EMOTION AND LEARNING IN CHILDREN ATTENDING SUMMER SCIENCE CAMP

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Abstract. With the overall health of the environment rapidly declining – mostly due to human behaviors, solving the problem of nature deficit disorder and getting more children interested and aware of nature could be paramount to improving the environmental health of our planet. In this study, the relationship between children's learning and emotion is explored. Pre- and post-tests were given to children attending a week-long summer freshwater ecology camp; their knowledge of and emotional connection to different ecological concepts were measured. Two separate ecosystems were tested – a freshwater ecosystem that was taught over the course of the week, and a marine ecosystem for comparison. Increases in knowledge and emotion were seen in every freshwater ecosystem concept. Additionally, the knowledge and emotion scores were correlated, suggesting a positive relationship between them. The marine ecosystem did not show improvements in concrete knowledge, but showed increases in abstract learning, indicating that the abstract concepts learned about the freshwater ecosystem were able to transfer to the marine. Overall results show the ability of a hands-on learning experience to foster an emotional connection between a child and the subject matter. However, long-term studies are needed to track the relationship between children and their knowledge of and emotional connection to the subject matter.

INTRODUCTION

Childhood is not what it once was. Computers, video games and other electronics have replaced friends, babysitters and playing outside. According to some, "childhood has moved indoors" (Driessnack 2009). While electronics use has skyrocketed, since 1988, visits to national parks in the United States are down over 20% (Pergams & Zaradic 2006). Though correlation does not mean causation, this trend has caused some to claim that an overreaching shift in values is occurring in the United States and nature has been placed on the backburner (Pergams & Zardic 2006). Richard Louv coined the term, "nature deficit disorder" in his 2005 book, *Last Child in the Woods*, to describe the phenomenon of children seeking electronics and indoor-living over the natural world. Additionally, in children and adults alike, environmental and scientific literacy remains low (Coyle, 2005; Gross 2006; McBeth & Volk 2010; Miller 2012; National Science Board 2004). With the overall health of the environment rapidly declining, mostly due to human behaviors, solving the problem of nature deficit disorder and getting more children educated, interested and aware of nature could be paramount to improving the environmental health of our planet (Wells & Lekies 2006; Damerell et al. 2013).

Several studies describe different relationships between environmental behaviors, emotions and education. For example, people who are more emotionally connected to nature engage in more pro-environmental behaviors (Geller 1995; Allen & Ferrand 1999; Mayer & Franz 2004; Wells & Lekies 2006; Cheng & Monroe 2012). Furthermore, interest in nature may have a positive effect on mental and emotional health (Geller 1995; Allen & Ferrand 1999; Mayer & Franz 2004; Pilgrim et al. 2007). However, simple, classroom-based environmental education does not create an emotional connection in children or foresee a change in pro-environmental behavior (Hungerford & Volk 1990; Pooley & O'Connor 2000). Using emotional language in environmental education programs can increase understanding (Reis & Roth 2010), but an increase in environmental knowledge does not necessarily mean an increase in pro-environmental behavior; it is a person's feelings and emotional connection that ultimately influence their behaviors (Hungerford & Volk 1990; Pooley & O'Connor 2000; Mayer & Franz 2004; Cheng & Monroe 2012).

However, non-traditional education can play a role in changing pro-environmental behaviors (Bogner 1998; Erdoğan 2011; Cheng & Monroe 2012; Collado et al. 2013). Immersive, outdoor summer camps with a focus on hands-on environmental education have been shown to increase children's emotional connection to nature and pro-environmental behaviors (Bogner 1998; Erdoğan 2011; Collado et al. 2013).

Rising 2nd through 7th graders arriving for a week-long summer ecology camp at the Cary Institute for Ecosystem Studies in Millbrook, New York were tested the first day on their knowledge of ecological concepts and their emotional connection to those concepts. The results of this pre- test were then compared to the same test given at the end of the week. The camp was themed around a freshwater ecosystem ("limnology explorers"), and a marine ecosystem was used as a comparison to test if they could extend what they learned from one ecosystem to another. In addition, a take-home questionnaire was distributed to gather more information about the children's experiences and background in ecology before the week-long camp experience. Previous ecology camp experience, family environmental practice, and outdoor activity were used as factors to compare knowledge and emotion.

