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Role of Significant Life Experiences in Building Environmental Knowledge and Behavior Among Middle School Students

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Significant life experience research suggests that the presence of role models, time outdoors, and nature-related media foster pro-environmental behavior, but most research is qualitative. Based on a random sample of middle school students in North Carolina, USA, we found limited positive associations between presence of a role model and time outdoors with behavior and a negative association between watching nature television and environmental knowledge. The strongest predictors of environmental knowledge and behavior were student/teacher ratio and county income levels, respectively. We also found that Native Americans engaged in environmental behaviors more than Caucasians, and that African American and Hispanic students had lower levels of environmental knowledge. Accordingly, life experiences appear less important than promoting small class sizes and addressing challenges associated with lower incomes in schools.

Keywords *children and nature, environmental behavior, environmental literacy, outdoor education, technology*

INTRODUCTION

The monumental environmental challenges we face today can be addressed only by an environmentally literate citizenry (Bickford, Posa, Qie, Campos-Arceiz, & Kudavidanage, 2012). Problems such as climate change, biodiversity loss, and water quality are complex and pressing, and though we have made great strides in addressing each of these, a public that lacks a strong grasp of environmental science is ill equipped to analyze these challenges. Further, without a

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citizenry motivated to engage in solving them, overcoming them is impossible. The goals of environmental education (EE) have included teaching content knowledge about the environment and promoting environmentally responsible behavior (UNESCO, 1977). Accordingly, EE scholars have focused on identifying forms of education that encourage both ecological understanding and environmental stewardship. Literature on this topic suggests school-based strategies including classroom instruction followed by field experiences (Duerden & Witt, 2010), place-based instruction (Birmingham & Calabrese Barton, 2013), and use of environment-based curricula (State Education & Environment Roundtable [SEER], 2000) as effective strategies. One important conclusion of this research, however, is that in-school activities fail to explain most of the variation in predicting environmental knowledge and behavior (Stevenson, Peterson, Bondell, Mertig, & Moore, 2013).

CONTRIBUTIONS AND LIMITATIONS OF SIGNIFICANT LIFE EXPERIENCE RESEARCH

Significant life experience (SLE) research, initiated by Tanner (1980) and pursued by several others (e.g., Chawla, 1999; Corcoran, 1999; Palmer, 1993) suggests that formative outdoor experiences as a child, adult role models who facilitate outdoor experiences, and reading nature books are all important factors that lead to an environmentally active adulthood. SLE research takes a retrospective approach in identifying factors that promote environmentally engaged citizens. Reviews by Chawla (1998) and Tanner (1998) examine studies that have explored how SLEs have influenced adults' paths to involvement in environmentally active careers or other leadership positions. Repeatedly, adults with high levels of environmental interest or actions attribute their pro-environmental behaviors to time spent in nature as a child, influences of role models such as parents or teachers, and indirect experiences through books (Chawla, 1999). In Chawla's comparison of environmental activists from Kentucky and Norway, she also demonstrated that these factors may positively influence pro-environmental behavior across cultures.

There is a need to expand this initial research by empirically testing the qualitative insights. In addition to providing empirical evidence for the qualitative claims, such research could shed light on the magnitude of effects associated with variables assumed to be integral within SLEs (e.g., time spent in nature, influential role models, experiencing nature through media), the degree to which SLE-related variables impact average (versus activist) citizens, and when the effects become evident (e.g., age ranges). Although highly active environmental advocates are undoubtedly citizens that EE efforts hope to produce, most people may engage in pro-environmental behavior on a much smaller scale in their daily habits. Tanner (1998) asserts that career activists are the ones that will save the planet, but environmental actions such as voting and consumer choices also have a critical, and perhaps greater, role to play (Peterson, Peterson, & Liu, 2013). Further, because SLE research focuses on a specific population (i.e., environmental activists), its implications are constrained to a narrowly defined group. Failure to examine different cultures, ethnicities, and ages limits the ability to identify how life experiences may affect citizen behavior (Chawla, 2001; Gough, 1999). Examination of how life experiences that have become significant to activists (e.g., spending time outdoors, having a role model for environmental sensitivity) affect larger audiences may provide insight on how to foster environmental behavior more broadly.

Beyond applying SLE research to more diverse audiences, efforts to address limitations of the retrospective approach used in much of SLE research could help identify the magnitude of effects associated with SLE-related variables and when the effects become influential (e.g., age ranges). Most SLE research relies on self-assessment and recall over a long time, which has been shown to be a poor measurement of actual events (Golden, Wrangham, & Brashares, 2013). Wells and Lekies (2006) addressed the need for an examination over a diverse audience by conducting a large-scale survey, however they suggested future studies address the challenges associated with recall because they also asked adults to describe experiences in their childhoods.

