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Comparing Teaching Methods in an Environmental Education Field Trip Program

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Abstract

This study investigates the impact of instructional methods based on a one-day informal science field experience comparing a teacher-centered methodology versus a student-centered (inquiry-based) methodology. The 5E learning cycle was selected as the framework for implementing the inquiry-based learning for the treatment groups as it provides the structure of the constructivist learning cycle (Duran & Duran, 2004). The research design followed a quasi-experimental design with a total of three control and three treatment groups representing two individual schools. Each school included at least one treatment and one control group. The study included 117 third grade students. Both groups were given a pre and post assessment measuring the impact of the instructional method of inquiry presented in the 5E format. An independent-measures t-test was used to analyze the results of the means for the post-test assessments (treatment and control) and the means of the retention assessments. Pre-tests indicated variations of prior knowledge between the control and treatment groups. Post-tests indicated similar results of knowledge gains. However, the retention tests for the treatment groups revealed students increased their knowledge from the time of their post-test. The control groups' retention results were similar to their post-test results indicating knowledge was maintained.

keywords: Informal education, science, field experience

Environmental education field trip experiences usually follow two different instructional options of student-centered (inquiry-based or self-guided) or teacher-centered (direct instruction) (Duran & Duran, 2004; Randler & Hulde, 2007). One goal of informal science field experiences is to give learners opportunities to engage with content experts in authentic contexts to learn the practices of scientists that will help with long-term memory of the content (Kirschner, Sweller & Clark, 2006). Inquiry encourages students' curiosity to discover and construct information through learning facilitated by teachers, without directly revealing information, but instead building on students' knowledge and experiences (Duran & Duran, 2004). In contrast, direct instruction refers to a teacher explaining all concepts and procedures fully before allowing students to explore content, with the goal of having students repeat knowledge of content post experience (Kirschner, Sweller & Clark, 2006). These methods of instruction engage students differently, impacting how they obtain and construct information.

Informal science education offers field trips as opportunities for students to study science in realistic contexts with experts in those areas of study. Informal science educators work with classroom teachers to help them utilize field trip programs to supplement and/or to compliment classroom learning (Lavie & Tal, 2015). Nature-based field trip experiences have shown to have a long-term impact on students' knowledge even a year after the event (Farmer, Knapp & Benton, 2007). Field trips that include experiential learning and inquiry-based instruction have shown to impact students' cognitive, affective, social, and behavioral aspects of their learning (Tal & Morag, 2009). Research supports that inquiry-based learning experiences in nature can support student learning and their long-term understanding of the content they experienced.

Direct instruction plays an important role in informal science education in terms of stating learning objectives, explaining steps to an activity, or modeling a process, and its lecturing format at times has become the primary teaching practice used (Subramaniam, 2020). An educator's prior knowledge of how to teach science concepts is shaped by their own experiences in conventional classroom education, and they are likely to reproduce in their practice what they experienced as learners (Subramaniam, 2020). Research on understanding prior knowledge of teaching science in informal settings showed that 44% of the 186 participants placed an emphasis on students being the consumers of knowledge through teacher-centered experiential learning with the teacher delegating actions that directed students on how they should learn the science content in the informal setting (Subramaniam, 2020). This practice does not support the goal of informal science field experiences, allowing students to have authentic learning experiences through curiosity and concept construction (Lavie & Tal, 2015; Tal & Morag, 2009).