In my study, the relationship between emotion and learning in children attending a summer science camp is further explored using comparisons between abstract and concrete thought. Concrete and abstract concepts are processed differently in our brains (Binder et al. 2005; Crutch & Warrington 2005). Each concept incorporates distinct parts of the brain (Binder et al. 2005), and each uses different internal representational pathways (Crutch & Warrington 200). Abstract concepts are more difficult to learn, and they generally lead to more educational errors (Reed & Dick 1968); though with certain types of concepts, abstract examples seem to work better for sustained knowledge (Kaminski et al. 2008). Abstract words are also more closely associated with emotion (Kousta 2011; Vigliocco 2013). Brain centers related to emotion processing are more active when focused on abstract words rather than concrete ones (Vigliocco 2013).

Ecosystem concepts were separated into concrete and abstract concepts. A concrete concept was defined as involving a physical, tangible organism i.e. the ecological role of an organism. Abstract concepts were intangible, ecological processes, such as a trophic cascade. Two separate kinds of knowledge were tested as well: one requiring concrete knowledge (i.e. "where can you find this organism") and the other requiring abstract thought (i.e. "How does this organism affect its environment").

I predicted that the children would demonstrate an increase in knowledge of freshwater ecological concepts as well as an increase in emotional connection toward the freshwater concepts. I also predicted that the changes in knowledge would be correlated to the changes in emotional connection.

Because the children were not learning about the marine ecosystem, I predicted that no change would be seen in the knowledge or emotional connection to concrete, marine concepts. I predicted that abstract, marine concepts would show increases in emotional connection due to the associations between emotion and abstract thought (Kousta 2011; Vigliocco 2013); but I did not think abstract, marine concepts would see increases in knowledge because the children did not learn about the ecosystem. Further, I predicted no correlation between changes in knowledge and emotion connection in the marine ecosystem concepts.

In relation to the take-home questionnaire, I predicted, 1) that children with previous camp experience would score higher than those without previous camp experience; 2) that children with higher environmental awareness, will score higher than children with low environmental awareness; and 3) that children with more outdoor activity will score higher than children with less outdoor activity.

METHODS

Study Site and Subjects

I studied children attending a science-based, summer day camp at the Cary Institute of Ecosystem Studies in Millbrook, New York in July and August 2012. Ascending 2nd through 7th graders attended, with 2nd through 4th grade camps alternating weeks with 5th through 7th grade camps. No more than twelve campers attended per week and two instructors were present for the duration. The camp ran from 9am – 3pm (younger students) or 4 pm (older students), Monday through Friday. Parental written consent was obtained for each child included in the study.

Methods

The children's knowledge of and emotional connection toward two types of ecological concepts (concrete and abstract) were measured with pre and post testing. An individual survey (see Appendix A) was administered to each group of campers with visual cues. The survey lasted approx. 16 minutes so that it could fit into the camp schedule (Larson & Diener 1987; Mayer & Franz 2004; Fulcher et. al. 2001 and Erdoğan 2011). Representational pictures of the eight ecological concepts were shown on a screen for 2 min each; in that time children individually answered four questions concerning the prompted ecological concept – two questions measured knowledge and two questions measured emotional connection. One knowledge question (referred to as "knowledge C") tested concrete information about the ecological concept while the other (referred to as "knowledge D") required abstract thought about the concept. Answers were coded on a 1 to 5 scale of correctness and complexity (see Appendix B for coding scheme). Emotional connection questions were self-reported on a line and measured campers' attitude and value toward the ecological concept (Larson & Diener 1987). Attitude and value scores were averaged to give an overall emotional connectedness score. Tests were administered on Mondays (pre) and Fridays (post) to examine the effect of the intervening camp experience on these outcomes. Comparisons were also made between concepts of high and low familiarity. Preliminary research meetings with the director of the camp and other camp counselors identified four separate concepts that were taught at camp: two for each type of concept (concrete, abstract), with one of high and one of low familiarity (see Table 1). A control was tested using a different ecosystem that campers had not experienced over the course of the week (marine), (see Table 2). Though, in the final data analysis, the high familiar, abstract concepts (freshwater and marine food web) could not be used.

