Importance of a Comparison Group and a Long-Term Follow-Up Test in Evaluating Environmental Education Experiences

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ARTICLE INFO	ABSTRACT
	This study evaluated the impacts on environmental literacy after a non-formal science-based program and compared the impacts to a non-formal non-science-based program. Both programs included children in grades six to eleven (ages 11 to 17) from the Syracuse, New York, USA area. Environmental literacy was assessed by administering environmental attitude and environmental knowledge pre-, post-, and follow-up tests to both programs' participants. Initially, environmental attitude scores were higher for the participants in the science-based program. However, this was not a lasting impact. According to the follow-up test, attitude scores were not elevated for the science-based program. Without the follow-up tests given weeks after the program end, we could have inferred environmental attitudes were increased by the science-based program. Environmental knowledge was higher at the end of the science-based program but also increased in the comparison group. The gains in environmental knowledge were sustained for several weeks, but differences between the two programs did not persist. Without the comparison group we could have inferred that environmental knowledge increased solely due to the science-based program. These results show incorporating both a comparison group and a follow-up assessment are necessary to properly evaluate the effectiveness of increasing environmental literacy from science-based programs.

INTRODUCTION

Overview

The multitude of environmental problems today need an environmentally literate population to solve (Dieu-Hang et al., 2017; Paço & Lavrador, 2017; UNESCO, 1975). It is imperative to increase environmental literacy throughout the world and across generations (Dieu-Hang et al., 2017; Paço & Lavrador, 2017; UNESCO, 1975). Creating change on a scale needed to combat today's environmental crises requires an informed and passionate population (Ertekin & Yuksel, 2014; Foster & Shiel-Rolle, 2011; Tucker & Izadpanahi, 2017; Zareie & Jafari Navimipour, 2016).

Environmental education can inform people of these issues, what they can do to help, and why the environment is important (Bogner, 1998; Dehart Hurd, 1958; Pooley & O'Connor, 2000; Tucker & Izadpanahi, 2017). Environmental education comes in many forms, from formal school curricula to informal, spontaneous interactions (UNESCO, 1975; UNESCO & UNEP, 1978). Because of the lack of adoption of environmental topics in schools, non-formal experiences are inordinately important for increasing environmental literacy (Ozdemir, 2010).

Although non-formal education experiences are structured, they are also voluntary (UNESCO, 1993) and frequently occur in informal settings outside the classroom. These can come in many forms, such as, structured talks at a zoo, ranger programs in a park, or a science camp during the summer (UNESCO, 1993).

This study focused on a non-formal science summer program run by undergraduate students from the State University of New York College of Environmental Science and Forestry (ESF). This program, Summer Camps Investigating Ecology in Neighborhood and City Environments (called SCIENCE), was comprised of participants from the Syracuse area who ranged in age from 11 to 17.

Current State of Environmental Education Field

Though environmental education is not a new field, it is expanding quickly in its practice and theoretical construction (Ardoin et al., 2017). To ensure environmental educators have the most impact they must use all paths available to them, advocating for policy requiring environmental education, focusing on improving attitude and behavior as well as knowledge, and utilizing non-formal education experiences (Ardoin et al., 2017; Bischoff et al., 2008). While there has been an increasing number of studies on environmental education and environmental literacy conducted around the world, especially within the past five years (Ardoin et al., 2017), holes remain in this body of research. Most studies focus on middle school students while assessing outcomes within a short time frame (six months or less) with no follow-up investigation to determine long-term effects (Ardoin et al., 2017).

Sweeping change in opinions or shifts in career aspirations are unlikely during the short time spans of these programs, but most claim an increase in environmental knowledge by the end of the program (Antink-Meyer et al., 2016; Bhattacharyya et al., 2011). Testing participants directly after a program almost ensures an increase in knowledge will be found (Bogner, 1998). The lack of follow-up in the majority of studies prevents evaluation of any lasting impact of these programs (Bogner, 1998; Redman & Redman, 2016).

The utilization of a comparison group is another study design component that is frequently missing from environmental education evaluations (Long, 2014; Paço & Lavrador, 2017). Sanacora (2017) explained how the lack of a comparison group in medical research lessens the impact of findings and prevents the discovery of confounding factors. This is true for environmental education research as well; comparison groups are necessary to help discern effects of interventions, such as treatments to improve environmental literacy from prior knowledge, skills, or attitudes (Sanacora, 2017).