Much of the current research focuses on program effectiveness in relation to long-term impacts, but not necessarily the methods of delivering content. Farmer, Knapp & Benton (2007) showed that students retained long-term environmental and ecological content and displayed evidence of an apparent increase in pro-environmental attitudes up to one year after a single- day program at the Great Smoky Mountains National Park. This program led by education rangers included hiking, inquiry-based learning activities that explored science content, and group discussions about the students' role in their environment, creating a multi-sensory learning environment to engage student learning (Farmer, Knapp & Benton, 2007). Research also shows that single day informal environmental science field trips provide optimum learning experiences, regardless of whether they are topic-focused or issue-focused (Knapp & Barrie, 2001). Although promising, there is limited research on the effectiveness of content delivery methods for these types of field trips. Duran and Duran (2004) state that utilizing the inquiry-based learning cycle approach supports research on how humans learn (impacting change in long-term memory) and is consistent with constructivist ideas of the nature of science. When providing student choice as a part of inquiry in natural contexts students are able to use their voices in the selection of their own learning, which empowers them as learners (Magee & Wingate, 2014).

The following study compared the impact of using a teacher-centered (direct instruction) versus a student-centered (inquiry-based) instruction when implementing a single day field trip. It asks the question: Is an inquiry-based method more effective on student understanding of the properties of soil than direct instruction when teaching third grade students on a one-day field trip? This study was conducted at The North Carolina Arboretum. This Arboretum is an Environmental Educational Center that serves as a one-day field trip destination for multiple school districts. Students visiting the center have a prime opportunity to engage in unique science experiences outside of the classroom allowing students to connect with science in a nature-based context. This study will provide informal science programs with information that can assist educators and curriculum developers who want to add an experiential field experience to their science curriculum.

Literature Review

Field Trips

Out of school, nature-based field trips have historically been used as a resource to supplement and enrich material that students are learning in the traditional classroom setting. Results have shown that students benefit from these field trip experiences by acquiring new knowledge, making connections to prior knowledge, and developing critical thinking skills (Alon & Tal, 2015). During a nature-based field trip students are given the opportunity to engage in a sensory exploration of the environment around them. Furthermore, field trips allow the instructor to bridge school learning and the curriculum with the environment and to promote science learning (Tal & Morag, 2009). These experiences provide an opportunity for students to explore natural surroundings with naturalists and environmental educators that display pro-environmental attitudes. Studies show that these engaging environmental experiences with experts influence students to display pro-environmental attitudes and the ability to recall specific content long-term (Farmer, Knapp & Benton, 2007).

Field trips are valuable, they allow students to discover different learning environments, provide enrichment opportunities, and respite from the daily school routine (Alon & Tal, 2015) Teachers have also noted personal benefits like improved relationships with their students, development in their teaching, and curriculum enhancement (Tal & Morag, 2009). Since field trips to natural environments are generally considered as enrichment to classroom teaching, and as most of them are facilitated by informal educators affiliated with environmental organizations rather than by teachers, pedagogy has typically been a secondary concern to the other considerations of schools and teachers (Alon & Tal, 2015).

How Students Learn

Inquiry-based Learning. Inquiry-based learning states that learning happens through exploration and the integration of real-world experiences, with learners controlling their own acquisition of knowledge as the instructor serves as a facilitator

(Dewey, 1938; Duran & Duran, 2004; Farmer, Knapp & Benton, 2007). Kirschner et al. (2006) defines inquiry-based learning as learners discovering and constructing their own knowledge through structured experiences rather than being presented with information by the teacher as the authority. In informal science education the practice of inquiry has been explored to understand how this practice helps students further their conceptual knowledge that accompanies the experiential learning opportunities (Zhang, 2016). Dewey (1938) refers to this as an organic connection between education and personal experience, stating that it is a sound education principle to first introduce students to science concepts with everyday applications.

Difficulties with Implementing Inquiry-Based Learning. This same body of research from Zhang (2016) shows some arguments against inquiry-based learning citing that the practice is weaker in helping students gain scientific investigation skills and that it either does not outperform textbooks in students' science learning, or that students in fact showed negative results on science learning assessments after being exposed to the practice. Kirschner et al., (2006) state that minimally guided instruction can be unsuccessful at times due to cognitive development. Kirschner et al. (2006) also state that minimally guided instruction causes a heavy cognitive load that prohibits learning because the working memory is too busy finding a solution to the problem presented, and therefore cannot access the prior knowledge to connect the new information to what is stored in the long-term memory. Cognitive development represents learning as moving from sensory regions to more permanent storage, shown as intellectual structures.