Additionally, a take-home questionnaire was given to children to be filled out by themselves and their parents (see Appendix C for the take-home questionnaire). The survey collected demographic and past experience information and was used to make further comparisons.

Data Analysis

Paired T-tests were used to compare mean knowledge and education scores across different tested concepts (pre-and post). However, because the ordering of the questions affected the answers to the familiar, abstract concept questions (food-web), I had to remove those data from the analysis. Pearson Correlations were used to test for relationships between knowledge and emotion. Three experience factors (past attendance at camp, family environmental practice, and outdoor activity participation) from the take-home questionnaire were tested using the student's t-tests.

RESULTS

Emotion and knowledge scores were analyzed using pre- and post- tests. One-tailed paired t-tests were used to test for significance between pre- and post- results (Table 3). In total, 64 tests were collected.

Students improved all aspects of their knowledge scores in concepts dealing with a freshwater ecosystem (questions 1, 2, and 3). Emotional connection for all three increased as well. Questions dealing with concrete marine ecosystem concepts (5 and 6) showed no advances in emotional connection or concrete knowledge questions (Knowledge C), but did show improvements in abstract thinking (Knowledge D). Abstract, unfamiliar marine concepts showed increases in both abstract and concrete knowledge, and emotion. I decided to eliminate the abstract-familiar questions (4 and 8), because scores indicated that the children were primed by previous questions (3 and 7, respectively) and did not answer genuinely. Changes in individual children's total knowledge score and emotion for each question were tested for correlation using a Pearson coefficient (Table 4). No question indicated a relationship between a change in knowledge and a change in emotion.

Scores were also grouped by ecosystem, combined and tested (Table 5). Data from freshwater ecosystem showed improvements in children's knowledge and emotion while the marine ecosystem only showed improvements in knowledge. The relationship between changes in knowledge and emotion were further explored using a Pearson correlation. The freshwater ecosystem data showed a positive relationship between increases in knowledge and increases in emotional connection (Table 6).

Past attendance at camp, family environmental practice, and outdoor activities were also used as factors to further examine the responses of individual children. A take-home questionnaire was distributed to children to return over the course of the week; 48 responses were collected.

Past attendance was shown to be a factor in a child's scores. Though both the 30 children who had never attended camp before and the 18 who had previously attended camp all increased their knowledge and emotion scores (Table 7), the knowledge of the previous campers was higher in both pre- and post- tests, while emotion remained consistent between the two groups (Table 8).

Family environmental practice was measured by the number of environmentally friendly activities the children and their families self-reported. Median scores were not used in the comparisons – only each extreme (minimal vs. maximal environmental awareness). The 26 children identified as having a high family environmental practice increased their knowledge and emotion scores over the course of the week, while the six that had a low family environmental practice did not (Table 9). However, when compared directly to each other, scores between children of high and low family environmental practice did not differ (Table 10).

Participation in outdoor activities was also used a comparative factor. Median scores were not used in the comparison, only the extremes (active vs. inactive). The 11 children reporting inactivity increased both knowledge and emotion scores (Table 11). The nine children that reported considerable activity improved their knowledge, but were unchanged emotionally. When compared against each other, high and low outdoor activity participation showed no difference in any scores (Table 12).

DISCUSSION

Overall, the summer camp experience had a positive impact on the children. Total knowledge scores increased in every question and emotional connection toward most of the concepts increased as well. The only ecological concepts that showed no change in emotion were concrete marine concepts that were not covered in the camp curriculum. Though knowledge and emotion both increased in each individual question, changes in knowledge and emotion were not necessarily correlated when examined across ecosystems. However, when the questions were analyzed by ecosystem, a relationship between learning and emotion can be seen.

When tested on the freshwater ecosystem that the campers experienced all week, total knowledge and emotion scores both improved significantly. Additionally, the scores were significantly correlated, indicating a positive relationship between learning and emotion. This is not the case with the marine ecosystem. Though total knowledge scores significantly improved, emotional connection did not. Additionally, the scores were not correlated. These findings suggest that learning did not act as an emotional driver, as knowledge increased in both ecosystems but emotion did not. The data suggest that it was the experiences with the freshwater environment curriculum that drove the emotional changes. Though I believe the hands-on experiences played a significant role in changing emotional connection, I think further investigation of the scores shows that learning has an effect as well.