Scores on pre-tests, post-tests, and follow-up tests can be compared and analyzed along with the scores of participants attending the science program (Sanacora, 2017). Without data from a comparison group, gains in environmental literacy cannot be definitively linked to the program studied (Long, 2014; Sanacora, 2017) since outside factors or flaws in experimental design can go undetected (Sanacora, 2017). A true control group is usually not possible with most environmental education studies since participants tend to choose their educational experience rather than be randomly assigned to one (Long, 2014). Still, the comparison group can alleviate many problems in data collection and interpretation of results (Sanacora, 2017).

Study Objectives

The objective of this study was to determine the importance of including

(a) a comparison group and

(b) a follow-up assessment in evaluating outcomes of an environmental education program.

We carried out this study in the context of asking a familiar type of education research question: "Does participation in a non-formal youth summer science program increase participants' knowledge and attitudes about the environment?" We addressed this question with particular consideration for how the inclusion of a comparison group might influence interpretation of our data, and how inclusion of a follow-up test might temper the magnitude of knowledge and behavior gains that we would attribute to the educational intervention.

METHODS

Study Group Selection

We partnered with an existing summer youth science program that is administered by ESF, in collaboration with the Syracuse City School District (SCSD) and a local non-profit organization. The program, SCIENCE, provides a one-week long environmental science education experience to SCSD students during the summer. Educational modules are instructed by ESF undergraduate students studying in a variety of environmental fields. All methods were reviewed and approved by the Institutional Review Board of Syracuse University.

Student participants were all residents of the City of Syracuse, New York, who ranged in age from 11-17 years, were enrolled in grades 6-11, and were drawn from one of the following programs or schools.

1. Father Champlin's Guardian Angel Society (Guardian Angels) is a Catholic charity that runs a free summer-long education camp for Syracuse students. Student participants are US-born children of immigrants attending SCSD schools. Children are typically enrolled to provide supervision and meals during the workday when schools are out of session.

2. Expeditionary Learning Middle School (ELMS) is a Syracuse public school that draws students from across SCSD. The school serves students who need more attention because of a learning disability, problems with bullying, or behavior issues. ELMS has a mandatory orientation for its incoming sixth grade class. The first week of orientation involves getting to know the school, its schedule, teachers, and team building. No instruction occurs. The second week of orientation is run by SCIENCE.

3. Syracuse Academic of Science (SAS) is a Syracuse charter school that has a specialized STEM-focused curriculum and yields graduation rates and test scores that surpass those of SCSD and the New York state-wide average. SAS runs a summer camp for students, one week of which is run by SCIENCE. Again, children are typically enrolled in the summer camp to provide supervised activities and meals during the work week.

SCIENCE participants were not self-selecting. They attended as part of another summer program that was not science focused. Most ELMS students were required to attend by their school, and the Guardian Angel's and SAS students were enrolled by parents or guardians. Therefore, it was not a concern that SCIENCE participants would have a pre-existing higher level of environmental literacy.

Comparison Group Selection

We structured the comparison group to include children who were participating in a similar supervised summertime recreation program, but which did not include a component of outdoor science education administered by SCIENCE. The comparison group was comprised of children attending the Town of Onondaga Parks and Recreation "Playgrounds" program. Playgrounds has been organized each summer for over 30 years. It is a recreation program without an education focus of any kind. It does not teach science or have any educational mandate. The object of Playgrounds is to let kids have fun. Activities range from playing games outside to arts and crafts projects. Unlike SCIENCE, whose instructors were ESF undergraduates studying science, Playgrounds' counselors were local teenagers who did not have science or education backgrounds. Though it is impossible to say no science topics were talked about during Playgrounds, the counselors did not have any expressed interests in science, the daily activities did not include science learning, and the kids were focused on sports and crafts. Most of the participants come from the SCSD. The children at Playgrounds are between 6 and 17 years of age, but only those 10 and older were included in this study. Playgrounds ran throughout the summer but only one week was sampled since the same children came each week. It is impossible to say no informal science education happened during the week sampled. However, we are certain Playgrounds' focus was not on science education and it is unlikely the topics covered in SCIENCE's curriculum and the environmental literacy tests we created were discussed at length.

