/carbon dioxide cycle, primary productivity, and adaptation.

Discussion

The quantitative data from this study provides no clear evidence that implementing a place-based inquiry curriculum results in any significant gains in achievement in high-stakes standardized testing. Equally important, however, is that student achievement did not appear to suffer because of it. Indeed, if one looked only at this data there would be no clear guidance for educators who are struggling to help students realize content achievement goals.

An analysis of the qualitative data provides a different point of view. The IHC and IAC showed clear deficiencies on the pre-test in identifying potential environmental consequences and remediating solutions when compared to the THC. These discrepancies largely disappeared when measured on the post-test. Furthermore, the IAC made the most significant gains in constructing responses that connected consequences to one another, and in improving potential solution responses to address these consequences. These results indicate a clearer benefit to participation in the inquiry-based curriculum than the one presented by the quantitative data.

However, even at these conclusions one should remember Johnston's (2008) critique of Settlage's (2007) call to demystify the science education community's commitment to open inquiry: we are in error if we are confronted with, and then accept, that the main goal of science education is the acquisition of content (Johnston, 2008). Knowing and being able to apply the processes, products, and features of scientific inquiry is not only critical in science, but in many fields, fosters good citizenship, and is part of being human (Johnston, 2008). The place-based inquiry curriculum is a much more authentic experience for students, the questions answered and activities performed more similar, and arguably a better preparation for the questions and activities that would be encountered as an active community member.

The literature suggests academic tracking may be correlated with or affect student science attitudes (Simpson & Oliver, 1990). Furthermore, Trautwein, Ludtke, Marsh, Koller, and Baumert (2006) indicate that math self-concept and interest attitudes may be correlated to the tracking that students are assigned. These studies support the independent *t*-test results performed on the pre-test attitude means for the two honors classes and two inquiry-based groups. The honors courses reported similar attitudes, and the academic class reported generally lower attitudes. These differences remained stable throughout the study, meaning that the effect of the curriculum treatment was not as significant an influence on student attitudes as the tracking condition itself.

During the course of this study both honors groups reported more negative feelings about traditional classrooms. This somewhat agrees with the findings of Simpson and Oliver (1990). However, unlike their study, the remainder of their attitudes remained stable and, while Simpson and Oliver (1990) explore general science attitudes, this study examined student attitudes about the kind of science instruction. Both classes' negative feelings about inquiry instruction also changed over the course of the study. The THC reported less negative feelings about inquiry instruction, which is synergistic with their increased negative feelings about traditional instruction. The IHC reported increased negative feelings about inquiry instruction. There are two reasons that this likely occurred. First, although all groups had been exposed to inquiry-based instruction prior to the beginning of this study, further scaffolding was likely necessary to minimize the level of frustration (Author, 2005). Second, the inquiry-based students became aware that their coursework was dramatically different from the control groups' coursework. Several students expressed a longing for traditional seatwork and lecture as opposed to the added rigor required from the inquiry-based curriculum. In other words, these students sought to maintain the status-quo (Wood et al., 2009). For example, two of the student participants lived in the same home. The student in the IHC expressed on a couple of occasions the perceived unfairness in having to do more work than her sibling who was in the THC group. In another example, one student expressed after, "I'd rather be bored and get an 'A' then have to do work and get a 'B' or 'C'." This student felt that achieving a high grade had more value than the actual process of learning. One can certainly understand where such a valuation would come from given the high-stakes competitive nature of today's high schools.

One of the surprising findings in this study was the lack of change in attitudes for the IAC. Simpson and Oliver (1990) observed that science attitudes tend to decrease throughout the school year, suggesting that these attitudes should have decreased throughout the school year as well. This begs further investigation into whether a place-based inquiry curriculum could stabilize student attitudes in science.