Total knowledge scores were composed of two questions; one of them required concrete information to answer correctly (question C), while the other (question D) required critical thinking and abstract thought. When comparing concrete ecological concepts to abstract concepts in the marine ecosystem, the data show that children did not improve concrete knowledge scores (question C) but did increase abstract knowledge scores (question D). Emotion scores for neither concrete ecological concept in the marine system changed. However, the abstract marine ecological concept saw significant improvements in concrete *and* abstract knowledge *and* emotion. This finding indicates two things: that students are able to transfer abstract thought across ecosystems, and, learning can play a role in the development of an emotional connection. Though they did not learn about a marine trophic cascade, children were able to transfer their knowledge of a freshwater trophic cascade to answer the marine questions correctly. The rise in emotion indicates that this understanding played a role in increasing emotional connection – it was not completely due to the effect of a hands-on experience.

This ability to transfer knowledge between subjects is a learning phenomenon often witnessed in pre- and post- testing studies (Katz 2006; Rohrer et al. 2010; Carpenter 2012). In these kinds of studies, post-testing is usually higher, thus indicating a performance improvement (Rohrer et al. 2010; Carpenter 2012). This improvement, called a testing effect, is usually a result of re-taking a test, not necessarily an increase in learning (Rohrer et al. 2010). However, what Rohrer et al. (2010), showed, was that an increase in transferred learning lowered the testing effect and thus indicated sustained learning improvements. In my study, the marine, concrete concept scores improved, however transferred learning was not observed. This suggests that the knowledge improvements were simply due to the testing effect and had no basis to assume sustained learning improvements. On the other hand, the marine, abstract concepts showed knowledge improvements and an ability to transfer between ecosystems indicating a lower testing effect and a higher probability of sustaining the knowledge. It is not surprising that abstract concepts transferred while concrete ones did not. Several studies show that, once learned, abstract concepts are easier to be transferred (Katz 2006; Kaminski et al. 2008)

In my study, I showed that the transfer of knowledge across ecosystems is related to differences between concrete and abstract thought processes. Differentiating and categorizing ecological concepts into distinct concrete and abstract forms could increase overall understanding of each, improve the way they are taught and provide information about emotionality toward each. Examining the difference between abstract and concrete ecological concepts could also be useful in studying the environmental affects in children toward human-created ecological problems as some are concrete (i.e. pollution) and some are abstract (i.e. climate change).

When I compared the differences in campers who had attended the camp in previous years and those that did not, I found that regardless of past camp experience, both knowledge and emotion increased. However, knowledge scores were significantly higher in those that had previously attended camp, both before and after the week. I think this highlights the value of recruiting previous campers back to camp. Returning to camp allows the child to build on their previous knowledge while also increasing their emotional connection to the surrounding ecosystem.

Campers were also asked about their environmental practices at home. I took the extremes on both ends (minimal and maximal environmental practice) and compared scores. Those with maximal environmental practice at home significantly increased their knowledge and emotion scores while those with minimal practice did not. Although, when the scores were compared directly between minimal and maximal practice, no significant differences were observed. I think this is due to the relatively small sample size of those with minimal practice (only six). Regardless, the fact that pre- and post-scores did not change among children with minimal family environmental practice shows that more pressure needs to be put on parents to engage their children in environmental awareness. It has been shown that once children learn environmental awareness, they are likely to talk to their parents about it and create better family environmental practices (Damerell et al. 2013). However, if parents took initiative first, children may have an easier time learning about and making emotional connections to nature.

Finally, participation in outdoor activities was used as a comparative factor. Again, median scores were left out and only extremes were analyzed (inactive vs. active). Both inactive and active children increased their pre- and post-knowledge scores, but only campers with less outdoor activity participation increased their emotion scores. When directly compared to each other, no significant differences appeared. This could mean that outdoor experience is beneficial to creating an emotional connection to nature as children without outdoor experience showed an increase in emotion. Several studies indicate that past experiences in nature are significant in forming an emotional connection to nature (Pooley & O'Connor 2000; Wells & Lekies 2006).