Survey Instrument

Environmental literacy (EL) tests were created (**Appendix A**) with two sections, one to test environmental attitude (EA) and one to test for environmental knowledge (EK). The EA portion was the same for all age groups and throughout the study. Since the EA portion was to measure changes in attitude and behavior it was easy to create questions understandable by the wide age range of participants, negating the need for two grade levels. Since answers are not "right" and "wrong" and needed to be compared for changes, analyses were more consistent with only one version. The first set of EA questions were answered using a Likert scale. Participants could select least interested or likely (0) to most interested or likely (4).

The EK tests, however, were prepared for two age classes: sixth to eighth grade and ninth to eleventh grade. It was decided that questions appropriately challenging for ninth graders would be too difficult for sixth graders. The two levels had similar questions but these were phrased differently, with increased levels of terminology or depth of knowledge included in the 9th-11th grade tests. The EK test also needed different versions for the pre-, post-, and follow-up rounds to prevent participants from remembering questions in previous rounds as they could have discussed or looked up the answers before the next test. All versions had ten questions and were scored as right or wrong with participants' EK score being a percentage of correct answers.

SCIENCE shared a schedule of a past camp to help determine test question topics. Once the curriculum for the 2017 camp was solidified, the rough draft of the EL test was

Table 1. Sample sizes for partner groups who participated in surveying while attending either SCIENCE or Playgrounds

	Partner group	Pre-test	Post-test	Follow-up test
Experimental	Guardian Angels	4	4	0
	ELMS	57	53	49
	SAS	14	11	9
	SCIENCE total	**75**	**68**	**58**
Comparison	**Playgrounds total**	**53**	**49**	**20**

given to the SCIENCE coordinator and counselors for review. They gave more updated feedback so the questions best reflected what would be covered in the camp. Questions were not pulled directly from curriculum activities nor were counselors instructed to teach what was on the test. The input was only to ensure topics mentioned on the EL test aligned with lessons during the camp.

Study Participant Selection

Pre-tests and post-tests were collected from children that participated in three of the six SCIENCE programs during summer 2017. Each program lasted one week with instruction occurring from 9:00 am to 3:00 pm. Playgrounds ran from 8:00 am to 4:00 pm at three different locations. Pre-tests and post-tests were collected from children at each location one week during the summer of 2017. Pre-tests were administered by the researcher on site the morning of the first day. Post-tests were administered by the researcher on site the afternoon of the last day. Follow-up tests were administered after the start of the following academic year (**Table 1**). Follow-up tests for Guardian Angels and Playgrounds were mailed out three months after the program week and had to be returned within a month. We administered follow-up tests for ELMS and SAS at the respective schools three months after the program week. Each mailed follow-up test contained a link to an identical online version, a paper version of the test, and a self-addressed stamped envelope for the test to be mailed back to the researcher. No participant filled out the online version, therefore all tests were completed on paper.

Data Collection

After each week, all the survey answers were entered into an Excel spreadsheet. EA and EK tests were kept paired for each participant. Participants created codes based on their initials and the year they were born (for example Joan Gabrielle Smith born 2007 would be JGS07). This allowed participant's pre-, post-, and follow-up tests to be matched while maintaining confidentiality. Answers were identified by this code on all research material.

Data Analysis

Summary statistics (average and standard error) of EA and EK scores were generated for the SCIENCE and Playground groups for the pre-test, post-test, and follow-up test. For EK scores, an unbalanced model I, 2×3 factorial ANOVA with an interaction term in 'R' was used to test for differences between the test means of the pre-, post-, and follow-up tests for SCIENCE and Playgrounds. To see if the data satisfied the assumptions of the test and were normally distributed, quantile-quantile plots were made for each group.