RESEARCH ON SLE-RELATED VARIABLES WITH CHILDREN

Although some impacts of SLE-related variables (e.g., spending time outdoors) may only become apparent to individuals in hindsight, their initial influence on knowledge and behavior should be discernible. Indeed, the effects of most environmental interventions are typically stronger immediately after the intervention and become weaker over time (Dwyer, 1993). An empirical examination of how SLE-related variables influence children would allow for an evaluation of when they become influential and the magnitude of that influence. Further, testing how SLE-related variables relate to environmental knowledge and behaviors among diverse groups of children could meet the need for diversity of subjects, reduced reliance on self-reporting, and a more rigorous evaluation of factors that promote the goals of EE (Blumstein & Saylan, 2007; Keene & Blumstein, 2010; Monroe, 2010). In-school activities may have limited influence over environmental knowledge and behavior (Stevenson et al., 2013), and a similar exploration of the influence of SLE-related variables could offer a more complete picture of how to best ensure current and future generations are equipped and motivated to tackle environmental challenges.

Research on how SLE-related variables affect children is mostly limited to environmental attitudes, which alone are poor predictors of pro-environmental behavior (Heberlein, 2012). Skelly and Zajicek (1998) found that participation in a garden program and outdoor activities was related to more positive environmental attitudes, and Cheng and Monroe (2010) found that among children, time outdoors and perceived family values related to nature are shown to foster pro-environmental attitudes and intention toward pro-environmental behaviors. Although environmental attitudes are seen as contributing to pro-environmental behavior, they have not been shown to directly lead to it unless paired with a deeper ecological understanding (Duerden & Witt, 2010), suggesting that building attitudes alone may not be a sufficient strategy for building stewardship. Solving environmental problems will require a citizenry that not only cares about the environment but also is knowledgeable and driven to act in environmentally responsible ways. Empirical examination of how SLE-related variables relate to environmental knowledge and behavior will deepen understanding of how best to encourage pro-environmental behaviors among children.

STUDY OBJECTIVES

We begin addressing these needs with an evaluation of how select SLE-related variables relate to environmental knowledge and pro-environmental behavior among middle school aged children in

North Carolina, USA. Specifically, we evaluated how time spent outdoors alone, outdoor experiences with family, the presence of an adult role model for environmental sensitivity, and indirect experiences with nature through books and television predicted environmental knowledge and behavior. We also accounted for student gender, age, ethnicity, student/teacher ratio, locale, and median county income. As teachers with advanced degrees have been shown to have students with significantly higher environmental knowledge and pro-environmental behavior levels (Stevenson et al., 2013) we also controlled for the education level of a child's teacher. We hypothesized that environmental knowledge and behavior levels of middle school children would be: (a) positively related to time spent outdoors alone, in groups, and with family; (b) positively related to the presence of an adult role model for pro-environmental behavior; and (c) positively related to indirect experiences with nature.

METHODS

Sampling

We focused on students in the sixth and eighth grades for this study because middle school represents a period in which children possess the cognitive development necessary to evaluate environmental issues and capacity to be influenced by experiences such as time outdoors, role models, and indirect experiences through television or books (Carnegie Council on Adolescent Development, 1989; McBeth, Hungerford, Marcinkowski, Volk, & Meyers, 2008). We sampled in three stages—schools, teachers, and students. First, we randomly selected 40 schools from a list of all 665 schools in North Carolina with sixth and/or eighth grades. Next, we identified all sixth and eighth grade science teachers within those schools by visiting school websites and calling the schools to confirm accuracy of the faculty rosters. This process yielded 135 teachers. We randomly selected 85 of these teachers to recruit for the study. Of the teachers contacted, 31 responded and 20 consented to participate. Two of the consenting teachers failed to receive permission from their principals and/or school districts to participate in the study. Finally, each participating teacher was asked to randomly select one class for participation by flipping a coin. Our final sample included ten sixth grade classes (234 students) and eight eighth grade classes (173 students). In January 2012, we visited all 18 classrooms and administered the student survey in person to all 407 students. Slightly more were female (51.6%), and most were Caucasian ($n = 263$, 64.1%) with fewer African American ($n = 75$, 18.5%), Hispanic ($n = 38$, 9.4%), American Indian ($n = 18$, 4.4%) and Asian ($n = 13$, 3.2%) students. In addition, we administered a short survey to all 18 participating teachers asking about their education and teaching experience.