Combing all facets of my study has led me to realize the connectedness of learning, emotion and experience. Though family and formal education play a role, summer camp is an effective way to combine aspects of all three. Learning, emotion and experience can affect each other, and all three are vital parts in creating an environmental conscious. Future studies are needed to investigate the ability of other kinds of non-traditional education to create and improve a child's environmental conscious. Children can have a significant influence on changing the environmental practices of adults (Damerell et al. 2013). Using children as the primary education informants could significantly change the environmental attitudes of all. A beneficial first step could be repeating the study on camp and doing follow up studies on the children and their parents. Additionally, traditional classrooms often do not include enough hands-on activities to create an emotional connection in children. Ways to incorporate facets of non-traditional education into classroom learning are also needed.

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TABLES

TABLE 1. Concepts to be taught in camp (Freshwater ecosystem).

		Familiarity	
		Low	*High*
Ecological Concept	*Concrete*	Dragonfly larvae	Dragonfly
	Abstract	Trophic Cascade (freshwater)	Food Web (freshwater)

TABLE 2. Control (Marine Ecosystem).

		Familiarity	
		Low	*High*
Ecological Concept	*Concrete*	Scallop	Sting ray
	Abstract	Trophic Cascade (marine)	Food Web (marine)

TABLE 3. Individual question t-statistics. Mean pre- and post- test scores for individual questions were analyzed using a paired t-test. *Shading represents pairing of each question to each tested ecosystem (freshwater and marine). Asterisk indicates significance <0.05; double asterisk indicates a p-value <.01.*

Question		*Pre Scores*	*Post Scores*	*n*	*t*	*p*
1 Concrete Unfamiliar	Knowledge C	2.59	3.24	64	-4.54	**
	Knowledge D	1.95	2.60	64	-4.19	**
	Total Knowledge	4.54	5.84	64	-5.44	**
	Emotion	84.63	97.05	64	-2.71	**
2 Concrete Familiar	Knowledge C	3.08	3.37	64	-2.25	*
	Knowledge D	1.94	2.71	64	-4.01	**
	Total Knowledge	5.02	6.08	64	-4.29	**
	Emotion	101.54	113.22	62	-3.65	**
3 Abstract Unfamiliar	Knowledge C	2.14	2.76	64	-3.46	**
	Knowledge D	1.97	2.62	64	-3.1	**
	Total Knowledge	4.11	5.38	64	-4.5	**
	Emotion	97.33	107.35	62	-1.89	n.s.
5 Concrete Unfamiliar	Knowledge C	2.79	2.94	64	-1.18	n.s.
	Knowledge D	1.59	2.17	64	-4.77	**
	Total Knowledge	4.38	5.11	64	-3.85	**
	Emotion	97.31	98.17	64	-0.23	n.s.
6 Concrete Familiar	Knowledge C	3.05	3.06	64	-0.17	n.s.
	Knowledge D	2.02	2.46	64	-2.65	**
	Total Knowledge	5.06	5.52	64	-2.37	*
	Emotion	116.11	120.08	64	-1.06	n.s.
7 Abstract Unfamiliar	Knowledge C	2.21	2.75	64	-2.96	**
	Knowledge D	2.60	3.17	64	-2.67	**
	Total Knowledge	4.81	5.92	64	-3.84	**
	Emotion	98.39	109.62	62	-2.38	*

TABLE 4. Correlations between knowledge and emotion in individual questions.

Question	*Coefficient*	*p*
1	0.199	n.s.
2	0.2297	n.s.
3	0.03834	n.s.
5	0.07803	n.s.
6	-0.01566	n.s.
7	-0.10584	n.s.

TABLE 5. Pre- and post- test scores for questions grouped by ecosystem type, freshwater and marine, were analyzed using a paired t-test. *Double asterisk indicates a p-value <.01.*

		n	*t value*	*p value*
Freshwater	Knowledge	64	-6.83	**
	Emotion	64	-3.9	**
Marine	Knowledge	64	-5.14	**
	Emotion	64	-1.35	n.s.