Table 2. ANOVA for the EA results

	df	Sum of squares	Mean squares	F values	p-values
Test type	2	1.34	0.67	1.18	0.31
Participant group	1	11.25	11.25	19.82	<0.00
Test: Group	2	4.09	2.05	3.61	0.03
Residuals	305	173.07	0.57		

Note. Test type refers to the three tests (pre-, post-, and follow-up) and participant group to SCIENCE and Playgrounds. Test: Group is the interaction within those two categories
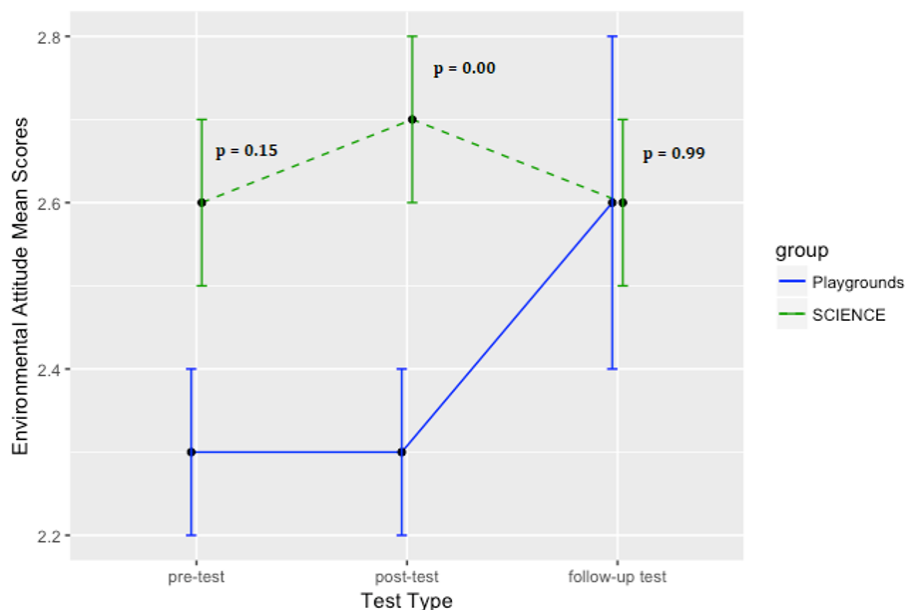
Figure 1. Interaction plot for the EA pre-, post-, and follow-up test means of SCIENCE and Playgrounds

For the EA, Likert scores (0-4) served as the response variables. Test type and participant group were the predictors. ANOVA with an interaction term in 'R' was included and simple effects were then tested. Interaction plots were made to show the distribution of mean scores for both programs over the three tests.

RESULTS

Environmental Attitude

The ANOVA revealed a significant main effect between the two participant groups, with the average SCIENCE EA scores being 10% higher than Playgrounds (**Table 2**). The SCIENCE EA score was higher independent of the test type. An interaction was detected between test type and participant group, so we analyzed the simple effect between participant groups for each test type. Our data indicate that while no difference existed in environmental attitudes between the groups during the pre-test, and that the post-test scores suggested a greater increase in environmental attitude that might be attributed to the SCIENCE program, these differences disappeared by the time participants took the follow-up exam (**Figure 1**).

On the EA portion of the tests, participants answered questions on a Likert scale of 0-4 with 0 indicating 'least interested' and 4 indicating 'most interested' and their individual EA score was the average of their Likert responses

to twelve questions. SCIENCE participants had a pre-test EA score mean (±1 SE) of 2.6±0.1, a post-test mean of 2.7±0.1, and a follow-up test mean of 2.6±0.1. Playground participants had a pre-test EA score mean (±1 SE) of 2.3±0.1, a post-test mean of 2.3±0.1, and a follow-up test mean of 2.6±0.2 (**Figure 1**). In **Figure 1**, data are EA score means (±1 SE) for the three test types associated with the two participant groups (SCIENCE and Playgrounds); points are connected to show the trend within the group; p-values next to the means report the simple effects of participant groups for each test; and to better show the data trends, the full y-axis (0-4) is not displayed.

Environmental Knowledge

On the EK portion of the tests, participants were scored on the proportion of ten questions that were answered correctly The EK scores for SCIENCE participants averaged (±1 SE) of 0.43±0.02 on the pre-test, 0.69±0.02 on the post-test, and 0.63±0.02 on the follow-up test. The Playground EK scores averaged 0.48±0.02, 0.62±0.02, and 0.73±0.03 for the pre-, post-, and follow-up tests, respectively.

The 2×3 factorial ANOVA (**Table 3**) detected a main effect of test type and an interaction between test type × group. The EK post-tests and follow-up tests for both groups were 50% higher than the pre-tests, independent of participant group. Participants gained knowledge regardless of instruction. However, SCIENCE scores increased from pre-test to post-test, then decreased partially for the follow-up test. Playground scores increased from pre-test to post-test and post-test to follow-up test.