Survey Instrument

We measured student environmental knowledge and behavior using relevant sections of the Middle School Environmental Literacy Survey (MSELS) tool (McBeth, Hungerford, Marcinkowski, Volk, & Cifranick, 2011; McBeth et al., 2008). We used the Ecological Knowledge component (Section I) to measure environmental knowledge and the Behavior component (Section

TABLE 1
Questions Measuring SLE Exposure Among Students

Variable	*Question*	*Mean score*
Time outdoors		
Alone	To what extent do you spend time in the out-of-doors alone—not as part of a class or youth group?	3.90 (1.08)
In groups	To what extent do you go camping with youth groups or organizations (Boy Scouts, 4-H, Girls Club, etc.)?	4.14 (1.17)
With family	To what extent do you take part in family vacations or outings in the outdoors?	3.96 (1.08)
Role model	To what extent do you have a teacher or youth leader who is a role model for environmental sensitivity?	3.69 (1.16)
Indirect nature experiences		
Books and magazines	To what extent do you enjoy reading books or magazines about nature and the environment?	3.66 (1.27)
TV and movies	To what extent do you enjoy watching television shows videos, CDs, or DVDs about nature and the environment?	3.65 (1.18)

Note: Each of these questions was multiple choice with the directions, "On your answer sheet, darken in the letter of the response that tells us the extent to which the statement is true for you." Choices were: (a) to a great extent; (b) to a large extent; (c) to a moderate extent; (d) to a small extent; and (e) to no extent, corresponding to values of 1–5 respectively. Mean scores are reported with standard deviations ($n = 407$).

IV) to measure environmental behavior (these sections are reproduced in the Appendix). Each component of the MSELS was validated through substantial pretesting by the original authors (see McBeth et al., 2008). The environmental knowledge and behavior sections had sufficiently high internal consistency when the scales were developed (Cronbach's alpha for environmental knowledge scale = 0.778, behavior scale = 0.774). Environmental knowledge includes understanding of ecology, energy flow, and other science concepts related to the environment. Behavior is a measurement of self-reported pro-environmental behaviors such as recycling, saving water, conserving energy, and making pro-environmental consumer choices.

Each student was assigned an environmental knowledge and behavior score according to the guidelines in the 2008 National Environmental Literacy Assessment (NELA) report (McBeth et al., 2008). The degree to which students spent time outdoors alone, in groups, or with family; whether they had a role model for pro-environmental behavior; and whether they engaged in indirect experiences with nature were measured by specific questions within a separate section of the MSELS not included in the environmental knowledge or behavior scales (see Table 1). Student demographic information (grade, gender, and ethnicity) was self-reported through responses to items included in the student questionnaire. To control for school-level demographics, we gathered information on the median county income and student/teacher ratio from the U.S. Census website (U.S. Census Bureau, 2010) and classification of the school's locale from the National Center for Education Statistics (NCES, 2006). Locale includes 12 categories: large city, midsize city, small city, large suburb, midsize suburb, small suburb, fringe town, distant town, remote town, fringe rural, distant rural, and remote rural areas (NCES, 2006). We collapsed these categories into urban (including all size cities and suburbs) and rural (including all size towns and rural areas). In their survey, teachers self-reported whether they had a master's degree.

Data Analysis

We analyzed data using STATA software, version 12.1. We used multiple linear regression to model environmental knowledge and pro-environmental behavior as a function of SLE-related variables most cited as influential in promoting pro-environmental behavior: time outdoors (the degree to which students reported spending time outdoors alone, taking outdoor vacations with family, participating in outings with scouts or other youth organizations), having a role model for environmental sensitivity, and indirect experiences with nature (reading nature books or magazines, and watching television or movies about nature). In addition, we controlled for student demographics of grade, gender, and ethnicity as well as school-level demographics of income (measured by median income of the county), locale (urban or rural), and whether the teacher had a master's degree. Because students from the same classroom may be exposed to similar educational experiences, we included a random effect for class. This accounts for the likelihood that students from the same classroom may have similar environmental knowledge and behavior levels instead of independent random deviations among student scores.

RESULTS

Students answered about 70% of the knowledge questions correctly (mean = 41.9 out of 60, $SD = 11.2$) and the difference in scores between sixth and eighth graders was negligible (0.17 point difference in means, $p = .89$). Both groups of students scored high on the behavior scale with sixth graders averaging 47.9 ($SD = 5.76$) and eighth graders averaging 46.9 ($SD = 5.55$) out of a maximum of 60.