TABLE 6. Correlations between knowledge and emotion in questions grouped by ecosystem. *Asterisk indicates significance <0.05.*

	Coefficient	*p*
Freshwater	0.30314	*
Marine	-0.05614	n.s.

TABLE 7. Mean pre- and post- test scores for campers with and without previous camp experience. *Asterisk indicates significance <0.05.*

		Pre Scores	*Post Scores*	*n*	*t*	*p*
No Experience	Knowledge	4.29	5.27	30	-4.14	*
	Emotion	97.48	105.72	30	-2.74	*
Previous Camper	Knowledge	5.27	6.50	18	-4.98	*
	Emotion	125.33	127.42	18	-3.2	*

TABLE 8. Comparison of children's scores between those that had previously attended camp and those who had not. *Asterisk indicates significance <0.05.*

		No Experience	*Previous Camper*	*n*	*t*	*p*
Knowledge	Pre tests	4.29	5.27	48	2.24	*
	Post tests	5.27	6.50	48	1.99	*
Emotion	Pre tests	97.48	125.33	48	-0.56	n.s.
	Post tests	105.72	127.42	48	0.66	n.s.

TABLE 9. Mean pre- and post- test scores for campers of minimal and maximal family environmental practice. *Asterisk indicates significance <0.05.*

Environmental Practice		*Pre- Scores*	*Post- Scores*	*n*	*t*	*p*
Minimal	Knowledge	4.28	5.19	6	-2.06	n.s.
	Emotion	94.62	93.17	6	0.29	n.s.
Maximal	Knowledge	4.74	5.74	26	-5.02	*
	Emotion	103.97	113.27	26	-2.05	*

TABLE 10. Comparison of children's scores between those of minimal and maximal family environmental practice.

		Family Environmental Practice *Minimal*	*Maximal*	*n*	*t*	*p*
Knowledge	Pre tests	4.28	4.74	32	0.7976	n.s.
	Post tests	5.19	5.74	32	0.7903	n.s.
Emotion	Pre tests	94.62	103.97	32	1.052	n.s.
	Post tests	93.17	113.27	32	1.709	n.s.

TABLE 11. Mean pre- and post- test scores for campers of high and low outdoor activity participation. *Asterisk indicates significance <0.05.*

Outdoor Activity Level		*Pre- Scores*	*Post- Scores*	*n*	*t*	*p*
Inactive	Knowledge	4.14	4.89	11	-2.38	*
	Emotion	98.46	113.08	11	-2.4	*
Active	Knowledge	4.70	5.98	9	-3.09	*
	Emotion	94.47	106.05	9	-1.26	n.s.

TABLE 12. Comparison of children's scores between those of high and low outdoor activity participation.

		Outdoor Activity Participation Low	High	n	t	p
Knowledge	Pre tests	4.14	4.70	20	0.8754	n.s.
	Post tests	4.89	5.98	20	1.297	n.s.
Emotion	Pre tests	98.46	94.47	20	-0.3735	n.s.
	Post tests	113.08	106.05	20	-0.6689	n.s.

APPENDIX A

1. Dragonfly nymph

a. How much do you like the animal in this picture? Place an "X" on the line below to indicate your answer.

Strongly Dislike — Strongly Like

b. How important is the animal in this picture to you? Place an "X" on the line below to indicate your answer.

Very — Very

Unimportant Important

c. Where can you find dragonfly nymphs?

d. How do dragonfly nymph affect other things in the environment?

2. Dragonfly

a. How much do you like the animal in this picture? Place an “X” on the line below to indicate your answer.

Strongly Dislike — Strongly Like

b. How important is the animal in this picture to you? Place an “X” on the line below to indicate your answer.

Very Unimportant — Very Important

c. Where can you find dragonflies?

d. How do dragonflies affect other things in the environment?

3. Freshwater trophic Cascade

a. How much do you like the diagram in this picture? Place an “X” on the line below to indicate your answer.

Strongly Dislike — Strongly Like

b. How important is the diagram in this picture to you? Place an “X” on the line below to indicate your answer.