Table 3. ANOVA for the EK results

	df	Sum of squares	Mean squares	F values	p-values
Test type	2	3.35	1.67	47.84	<0.001
Participant group	1	0.03	0.03	0.80	0.40
Test: Group	2	0.32	0.16	4.52	0.01
Residuals	303	10.60	0.04		

Note. Test type refers to the three tests (pre-, post-, and follow-up) and participant group to SCIENCE and Playgrounds. Test: Group is the interaction within those two categories
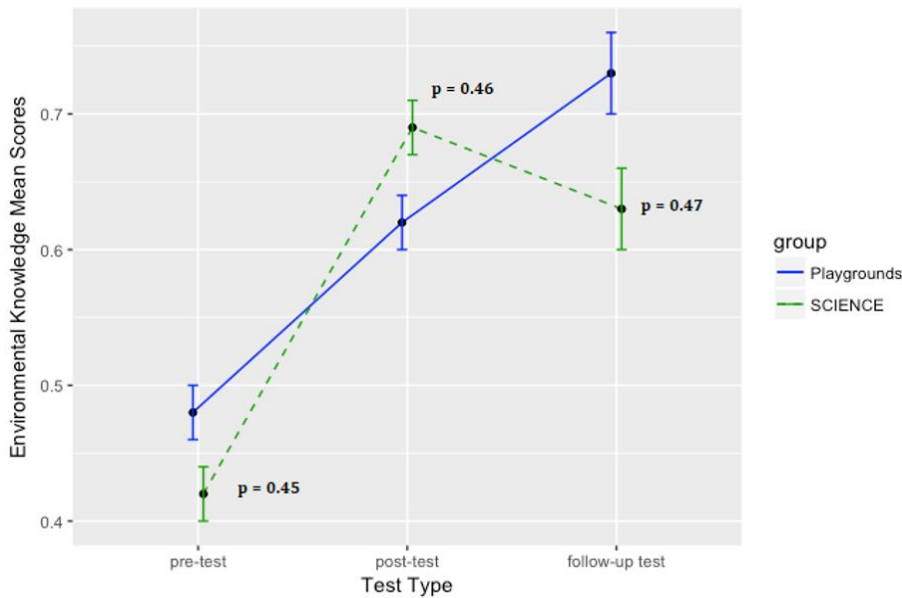
Figure 2. Interaction plot for the EK pre-, post-, and follow-up test means of SCIENCE and Playgrounds

Although an interaction was detected between test type and participant group, none of the simple effects between participant groups for each test type were significant. The simple effects between the pre-test and post-test were significant for both SCIENCE (p<0.001) and Playgrounds (p=0.01). Also, the simple effects between the pre-test and follow-up test for both SCIENCE (p<0.001) and Playgrounds (p<0.001) were significant. **Figure 2** reports the interaction between test type and participant groups for EK scores. In **Figure 2**, data are EK score means (±1 SE) for the three test types associated with the participant groups (SCIENCE and Playgrounds); points are connected to show the trend within the group; p-values next to the means report the simple effects of participant groups for each test; and to better show the data trends, the full y-axis (0.0-1.0) is not displayed.

DISCUSSION

The results were not expected and revealed some interesting trends within the data. Some study limitations could have impacted the results and should be considered for future studies. Even with the unexpected outcomes, conclusions can be drawn and there are recommendations for future evaluation studies.

Environmental Attitude

These results show environmental attitude post-test scores of SCIENCE participants were not higher than their pre-test score and their post-test scores were not significantly different

from their follow-up score. The EA scores for SCIENCE were not different across the three tests. The SCIENCE program did not increase the EA for participants. A short timeframe limits the impact on environmental attitude (Antink-Meyer et al., 2016). Antink-Meyer et al. (2016) found influencing attitude and behavior changes should be long term goals and even small increases in environmental attitude are encouraging.

SCIENCE participants did have an elevated EA before the program when compared to the comparison group. Playgrounds EA scores also did not increase across the three tests, which was expected since it was not a science-focused program. The test for simple effects, in **Table 2** and illustrated in **Figure 1**, did show a difference between SCIENCE and Playgrounds' post-test scores. SCIENCE participants' attitude increased more throughout the week than Playgrounds, however this gain is erased by the time the follow-up tests were administered.