Implications and Conclusions

There are multiple stakeholders in maintaining student interest in science. Administrators are not only under increasing pressure to demonstrate student performance on standardized tests, but also to develop and enroll students in Advanced Placement (AP) courses. Although multiple reasons explain why students may choose to enroll in such courses, attitudes toward science are likely a factor (Simpson & Oliver, 1990). The National Science Board (NSB) (2010) has identified science, technology, engineering, and math (STEM) fields to be essential to continual economic, academic, and health advances of industrialized nations, and policy makers have followed by increasingly calling for students to enroll in STEM coursework. Communities also have a stake in students participating in more science coursework. Knowing scientific methods and processes, content, and the nature of science (NOS) enables students to become scientifically literate members of society (AAAS, 1990); able to make informed decisions on a variety of issues. This discussion of stakeholders and the reasons why they have an interest in maintaining student interest in science is in no way exhaustive; it is merely meant to serve as a rationale for why we are even concerned with whether students continue to take science-related coursework.

Most important to this research project are the implications for teachers in the classroom. One of our jobs as educators is to "turn kids on" to the content of our fields, as well as to foster critical thinking skills in our students. We accomplish this through a variety of means and methods, including finding ways to improve student attitudes about the subjects they study, the coursework in which they participate, and about themselves. Although this study revealed no clear guidance on how place-based inquiry curricula affect these attitudes, some insight emerged:

1. Students must “own” their work. Although place-based curricula has the potential to be much more authentic to students’ lives than traditional curricula (Wyner & Desalle, 2010), if students are not allowed to participate in the curriculum decision making and design process, it remains a set of tasks and instruction that is handed down to them. The realities of the classroom may preclude this kind of interactive participation in many scenarios but, for the sake of keeping our kids turned on to science, should continue to be explored.
2. Students should be scaffolded into higher order inquiry instruction (Author, 2005; Wilson et al., 2010), although scaffolding during the school year by itself may not be sufficient.
3. Students will actively resist inquiry instruction if it is not the norm (Wood et al., 2009), especially if it is seen as more challenging than the instruction of their peers.

While one of our goals as educators is to foster an interest in learning in our students, it can be argued that the central goal as an educator is to help these students learn, and applies whether you subscribe to a behaviorist, cognitivist, or constructivist model. For good or bad, in today’s climate of teacher accountability, learning is often measured in high-stakes-style testing. This study has shown that place-based inquiry curriculum even when designed and implemented by a novice teacher, can be at least as effective as a traditional one in student achievement on these tests, and may be more effective when analyzing student constructs of the subject matter. Critical thinking skills – the kinds of skills we want our students to have as lifelong learners and active members of society – are clearly better developed by participation in an environment where it must be used (Geier et al., 2008; Miner et al., 2010).

Irregularities were discovered that related to the alignment of assessments with GLEs and the observation that the science as inquiry GLEs mainly described scientific investigations as experimental in nature. It is reasonable to assume that educators who are increasingly evaluated based on student performance on high-stakes tests will tend to devote more classroom instructional time to the topics that are covered on these tests. The results of this study indicate that devoting more time to inquiry process skills does not negatively affect student achievement on content (although this argument would be more sustainable had there been more that one science as inquiry assessment question on the test). This should give pause to those who may be tempted to neglect inquiry process skills in favor of content, and give reassurance to educators who are striving to develop and use lessons that integrate these skills with the content being covered. Even when using science inquiry skills that do not perfectly align with state standards (having students evaluate studies and findings that came from investigations that were not experimental in nature), the assessment shows that students perform equally as well. However, the discovery that experimental science investigations are still dominant over other forms in the state standards should be a call for the science education community to actively push for reform of these documents in these areas.

Limitations/Future Research

It is important to remember that first and foremost this was an action research project, and as such has a somewhat limited ability to inform audiences outside of the principle investigator and participants (Mertler, 2009). Sample size was limited in this study to only three classrooms, two of which were honor track. Additionally, the classes in this study were not representative of the school population. A more robust study would include samples from classrooms from various schools, and would add a traditional classroom treatment to academically tracked students.