Very Very

Unimportant Important

c. What does this trophic cascade show?

d. To the best of your abilities, explain what would happen to the surrounding ecosystem if the fish population were to die off.

4. Freshwater food chain

a. How much do you like the diagram in this picture? Place an "X" on the line below to indicate your answer.

Strongly Dislike Strongly Like

b. How important is the diagram in this picture to you? Place an "X" on the line below to indicate your answer.

Very Unimportant Very Important

c. What does this food chain show?

d. To the best of your abilities, explain what would happen if the dragonfly nymph population went up.

5. Scallop

a. How much do you like the animal in this picture? Place an "X" on the line below to indicate your answer.

Strongly Dislike Strongly Like

b. How important is the animal in this picture to you? Place an "X" on the line below to indicate your answer.

Very Unimportant Very Important

c. Where can you find scallops?

d. How do scallops affect other things in the environment?

6. Stingray

a. How much do you like the animal in this picture? Place an “X” on the line below to indicate your answer.

Strongly Dislike — Strongly Like

b. How important is the animal in this picture to you? Place an “X” on the line below to indicate your answer.

Very Unimportant — Very Important

c. Where can you find stingray?

d. How do stingrays affect other things in the environment?

7. Marine trophic Cascade

a. How much do you like the diagram in this picture? Place an “X” on the line below to indicate your answer.

Strongly Dislike — Strongly Like

b. How important is the diagram in this picture to you? Place an “X” on the line below to indicate your answer.

Very Unimportant — Very Important

c. What does this trophic cascade show?

d. To the best of your abilities, explain what would happen to the surrounding ecosystem if the shark population were to die off.

8. Marine food chain

a. How much do you like the diagram in this picture? Place an "X" on the line below to indicate your answer.

Strongly Dislike — Strongly Like

b. How important is the diagram in this picture to you? Place an "X" on the line below to indicate your answer.

Very Unimportant — Very Important

c. What does this food chain show?

d. To the best of your abilities, explain what would happen if the shark population went up.

APPENDIX B

1. Dragonfly nymph

c. Where can you find dragonfly nymphs?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	grasslands
3	Simple answer with no demonstration of higher thinking	you can find dragonfly nymphs in water
4	Simple answer with demonstration of higher thinking	in freshwater ponds
5	Complex answer with demonstration of higher thinking	In streams and slow moving rivers

d. How do dragonfly nymph affect other things in the environment?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	by eating it
3	Simple answer with no demonstration	they are food for other animals

	of higher thinking	
4	Simple answer with demonstration of higher thinking	they eat mosquito larva and algae which is food for other fish
5	Complex answer with demonstration of higher thinking	when they grow up they eat mosquitoes, which affects humans and other animals

2. Dragonfly

c. Where can you find dragonflies?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	in the sky flying
3	Simple answer with no demonstration of higher thinking	an area where there is grass and trees
4	Simple answer with demonstration of higher thinking	Some can be found near water and some can be found in land
5	Complex answer with demonstration of higher thinking	in the air around ponds and murky water with thick air close to the surface

d. How do dragonflies affect other things in the environment?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	they affect the environment by eating nature
3	Simple answer with no demonstration of higher thinking	they eat smaller insects
4	Simple answer with demonstration of higher thinking	it gives food to its predators
5	Complex answer with demonstration of higher thinking	dragonflies eat things such as mosquitoes if otherwise not eaten world would soar in population

3. Freshwater trophic cascade

c. What does this trophic cascade show?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	it shows what animals live in freshwater
3	Simple answer with no demonstration of higher thinking	a diagram of insects and living things
4	Simple answer with demonstration of higher thinking	it shows how certain things affect other things in nature
5	Complex answer with demonstration of higher thinking	what eats what and how if one thing more of another that there will be less of that so more something else etc

d. To the best of your abilities, explain what would happen to the surrounding ecosystem if the fish population were to die off.