The EA scores were different between SCIENCE and Playgrounds, as seen in **Table 2** and **Figure 1**. SCIENCE had a higher EA score than Playgrounds at the beginning of the study, indicating SCIENCE participants came to the program with an elevated EA compared to Playgrounds' participants. This pre-existing difference was unexpected since participants of neither group self-select. SCIENCE is an environmental camp; however, most participants do not choose to go because of an interest in environmental science. The three partner organizations hired SCIENCE as part of larger summer camp programming that participants are enrolled in by parents out of need or requirement.

Only the SAS participants had a choice to attend the SCIENCE summer program. They accounted for about 20% of the total participants, so it is possible they influenced the pre-test estimate if they possessed higher pre-existing environmental attitude. SAS is also science focused school and students could be more interested in science than the general SCSD school population. To see if SAS was skewing the EA score it was separated from the SCIENCE participant group into its own and the ANOVA was redone. This analysis revealed that SAS actually had a lower EA average than the rest of SCIENCE participants and therefore did not positively skew the SCIENCE EA score. Despite being the only science-inclined and voluntary group, SAS participants do not explain the elevated EA score.

Guardian Angels was focused on science learning during the 2017 summer. However, the focus changes each summer, and advertising did not stress it was science-based. The four participants from Guardian Angels in this study had a lower EA average score than ELMS, indicating Guardian Angels also did not positively skew the SCIENCE EA score.

The largest subset of SCIENCE participants, ELMS, requires incoming students to attend their orientation, which includes a week of the SCIENCE program. ELMS is not a science magnet school, and it does not do any preparatory teaching before SCIENCE that would influence environmental literacy. Even still, the ELMS participants must account for the elevated pre-test scores in environmental attitude. Having a comparison group exposed the elevated pre-test scores and could indicate a change in methodology is needed to prevent this in the future.

Pooley and O'Connor (2000) found it difficult to study environmental attitude because it is hard to quantify or qualify. Despite the difficulties, environmental attitude is essential to understanding how to influence behavior (Manoli et al., 2007). Knowledge alone does not affect behavior and the two in tandem must be studied to affect change (Pothitou et al., 2016).

Environmental Knowledge

SCIENCE and Playgrounds EK scores both increased by the end of the program and stayed higher into the school year. However, there was no difference between the participant group scores at each test (**Table 3** and **Figure 2**) even when the simple effects were examined. Both participant groups' test scores increased over time despite only SCIENCE participants getting environmental programming.

SCIENCE participants' EK did increase at the end of the program. This elevated EK did not diminish months after the program; it stayed at the higher level. However, the comparison group had similar results. Playgrounds scores increased from pre-test to post-test. Their follow-up test score was also higher than the pre-test, but not different than the post-test. This makes it impossible to state the SCIENCE program was what increased participants' EK.

The testing effect could have increased the post-test scores (Hartley, 1973). The testing effect is an increase in future test performance due to exposure to previous, similar testing (Hartley, 1973). The potential for the testing effect to increase both groups' scores is high. Hartley (1973) explained giving a pre-test influences the performance on a post-test, but acknowledged it is an ongoing debate. Even with changing the test questions each time, participants are still more familiar with the structure of the test and type of questions asked (Hartley, 1973). More recently, Kromann et al. (2009) studied how assessing skills helped develop them and found testing did increase knowledge of the material. The follow-up test scores could have been influenced by both the testing effect and the start of the school year. Being back in the school environment could have increased performance, participants might have taken the test more seriously in a school setting (von der Embse & Hasson, 2012). The percentage of open-ended responses was the highest for ELMS, who took the follow-up test during school hours, administered by teachers, in the classroom. This could indicate the test was taken more seriously.

These outside factors would not have been investigated without the EK scores of the comparison group. Looking at SCIENCE participant scores alone the results would have been as expected: the science program increased science knowledge and the knowledge increase was not temporary. It is only when compared to a non-science program that the results are called in to question. Since EK scores increased for the comparison group, the programming from SCIENCE cannot be said to have increased EK in participants.