An additional limitation of the project is the decision to use two different teachers to implement the curricula. Due to time constraints, the lead mentor teacher in the classroom was not available to be trained in the inquiry-based curriculum. Likewise, the first author was not available to be trained in the mentor teacher's traditional curriculum. The authors felt that an unprepared teacher would have a greater effect on student achievement and the validity of results than having two separate teachers who were highly qualified to implement their respective curricula.

One of the questions developed during the course of this study was revealed when the EOC test was evaluated for the learning goals it was assessing. Only one question, number 30, was considered an assessment of inquiry skills. This raises important questions: What are the science as inquiry learning goals for this state if their assessment takes such a subordinate role to those of content? Are the state's goals accurately reflected in the sample EOC assessments? Are the state's goals accurately reflected in the standards and benchmarks? Additionally, the lack of peer-reviewed sources that addressed environmental place-based education's effects on ability tracking suggests future research possibilities.

While not realizing such opportunities in this project was disappointing, it also helps to highlight the cyclical nature of action research. What is important at this point is to take these limitations, the information gained and lessons learned about the original problem, and the questions that arose from it, and use this to inform and generate further research.

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Appendix A. ***Grade Level Expectations***

GLE #	GLE Text	Benchmarks
LS 23	Illustrate the flow of carbon, nitrogen, and water through an ecosystem	(LS-H-D1) (SE-H-A6)
LS 24	Analyze food webs by predicting the impact of the loss or gain of an organism	(LS-H-D2)
LS 25	Evaluate the efficiency of the flow of energy and matter through a food chain/pyramid	(LS-H-D2)
LS 26	Analyze the dynamics of a population with and without limiting factors	(LS-S-D3)
LS 27	Analyze positive and negative effects of human actions on ecosystems	(LS-H-D4) (SE-H-A7)
LS 28	Explain why ecosystems require a continuous input of energy from the sun	(LS-S-E1)
LS 29	Use balanced equations to analyze the relationship between photosynthesis and cellular respiration	(LS-H-E1)
LS 31	Compare the levels of organization in the biosphere	(LS-H-E3)
LS 35	Explain how selected organisms respond to a variety of stimuli	(LS-H-F3)
LS 36	Explain how behavior affects the survival of species	(LS-H-F4)
ESS 1	Describe what happens to the solar energy received by Earth everyday	(ESS-H-A1)
ESS 2	Trace the flow of heat energy through the process in the water cycle	(ESS-H-A1)
ESS 13	Explain how stable elements and atoms are recycled during natural geologic processes	(ESS-H-B1)
ESS 15	Identify the sun-driven processes that move substances at or near Earth’s surface	(ESS-H-B2)

Appendix B. *Attitude Survey*

Science Survey Questions

Below are several statements. Please circle the number that **most closely** shows how much you agree with each statement.

1. I learn science best with hands-on activities in class, such as labs or using models.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

2. I view myself as good at science.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

3. In class you are given several samples of various food items, such as bread, apple, cooked chicken, and potato. You are also given several indicators that may tell you which substances contain protein, which ones contain starch, and which ones contain sugar, but you do not know which one. Your assignment is to correctly identify which indicators will tell you whether a food item has protein, sugar, or starch. You are given no instructions on how to find the answer beyond following regular lab safety rules.

a. I would learn effectively in this activity.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

b. This kind of activity would be frustrating to me.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

c. This kind of activity would be fun to me.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

d. This activity is science.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

4. My friends see me as being good at science.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

Name: ___________________________

5. I get to decide what to study in my science classes.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

6. I would like to decide what to study in my science classes.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

7. I learn science best when I read from a textbook.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

8. I will use what I learn in my science classes when I am an adult.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

9. The activities I do during my science classes are "science."

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

10. While studying ecosystems, you learn about endangered species. The teacher selects an endangered species and then asks you to prepare a presentation on that species as a way to learn about them.

a. I would learn effectively from this activity.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

b. This kind of activity would be frustrating to me.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

c. This kind of activity would be fun to me.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

d. This activity is science.