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	it would die
3	Simple answer with no demonstration of higher thinking	some populations would increase, and others decrease
4	Simple answer with demonstration of higher thinking	Dragonflies would be everywhere if the fish went down
5	Complex answer with demonstration of higher thinking	the dragonfly nymph would be more numerous and the dragonflies would also eat the bees would be less numerous and the duckweed and other plants would grow more

5. Scallop

c. Where can you find scallops?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	water
3	Simple answer with no demonstration of higher thinking	The ocean
4	Simple answer with demonstration of higher thinking	bottom of the ocean

5	Complex answer with demonstration of higher thinking	on the bottom of the ocean or near a bay

d. How do scallops affect other things in the environment?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	as food
3	Simple answer with no demonstration of higher thinking	by eating other animals
4	Simple answer with demonstration of higher thinking	they are eaten and they eat plankton and other smaller things
5	Complex answer with demonstration of higher thinking	they are the filter feeders, with out them the bad water would not be filtered out of the bay

6. Stingray

c. Where can you find stingray?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	water
3	Simple answer with no demonstration of higher thinking	In the ocean
4	Simple answer with demonstration of higher thinking	in the warmer ocean water
5	Complex answer with demonstration of higher thinking	anywhere from South Carolina to northern Argentina; tropical water

d. How do stingrays affect other things in the environment?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	They sting other things
3	Simple answer with no demonstration of higher thinking	they eat fish
4	Simple answer with demonstration of higher thinking	can be a food source to sharks
5	Complex answer with demonstration of higher thinking	they eat fish, which if they did not eat there would become overpopulated

7. Marine trophic cascade

c. What does this trophic cascade show?

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	a shark a ray a scallop
3	Simple answer with no demonstration of higher thinking	a food chain of marine life
4	Simple answer with demonstration of higher thinking	each animal relies on each other
5	Complex answer with demonstration of higher thinking	the trophic cascade shows if some population decreases another will increase or decrease

d. To the best of your abilities, explain what would happen to the surrounding ecosystem if the shark population were to die off.

Score	Description	Example
1	Blank, "I don't know," or other blatantly incorrect response.	I don't know
2	Overly simple answer that does not demonstrate higher thought.	the cascade would be affected
3	Simple answer with no demonstration of higher thinking	many other things would either go down or die off
4	Simple answer with demonstration of higher thinking	if the sharks would there would be too many stingrays
5	Complex answer with demonstration of higher thinking	the stingrays would be more numerous and the scallop would be eaten more and zooplankton would be more numerous and the phytoplankton would be eaten more

APPENDIX C

Cary Institute of Ecosystem Studies

Student Learning in Ecology Camp Project Questionnaire

This questionnaire will help us understand what experiences might influence your (the camper) feelings, interest and knowledge about the environment. Please answer the questions as honestly and completely as you can. Return the form to your camp counselor by Friday, the last day of camp. Thank you.

1. Circle one.

   Male   Female

2. What is your (camper) age?

3. Have you attended the Cary Institute's Summer Camp in previous years?
   Yes No
   If yes, how many times?

4. Have you attended other science-based summer camps in previous years?
   Yes No
   If yes, how many times?

5. At your house, does your family do any of the following? Choose all that apply
   ☐ Recycle
   ☐ Use reusable shopping bags for groceries
   ☐ Grow a garden
   ☐ Compost
   ☐ Shop at farmers' markets

6. Do you do any of these activities? Choose all that apply.
   ☐ Camping
   ☐ Hiking
   ☐ Fishing
   ☐ Hunting
   ☐ Biking in parks or on trails
   ☐ Snowmobiling
   ☐ Ride an ATV
   ☐ Snow sports (e.g. snowboarding, skiing, sledding)
   ☐ Team sports (e.g. soccer, basketball, baseball)
   ☐ Individual sports (e.g. martial arts, running, swimming)
   ☐ Motorized water sports (e.g. boating, jet skiing, waterskiing)
   ☐ Non-motorized water sports (e.g. canoeing, rafting, windsurfing)
   ☐ Ocean water sports (e.g. scuba diving, surfing)
   ☐ Have a pet

7. How often do you participate in the following activities? Mark the corresponding box.

	Daily	Every few days	Weekly	Monthly	A few times per year	Never
Play sports outside						
Ride a bike/ skateboard/ skates/ scooter						
Watch TV						
Watch nature-themed TV						

Play videogames						
Surf the internet						
Read						
Read nature-themed material						