CONCLUSIONS AND REPERCUSSIONS FOR THE FIELD

ESF's summer program, SCIENCE, does expose Syracuse children to environmental science and scientists. However, the impact it had on increasing environmental literacy was not significant for attitude or knowledge. This study predicted no increase in EK or EA from the comparison group; and for participants involved in the experiential science program an increase in EA and EK, that would be sustained over time. Many of the results were not expected and did not follow the literature. Future studies should use the same framework to attempt to understand why the results were not as predicted. Particularly the inclusion of a follow-up test to see if any gain from the program is sustained and a comparison group to uncover confounding variables.

Including a follow-up test uncovers the lasting impact of the environmental education intervention. Evaluating environmental literacy directly afterwards can show an immediate increase in environmental attitude or knowledge. Yet, to determine if this increase was sustained an evaluation must be conducted after significant time has passed. If a participant was truly inspired by the program, they will be more likely to have retained information and sought out further knowledge. Finding the ideal passage of time between intervention and follow-up group is not a simple endeavor. The longer the interval between the two the more difficult it is to follow-up with participants, which can result in too small of a sample size. The length of the program is also a factor, a follow-up to an hour-long talk may not need to be as delayed as long as the follow-up to a months-long camp. Further study into these factors would benefit future environmental education research. If a follow-up test had not been

administered in this study, it could have been assumed the increase in SCIENCE participants' EA was sustained after the program ended.

This study also revealed how important a comparison group is to analyzing results. Without the data from Playgrounds, we would have inferred that SCIENCE increased participants' EK. Instead, we found EK increased for both groups, and therefore cannot attribute the knowledge gain to SCIENCE. It is uncommon for environmental education studies to include a comparison group. Lacking this key component in study design inhibits more complete data analysis from being conducted. Including a comparison group prevents incorrect conclusions from being reached and will allow our field to better analyze the impact of environmental education programming. We can recognize which interventions work with more accuracy. We will also be able to better identify confounding variables and discover how potentially to avoid them. Future studies should include a follow-up test and comparison group. These elements will ensure an improved evaluation of the environmental education program being studied.

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APPENDIX A-ENVIRONMENTAL LITERACY TESTS

Environmental Attitude Questions

Answer the following marking the box for 0, 1, 2, 3, or 4 with 0 being not interested, not likely, or not at all and 4 being very interested, very likely, or very much (only mark one box per question).

Questions	0	1	2	3	4
1. How interested are you in science?					
2. How likely are you to do a science related activity outside of school?					
3. How likely are you to consider a career in science?					
4. How likely are you to go outside for fun?					
5. How likely are you to recycle?					
6. How likely are you to support scientific causes with your time?					
7. How likely are you to agree with laws that protect the environment?					
8. How likely are you to take actions to conserve water?					
9. How likely is it for you to read science books or watch science shows on your own time?					
10. How likely are you to donate money to an environmental cause?					
11. How much do you think about environmental issues?					
12. How likely are you to have a conversation about the environment with your friends and family?					

Further questions

1. What science careers have you considered? Write all the career you have considered, write none if you have not considered a career in science.
2. What actions (in any) do you do to conserve water?
3. With what scientific causes do you volunteer (if any)?
4. What environmental cause do you support with your money? If you do not support any environmental causes, do you support other causes? If so which ones?

Pre-Test

Environmental knowledge questions (Grades 6-8)

1. Can you use insects to determine how clean a stream or river is?

   True   False

2. What is the name of the big lake in Syracuse?

3. How do trees prevent erosion?
   a. They stabilize the soil with their roots
   b. They absorb any loose soil with their roots
   c. Their leaves tie the soil down
   d. All of the above

4. What is a hypothesis?
   a. A theory the scientist creates to explain a phenomenon
   b. The expected outcome of a scientific experiment
   c. The question a scientist plans to investigate and gather evidence about
   d. A proposed explanation based on some evidence that needs further investigation

5. Where is the majority of freshwater on Earth?

6. Is biomagnification in food chains a good thing or a bad thing?

   Good   Bad

7. Is a deer a predator or prey species?

8. Name one tree species native to New York State.

9. Is porous pavement or cement an example of green infrastructure?

10. Which of these are the basic parts of an ecosystem?
    a. Predators and prey
    b. Animal, vegetable, and mineral
    c. Producer, consumer, and decomposer
    d. Trees, shrubs, and flowers

Environmental knowledge questions (Grades 9-11)

1. If there are pollution tolerant macroinvertebrates in a stream that means it is polluted.
    True   False

2. What are three major streams that flow into Onondaga Lake?

3. What is the process of soil or rock gradually wearing away called?

4. In scientific experimentation, what is a proposed explanation based on some evidence that needs further investigation called?