Bridging Inquiry-based Learning and Content. Kirschner states that learners are best able to learn, and problem solve when they can access their prior knowledge and rehearse/practice their new knowledge stored in their working memory through well scaffolded instruction (Kirschner et al., 2006). Liu et al., (2009) suggest that a more "guided" inquiry approach offers students a science practice-based pedagogy that can enhance understanding. The key is to provide a structure that supports research on how learning happens while also allowing students to construct concepts through their learning experiences. Zhang (2016) provides both arguments for and against inquiry-based learning showing that teaching science is a continuum that contains both direct instruction and inquiry-based instruction and that a 5E Instructional Model is one way of combining the two. Duran and Duran (2004) provided a review of multiple studies that compare the effectiveness of a learning cycle method to traditional teacher-centered pedagogy. The study was completed using the 5E Instructional Model in two different teacher professional development programs (Duran & Duran, 2004). Teacher participants revealed that the 5E Instructional Model allowed for assessment of student prior knowledge, specific skills in science that students' need, and more importantly students are able to be actively engaged in their own learning (Duran & Duran, 2004).

A 5E Instructional Model can provide a structure for guided inquiry to address the content for students and provide educators with a framework. The model is designed to follow a learning cycle where students use constructivist principles to develop and test their own ideas and evaluate them through self-reflection (Duran & Duran, 2004). The 5E Instructional Model consists of five phases: Engage, when the teacher accesses and assesses students' prior knowledge with an inviting and intriguing introduction to new content; Explore, when students use prior knowledge to complete activities based on the new content and explore questions and possibilities through investigation; Explain, when students use the information gained from the activities to explain their ideas based on the new information. Teachers can clarify misconceptions at this time while monitoring student comprehension. The next phase is Elaborate, where students develop broader and deeper understanding of the content by applying it in a new context. The final phase is Evaluation, which takes place during each phase through formal and informal monitoring of students' understanding (Lui et al., 2009; Duran & Duran, 2004). This model can be used for a single day lesson or in a week-long lesson or unit.

Soil Science. Randler and Hudle (2007) compared the two instructional methods student-centered and teacher-centered of a soil science lesson in a traditional classroom. They reported that student-centered lessons allow for participants to autonomously explore new fields of knowledge and that the exploration opportunities enhance learning and retention. The results of their research showed that while the teacher-centered lesson did result in an increase in student content knowledge, the experiential (hands-on), student-centered approach was more engaging for the students and resulted in higher rates of knowledge retention. Magee and Wingate (2014) documented the impacts of a student-centered approach with soil science. In this study, teachers participated in a six-week inquiry unit focused on soil science before implementing the practices with students. Results showed that the student-centered approach allowed for student voice and choice in their learning, allowing teachers to design instruction that meets the students' needs and interest (Magee & Wingate, 2014).

The Intent of the Research

Beyond agriculture, soil science can be connected to geography, math, social sciences, and history (Bryce, 2015). In North Carolina the study of soil properties and components is a required standard for third grade students in relation to its impact on plant growth and development. Although soil can be seen as a silent supporter in food production, understanding soil means also understanding the nutrients cycle, water filtration, its role in geologic time, and the Earth's biodiversity (Bryce, 2015). Teachers may not feel prepared or have limited knowledge of soil science, so it is beneficial to have resources like professional development for teachers, hands-on lab work, and experiments for classroom learning, and inquiry-based projects to engage students (Bryce 2015, Randler & Hudle 2007, Magee & Wingate 2014). While teaching soil science using teacher-centered or student-centered (inquiry-based) methodology [in a classroom setting] can both have similar immediate results, long-term retention evaluations show that students who participate in a student-centered soil science lesson are significantly higher than those in the teacher-centered approach (Randler & Hulde, 2007). When soil science lessons incorporate both inquiry-based, student-centered, and an interdisciplinary approach, students are more engaged and feel they are part of the learning process (Magee & Wingate, 2014).