1	2	3	4	5
Never	Seldom	Sometimes	Mostly	Always

11. What I learn in my science classes will be useful to me as an adult.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

12. Building a school garden is a scientific activity.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

13. To be a scientist, you have to be objective.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

14. My parents think I am good at science.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

15. In order to learn about cell parts and functions, you are given a worksheet with an unlabeled cell. By following lecture notes you are able to fill in the labels for the cell. Your grade will partially depend on how correctly the worksheet is filled out.

a. I would learn effectively in this activity.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

b. This kind of activity would be frustrating to me.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

c. This kind of activity would be fun to me.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

d. This activity is science.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

16. I learn science best in class discussions.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

17. I would rather learn about plants and animals from exotic locations than local ones in science class.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

18. A laboratory is the best place for science to take place.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

19. I would rather learn about local plants and animals than ones from exotic locations in science class.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

20. Your class visits Black Bayou creek. While there you are asked to design an investigation that relates to this bayou and the ecosystem unit your class has been working on. Your grade will partially depend on how well your investigation addresses the topics you have discussed in class.

a. I would learn effectively in this activity.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

b. This kind of activity would be frustrating to me.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

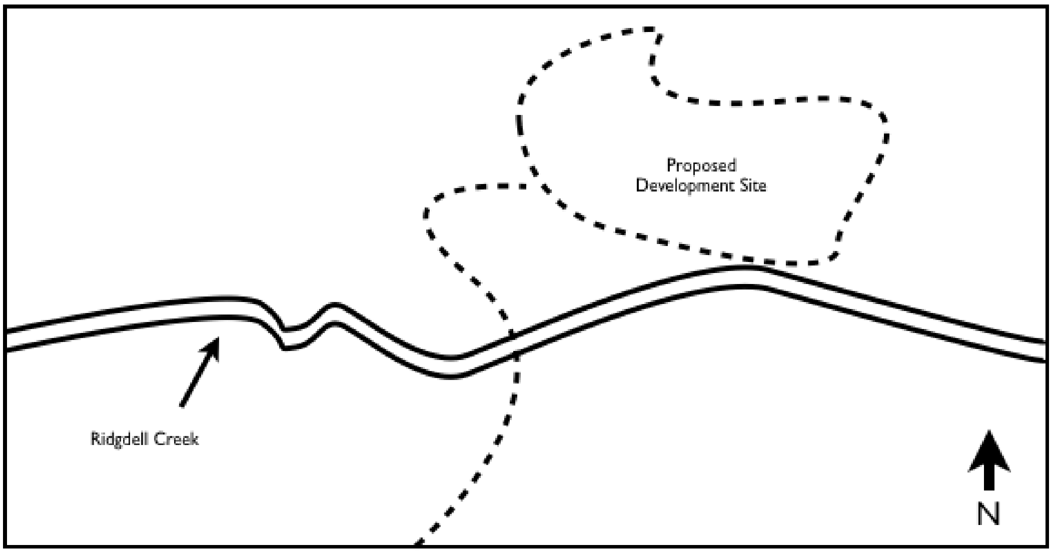
c. This kind of activity would be fun to me.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

d. This activity is science.
1 Never 2 Seldom 3 Sometimes 4 Mostly 5 Always

Appendix C. *Pre- and Post-Test Assessment*

Name: ____ Date: ______________________

A large residential development has been proposed to be built in the middle of a large 7,000-acre forest in southeastern Louisiana. This forest is mostly bordered by farmland, with a small urban area to the south.



Before European settlement this land burned frequently, leading to the maintenance of a longleaf pine savannah. Starting in the early 1800's, the land was cleared for agriculture. In the early 1900's, farming was abandoned and a mixed hardwood and loblolly pine forest began to emerge. This area has been managed as a mixed hardwood and loblolly pine plantation for the production of lumber and pulpwood ever since. The developer intends to stop all logging on this property after the development is started.