5. What percentage of the current water on Earth is from when the planet was first formed?

6. If a toxin biomagnifies, where in the food chain are higher concentrations found?

7. Does a balanced food web have more predator or prey species?

8. Name one characteristic of white pine that can be used for identification.

9. Name one example of green infrastructure.

10. What are the three categories of organisms that make up an ecosystem?
    a. _____
    b. _____
    c. _____

Post-Test

Environmental knowledge questions (Grades 6-8)

1. Can the presence of specific insects help you determine if a stream is clean?
    Yes   No

2. Where is the final destination for the water from Onondaga Lake?

3. How does erosion impact a habitat?
    a. Less nutrients available to the plants
    b. More difficult for plants to grow in shallower soil
    c. Water bodies become less clear from the run-off
    d. All of the above

4. Do you form a hypothesis at the beginning or during an experiment?

5. Is a larger portion of Earth land or water?
    Land   Water

6. If a toxin biomagnifies, would you expect to find a high concentration in a fish that eats plants, or a fish that eats other fish?
    a. Herbivore fish
    b. Carnivore fish

7. Are predators producers, consumers, or decomposers?

Producers   Consumers   Decomposers

8. Are sugar maples native to New York State?

Yes   No

9. Can green infrastructure prevent water run-off?

10. Are ecosystems with only animals complete?

Environmental knowledge questions (Grades 9-11)

1. Can macroinvertebrates help you to determine if a stream is clean?

Yes   No

2. Where does the water in Syracuse's watershed end up?

3. Does erosion affect the amount of nutrients available to plants?

Yes   No

4. What is the difference between a theory and a hypothesis?

5. What percentage of Earth is covered in water?

6. If a toxin biomagnifies, would you expect to find a high concentration in a fish that eats plants, or a fish that eats other fish?

   a. Herbivore fish
   b. Carnivore fish

7. Are predators higher or lower in the food chain than producers?

Higher   Lower

8. Are sugar maples deciduous or coniferous trees?

Deciduous   Coniferous

9. State one benefit of green roofs.

10. Can you have a complete ecosystem without decomposers?

Follow-Up Test

Environmental knowledge questions (Grades 6-8)

1. Can a polluted stream support the same variety of insect species as a clean one?

Yes   No

2. Does water from the Atlantic Ocean flow into Onondaga Lake?

Yes   No

3. Can erosion on land impact a river ecosystem?

Yes   No

4. Which of the following are benefits of a green roof?

   a. Keeps the building cooler inside during hotter weather
   b. Prevents run-off of rain
   c. Adds habitat for pollinators
   d. All of the above

5. Is the majority of water on Earth saltwater or freshwater?

Saltwater   Freshwater

6. Does a toxin biomagnify as it moves up the food chain or down the food chain?

Up   Down

7. Do predators eat plants or other animals?

   Plants   Animals

8. Do deciduous trees lose their leaves?

   Yes   No

9. Does an ecosystem include only living things?

   Yes   No

10. Are a theory and hypothesis the same thing?

    Yes   No

Environmental knowledge questions (Grades 9-11)

1. Can a polluted stream support the same variety of macroinvertebrate species as a clean one?

   Yes   No

2. Does water leaving Onondaga Lake flow towards or away from the Atlantic Ocean?

   Towards   Away

3. Is erosion on a problem for land ecosystems?

4. How does porous pavement prevent water pollution?

5. In there more water in the ocean or in glaciers?

   Ocean   Glaciers

6. Does a top predator have a higher concentration of a biomagnifying toxin compared to an herbivore?

   Yes   No

7. What type of food to predators eat?

8. Do we have deciduous trees in New York State?

   Yes   No

9. Number the following steps of the scientific method in order from first to last.

   __ Making observations

   __ Analyzing results

   __ Forming a hypothesis

   __ Creating experiment

10. Does an ecosystem include abiotic factors?

    Yes   No