Traditionally, a single-day field trip program is inherently teacher-focused with the educator dominating the talk with content delivery asking for students to apply information in a directed learning context (Magee & Wingate, 2014). Research shows that prolonged inquiry-based experiences that occur over multiple days or at weekly/monthly intervals have a positive impact on content retention in students (Counsell, Jacobs & Gatewood, 2017). Residential and multi-visit field trip programs have been evaluated for student content retention and for changes in environmental awareness, and inquiry-based pedagogies have been researched for effectiveness (Lavie Alon & Tal, 2015; Randler & Hulde, 2007; Magee & Wingate, 2014). However, there is limited research on single-day field trip programs investigating the effectiveness of using a teacher-centered approach vs. student centered (inquiry-based) approach to improve students' knowledge of soil.

This study focused on the following question:

> Which instructional method—teacher-centered approach vs. student-centered (inquiry-based) approach—had more impact on student understanding of soil science?

Research Design

The research design follows a quasi-experimental format using a pretest-posttest and retention test design using a control group and a treatment group. This design was selected for comparison purposes between the two teaching methods. The students were randomly assigned to control and treatment groups prior to their arrival for their field trips.

Teachers, principals, and parents were informed of the study prior to arriving for their program by the receiving of IRB consent forms. The form provided a description of the study as being research on two different teaching methods in an Environmental Education program and informed the teachers and parents that no personal information would be collected from them or from students. An opt-out waiver was also provided. Upon arrival, information was also collected from teachers regarding the number of males and females from each class. This response was included with the data, as well as the total number of students in the group.

The soil programs were delivered by the same four staff members throughout the study, two providing the control programming (teacher-centered) and two providing the treatment programming (student-centered). These staff are trained environmental educators familiar with the state science standards and the 5E Instructional Model. The content of soil science was the same for each program, though the control was more teacher-centered and the treatment more student-centered using a 5E Instructional Model (see Table 1) (Duran & Duran 2004). These procedures are similar to the Randler and Hulde (2007) study.

Table 1

Comparison of Content Delivery Methods

Teacher-Centered Method	Student-Centered Method (5E)
Ask pre-assessment questions for data collection.	Ask pre-assessment questions for data collection.
Introduce soil composition with pie chart and particle sizes of soil. Comparison of particle size for water retention made by feeling sand, silt, and clay; instructor passes these around in bowls and talks about them, asks students for observations. Students are provided with worksheets describing different particle sizes of soil. Demonstrate particle size using students spaced at different distances (arm length, elbows touching, shoulder to shoulder) while other students act as water to get through them.	ENGAGE: Pair-Share Ask students to “Describe an experience you’ve had with soil.” Have them share using a Pair-Share method or a Walk and Talk method with a partner.
Introduce soil probes and how they work. Students are directed to find soil samples in the woods off the trail. Students are instructed to find different soil types and to collect them in bags.	EXPLORE: Let’s get down and dirty with soil! Use minds-on observation skills and allow students to make connections with their observations: “I notice…I wonder…It reminds me of…” provide hand lenses for students to explore the surface layer of soil. What if you wanted to know more? Introduce the soil probe: this provides a window into what’s under our feet.
Soil dissection at study site using soil samples to help students sort what they find in their sample; teacher leads discussion of what each group may be finding in their samples: example typical sorts include things from plants and trees	EXPLAIN: Students collect a soil sample and sort what they find into categories of their choice (usually includes living and non-living things, or things from plants and things from rocks/dirt) A. Fill in the first sections of the pie chart of Soil Composition for Organic (changed to