What ecological consequences may result from the building of this development?

Are there any alternative plans to suggest to the developer that allow for development and may also improve the ecosystem? Explain.

Appendix D. *Short Answer Scoring Guide*

Sample Answers – Question 32

Part A
The catfish population would most likely decrease because its two food sources are crabs and shrimp, which depend on grasses for food.

Part B
The muskrat population would most likely decline because there would be more shrimp competing with them for food, and because the eagles and alligators would be more dependent on the muskrats for food.

Scoring Rubric

Score	Description
2	The student gives two correct key elements. There are no errors.
1	The student gives one correct key element. There are one or more errors.
0	The student's response is incorrect, irrelevant, too brief to evaluate, or blank.

Sample Answers – Question 33

Part A
No, because adding only phosphorus does not help those plants to grow.

Part B
Plants with added phosphorus and nitrogen grew better than plants with only nitrogen or only phosphorus.

Part C
Any two of: carbon dioxide, sunlight, water, space, temperatures/growing season, competition with other plants, predation, etc.

Part D
Weeds would compete with crop plants for factors that are already limiting the growth of crop plants--such as nutrients, water, or sunlight--and therefore would reduce the yield.

Scoring Rubric

Score	Description
4	The student gives four correct key elements. There are no errors.
3	The student gives three correct key elements. There are one or more errors.
2	The student gives two correct key elements. There are one or more errors.
1	The student gives one correct key element. There are one or more errors.
0	The student's response is incorrect, irrelevant, too brief to evaluate, or blank.

Sample Answers – Question 34

Part A
Large numbers of birds can confuse predators.
or
Groups of swallows can chase away predators.

Part B
The parasitic behavior relieves the female of nest building and chick raising, both of which require large amounts of energy. It is likely that she would be able to lay more eggs than she could raise by herself even with a mate.

Scoring Rubric

Score	Description
2	The student gives two correct key elements. There are no errors.
1	The student gives one correct key element. There are one or more errors.
0	The student's response is incorrect, irrelevant, too brief to evaluate, or blank.

Sample Answers – Question 35

Part A
The energy comes from the Sun.

Part B
Evaporation requires a direct input of energy.

Scoring Rubric:

Score	Description
2	The student gives two correct key elements. There are no errors.
1	The student gives one correct key element. There are one or more errors.
0	The student’s response is incorrect, irrelevant, too brief to evaluate, or blank.

Ortaöğretim sınıflarındaki çevresel yer temelli sorgulamada öğrencilerin tutum ve başarılarının araştırılması

Öğrencilerin, üç ortaöğretim biyoloji 1 dersindeki, fenne yönelik tutumları ve içerik başarıları, geleneksel öğretim programı kadar çevre tabanlı öğretim programları da kullanılarak analiz edilmiştir. Öğrencilerin tutumları, okul yılının başında bir hafta süren çevrebilim öğretim programı tamamlandıktan sonra uygulanan likert tipi fen tutum anketi kullanılarak ölçülmüştür. İçerik başarıları, ünite sonu testi yanında ön-test ve son-test ile ölçülmüştür. Nicel veriler, tutum ölçümlerinin yetenek grup takipleri ile ilişkili olduğunu ve üç grupta uygulamalarda elde edilen fen tutumlarında az bir değişimin olduğunu göstermektedir. Bulgular, ayrıca, ünite sonu testine ilişkin genel test puanlarının, sorgulama temelli ve geleneksel öğretim programları arasında anlamlı olarak farklılaşmadığını göstermiştir. Ön ve son testlerin nitel analizleri, üç grup için çevrebilim bilgisinde artış ve sorgulamaya dayalı akademik sınıfta en yüksek kazanımın olduğunu göstermektedir.

Anahtar kelimeler: Çevre eğitimi, yer-temelli eğitim, sorgulama, standardize ölçüm