and rocks and "dirt" or clay. Teacher shows students classification charts.	Living/Once Living) and Inorganic (changed to Never Living). B. Explain that soil also has different textures; Have students sort their soil sample again by texture. Ask "What do you notice about the textures?"
Soil sorting part 2 – What are other ways you could sort the soil? Encourage students to think back on what was learned about particle sizes. Allow them to sort their soil by type or texture. Teacher shows students charts that indicates various soil sizes.	ELABORATE: Demonstration of Sand, Clay, and Humus particle size, and how each one holds, or doesn't hold, water on its own. Demonstrate particle size using students spaced at different distances (arm length, elbows touching, shoulder to shoulder-spaces represent places for water and air in the soil) while other students act as water to get through them. Encourage students to think back on their samples from the soil probes and their amounts of sand, humus, and clay. Did they only find clay, sand, or humus? Was there a mix of all of them? What does that look like in the demonstration? A. How could soil be different in different places? B. Fill in Air and Water portions of the pie chart for Soil Composition.
*Perform Post-Assessment Probe at the end of the program, record results, ask students if and why their answers changed. What helped you learn about soil today? What is something you can tell a family member about soil?	EVALUATE: *Perform Post-Assessment Probe at the end of the program, record results, ask students if and why their answers changed. What helped you learn about soil today? What is something you can tell a family member about soil?

Research Sample

Participants consisted of 117 third grade students from two schools from the western part of the state.

Table 2

Disbursement of Students in Control and Treatment Groups per School

School	Treatment Groups 1-3	Control Groups 1-3	Totals
A	20, 18	19	57
B	21	19, 20	60

These two schools were selected from the spring 2019 field trip reservations because they brought the entire third grade which consisted of three classes from each school, and because they had already selected the Down and Dirty with Soil program.

Data Collection

Formative assessment probes are used to uncover student ideas as a pre-test informs instruction and can be used to monitor learning throughout the lesson, and used for reflection as a post-test (Keeley, 2011). Students participated in an adapted version of Page Keeley's "What do you know about soil?" assessment probe (Keeley, 2016). This assessment probe addressed the learning targets for the standard being taught and allowed for adaptability to be used in different formats. In this study the probe was adapted from a checklist of fifteen true and false statements about soil to five items that fit the learning targets of the state science standards on soil science used in the field trip. The five items were presented as agree/disagree options. The probe questions were piloted with two previous groups and revised for word changes to address student reading comprehension. The probe assessment was administered with the educator reading the statement out loud, i.e. Soil contains air, and if the student(s) agreed they moved to line one. If they disagreed, they moved to another. Totals were collected for each of the five questions for both agree and disagree and then recorded on the data sheet. The groups were labeled as Control 1, 2, 3 or Treatment 1, 2, 3.

Instrumentation and Analysis

Data were collected on data sheets (see Appendix), then transferred to an Excel file. A retention test was also provided for each of the participating groups 2-4 weeks after their field trip programs. The teachers were provided with the retention test questions – the same as the questions used in the pre and post-tests – on a data sheet, and the results were returned for analysis and comparison to the post test results.

Limitations

Students. The data were not collected on a student-to-student basis, but on a class-to-class basis. Another limitation is based on the content—there were no data collected on the student background knowledge of the soil content. Therefore, the research does not account for whether the students were being introduced to the content in their classroom, in situ, or if the field trip program was simply meant for review.

Assessment. The wording of two of the questions in the pre and post assessments have been confusing for the students. The questions were pulled from the "What Do You Know About Soil?" probe by Page Keeley (Keeley, 2015) and are formatted as True/False statements to determine misconceptions students might have. Two of the questions contain a true portion of the statement and a false portion, making the overall statement false. The negative in the statement and determining that it is false is a complicated thought process for young students. This complication may have an influence on the data collected if students had determined their answer by only considering part of the statement. Also, because the teachers administered the retention tests, there is no way of knowing their administrative procedures.

Results

Data Analysis. For the analysis, the difference in mean gain was found by subtracting the pre-test scores from the posttest scores. This analysis was done to determine the percent gained between the pre and posttests for the treatment and control groups. The null hypothesis was that the treatment group scores would be less than or equal to the control group, and that was rejected. However, it is important to note that both groups did have a high mean gain score between their pre and posttests, possibly indicating that the hands-on (common) experience alone was enough to improve student understanding of soil properties. The same analysis was performed to compare mean gain scores of the posttests and retention tests for both groups. In this case, the treatment group showed a positive change in scores from their posttests, while the control group showed no change in score (see Figure 3) from their posttest. There was a total of 114 student participants who completed the pre, post, and retention tests (Figure 1), as some were absent the day of the retention tests.

Figure 1

Between-Subjects Factors

		Value Label	N
group	1	treatment	59
	2	control	55

Note. Number of participants in the treatment and control groups.

Data Analysis of pre-test groups to form baseline data was conducted by calculating the means of each groups' pre-test scores. Figure 2 shows that the treatment group scored higher on the pre-test than the control group. This slight increase in prior knowledge with the treatment group could represent teachers' providing information about soil to students prior to the field trip. Our methods did not include interviewing or surveying teachers about their preparation tasks and lessons prior to the field trip. This information of the baseline knowledge data is not imperative to our research question since we are measuring the impact of inquiry instruction to the two groups over time (time point 1 (pre-test), time point 2 (post-test), and time point 3 (retention test).

Figure 2

Group

Dependent Variable: pre_sum

Group	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 treatment	3.373	.149	3.078	3.668
2 control	2.983	.150	2.685	3.281

Note. Comparison of means of pre-test scores for treatment groups and control groups.

Figure 3

Group * Time

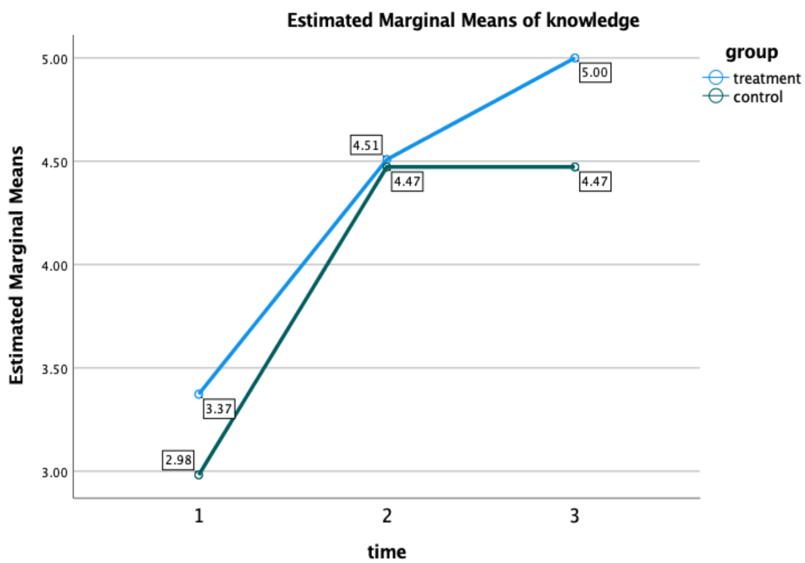
Measure: knowledge

Group	Time	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
1 treatment	1	3.373	.151	3.074	3.672
	2	4.508	.103	4.304	4.713
	3	5.000	.076	4.850	5.150
2 control	1	2.982	.156	2.672	3.292
	2	4.473	.107	4.261	4.685
	3	4.473	.078	4.318	4.628

Note. Represents the summary of means for each time test and time point.

To determine if there was an impact of the treatment (inquiry-based lesson) on students' knowledge of soil over time we first determined the means of each test (pre, post, and retention). The data were imported into SPSS and the summary/means of each test was calculated. Once the mean was determined for each test pre, post, and the retention tests we completed the comparison test. To measure the impact of knowledge over time we completed a linear model (Figure 4) with knowledge as the dependent variable and time as our independent variable to compare the two groups (treatment and control).

Figure 4



Note. Graphical representation of the data of each time point and test.

Figure 3 represents the change over time for each group from time point 1 (pre-test), time point 2 (post-test), and time point 3 (retention test). The control group had a mean score of 2.98 at the time point 1 and then scored a 4.47 at time point 2. The treatment group had a mean score of 3.37 at time point 1 and then scored a 4.51 at time point 2. These scores indicate that the control group increased their knowledge of soil more than the treatment group from time point 1 to time point 2. Although there was a slightly greater increase in the control group than the treatment group, both groups increased in their knowledge from time point 1 and time point 2. The treatment group showed an increase from time point 2 to time point 3. The control group did not show an increase from time point 2 to time point 3 nor did this group decrease. The control groups' knowledge remained consistent from time point 2 to time point 3.

Discussion

This study strived to address the research question of which teaching method is more effective on student understanding of soil properties. Based on these findings, both the teacher-centered method and the student-centered (inquiry-based) method using the 5E Instructional Model were both effective during the field trip program (Randler & Hulde, 2007). Student participants showed positive change in their posttests for the control and treatment groups during the field trip program (Farmer, Knapp & Benton, 2007; Randler & Hulde 2007; Alon & Tal, 2015). When the retention test was administered two-four weeks after the field trip program, the treatment groups displayed a positive increase from their posttests. The control groups however, maintained the same scores as their posttests. One of the limitations noted is not knowing if the students continued with the content once they returned to their classroom. The treatment groups may have done more follow up, therefore increasing their retention test scores. However, it should also be noted that the treatment groups were randomly selected from the two different schools, and it seems unlikely that those random groups also happened to follow-up with the content. The data shows that the experience of a hands-on experiential learning opportunity benefited both the control and the treatment groups, and it is possible that the use of the 5E Instructional Model impacted the students' long -erm recall of content.

This study indicated similar results of previous research showing the treatment group (student-centered) having more retention of the content learned (Randler & Hulde, 2007). As stated by Farmer, Knapp & Benton (2007) when [environmental science] experiences are engaging and hands-on students continue to show pro-environmental attitudes and can recall specific content and activities long term (Farmer, Knapp & Benton, 2007). This could indicate that the soil properties content, and possibly other areas of content, may be retained for a longer period of time when an experiential learning method is used. These findings also reflect previous research of inquiry-based learning in residential programs when students have more time with the content. One example shows that prolonged inquiry-based experiences that occur over multiple days or at weekly/monthly intervals have a positive impact on content retention in students (Counsell, Jacobs & Gatewood, 2017). Based on the results of this study, it could be inferred that inquiry-based methods can also be effective in a short-term program, when structure is provided using a student-centered method, like the 5E Instructional Model. The use of inquiry within natural contexts provides students with the opportunity to explore places that may not be familiar to them, which may encourage students to feel empowered as a learner (Magee & Wingate, 2014). This exploration of nature-based environments and empowerment has shown to have a long-term impact on students' culture of learning (Farmer, Knapp & Benton, 2007).

The experience of a hands-on experiential learning opportunity is shown to benefit both the control and the treatment groups, and it is possible that the use of the 5E Instructional Model impacted the students' long-term recall of content. This could indicate that the soil properties content may be retained for a longer period of time when an experiential learning method is used. Based on the results of this study, it could also be inferred that inquiry-based methods can also be effective in a short-term program, when structure is provided using a student-centered method, like the 5E Instructional Model.

Practical Implications. This experience has significantly impacted the way the Education Department at The North Carolina Arboretum is designing and evaluating their informal programs. After a comprehensive review, the staff re-designed all the field trip programs into the 5E Instructional Model using a student-centered approach. The informal environmental educators are incorporating assessments during the Engage phase to check for prior knowledge, then mirroring these assessments during the Evaluation phase. This allows students to reflect on their learning and for educators to collect data as an evaluation tool of environmental informal science programs. These assessments can also be shared with the participating classroom teachers and administrators to authenticate and validate the rationale for schools to continue to use informal environmental centers for field trips.

The use of a 5E Instructional Model as "guided-inquiry" allows the students to access prior knowledge, construct new ideas, and apply what they have learned while the instructor is still able to address the required grade level content using a hands-on, experiential method. To explore the impact of these instructional methods further it would be important to collect qualitative analysis of the data on the students' work completed during the Elaboration and Evaluation sections of the 5E model. It would also be beneficial to collect data of students' knowledge through interviews on what they learned specifically about soil and what they liked about the instructional methods used in the field experience.

Conclusion

The results of this study show the effectiveness of single-day, outdoor educational field trip programs to supplement students' learning in the classroom with nature-based contexts and experiential learning activities. To determine if these programs positively impact student understanding of the content, it is necessary to consider the delivery of the instruction. While both teacher-centered and student-centered (inquiry-based) methods have similar short-term results showing positive changes in student understanding, the long-term results show that a more student-centered approach could help with retention of content (Randler & Hulde, 2007).

Technological devices have detached us (especially children) from our natural world and informal environmental science educators provide opportunities for students to explore and discover the outdoors (Louv, 2005). Therefore, informal environmental science centers are vital to our communities, schools, and especially to elementary students. Elementary students' that are involved in informal science experiences, specifically when the field experiences are relevant to their daily lives, that illustrate science as practical and could be applied to the real-world have shown to increase students' interest in science and more importantly their aspirations to pursue careers in science (Sadler, Burgin, McKinney, & Ponjuan, 2010; Thiry, Laursen, & Hunter, 2011). It is important to utilize environmental science centers for the purpose of educating our youth and our community on aspects of science and the importance of nature by the programs designed by informal educators.

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Appendix A

Data Collection Sheet

Control or Treatment: 1 2 3 4 5 Total number of students:______

Males: _______________ Female: _________________

Pre-Assessment – count the number of students who agree and disagree for each statement.

Key (do not share with students)	What do you know about soil?	Agree/Yes/True	Disagree/No/False
T	1. Soil contains water.		
F	2. Soil does not contain living things such as Fungus, Bacteria, and Invertebrates.		
T	3. Soils can form in deserts.		
T	4. Air is a part of soil.		
F	5. Decomposed material, such as humus, does not become part of the soil.		

Post- Assessment – count the number of students who agree and disagree for each statement.

What do you know about soil?	Agree/Yes/True	Disagree/No/False
1. Soil contains water.		
2. Soil does not contain living things such as Fungus, Bacteria, and Invertebrates.		
3. Soils can form in deserts.		
4. Air is a part of soil.		
5. Decomposed material, such as humus, does not become part of the soil.		

Appendix B

Data Collection Sheet (Retention Tests)

Our "Down and Dirty with Soil" instructor at The NC Arboretum was: Male Female

Post-Assessment – count the number of students who agree and disagree for each statement.

Key (do not share with students)	**What do you know about soil?**	**Agree/Yes/True**	**Disagree/No/False**
T	1. Soil contains water.		
F	2. Soil does not contain living things such as Fungus, Bacteria, and Invertebrates.		
T	3. Soils can form in deserts.		
T	4. Air is a part of soil.		
F	5. Decomposed material, such as humus, does not become part of the soil.		

*For the two False statements, they are meant to disagree, but the wording can be confusing. You can adapt the questions by using the following variations:

2a. Do you think soil **does** **not** contain living things such as Fungus, Bacteria, and Invertebrates?

2b. Do you think soil **does** contain living things such as Fungus, Bacteria, and Invertebrates?

- Answers to 2a will go in the Agree column; answers to 2b will go in the Disagree column.

5a. Do you think decomposed material, such as humus, **does** **not** become part of the soil?

5b. Do you think decomposed material, such as humus, **does** become part of the soil?

- Answers to 5a will go in the Agree column, answers to 5b will go in the Disagree column.