Our results provide some support for hypothesis one as time outdoors in groups was a weak positive predictor of environmental knowledge and time outdoors with family and alone were also weak positive predictors of pro-environmental behavior (Table 2). We found similar support for hypothesis two as having an adult role model for environmental sensitivity was only weakly related to pro-environmental behavior (Table 2).We found evidence contrary to hypothesis three, with time watching nature-related television being a negative predictor of environmental knowledge (Table 2).

Although we included student, teacher, and school-level demographics primarily as control variables, several significant relationships were of interest. The strongest negative predictor of environmental knowledge was class size (student/teacher ratio), and the strongest positive predictor was whether students had a teacher with a master's degree (Table 2). Minority students (American Indian, Hispanic, and African American) scored significantly lower than Caucasian students in environmental knowledge (Table 2). However, a similar relationship was not present between ethnicity and pro-environmental behavior among African American and Hispanic students, and a positive relationship was present between Native American ethnicity and pro-environmental behavior compared with Caucasian students (Table 2). Median county income was positively related to environmental knowledge and behavior and was the most important predictor of pro-environmental behavior (Table 2). Also, random effects in both models were significant, suggesting that students who are in the same class have environmental knowledge and behavior levels that are more similar than can be attributed to random chance.

TABLE 2
Regression Models Predicting Environmental Knowledge and Behavior

	Knowledge			*Behavior*		
Item	*Beta*	*Std. Beta*	p	*Beta*	*Std. Beta*	p
SLEs						
Time outdoors with family	0.718	0.069	.130	0.517	0.099	.053
Time outdoors in groups	0.838	0.087	.050	0.139	0.029	.563
Time outdoors alone	0.388	0.037	.424	0.472	0.090	.084
Read nature books or magazines	–0.406	–0.046	.348	0.093	0.021	.704
Watch TV about nature	–1.062*	–0.111	.024	0.281	0.058	.289
Have a role model for environmental sensitivity	–0.326	–0.034	.464	0.468	0.096	.062
Student demographics						
Grade[1]	–0.964	–0.043	.409	–0.012	–0.001	.986
Gender[1]	–1.139	–0.051	.255	0.734	0.065	.192
Ethnicity[2]						
American Indian	–5.490*	–0.101	.024	2.694*	0.098	.050
Asian	3.476	0.055	.222	1.056	0.033	.509
Hispanic	–6.374***	–0.166	.000	–0.482	–0.025	.625
African American	–5.686***	–0.197	.000	0.652	0.045	.398
School demographics						
Median income of the county[4]	0.148**	0.144	.004	0.065*	0.125	.025
Urban[4]	–1.806	–0.078	.187	–0.253	–0.022	.743
Student/teacher ratio	–1.285***	–0.230	.000	–0.205	–0.073	.31
Teacher has master's[5]	4.545***	0.186	.000	0.171	0.014	.792
Intercept	55.230***		.000	39.185***		.000
Adjusted R^2	0.236			0.095		
N	405			405		

[1]0 = 6th Grade, 1 = 8th Grade. Random effects are significant (non-zero) in both models. 0 = Male, 1 = Female
[2]Reference category is Caucasian students
[3]The unit for median county income is $10,000.
[4]0 = Rural, 1 = Urban
[5]0 = no, 1 = yes

DISCUSSION

Although our results may hint at future impacts of SLEs on environmental knowledge and behavior, we found limited evidence that such relationships were already developed among NC middle school students. In Chawla's (1999) work, having a role model for environmental behavior was one of the most frequently mentioned factors that participants cited as influencing their involvement in environmental activism, however, we found only a limited relationship between the reported presence of such a role model and pro-environmental behavior among middle school children. These findings could be explained by the effect not being well-expressed until children reach adolescence and adulthood (Vollerberg, Iedema, & Raaijmakers, 2001), only occurring in special circumstances (e.g., a particular type of outdoor role model is required), impacting a

narrow suite of behaviors not included in this study, or only being present within a small subset of the general population.

The weak relationship between spending time outdoors and environmental knowledge and behavior is somewhat surprising but may reflect the changing relationship children have with nature. Other studies have shown a clear link between time outdoors and increased eco-affinity (Larson, Whiting, & Green, 2011) and pro-environmental behavioral intention (Cheng & Monroe, 2010). We would expect to see a similar relationship in this study. However, as Larson, Green, and Cordell (2011) found in an analysis of the National Kids Survey, the amount of time children are spending outdoors is relatively stable, but types of outdoor activities are changing, with more focus on organized activities such as sports, active recreation (e.g., jogging or biking), and use of electronics through geocaching or listening to music outdoors. The prominence of these activities is coupled with a pervasive shift away from nature-based use of national parks, which Pergams and Zaradic (2006) linked to increased technology use. Thus, the weaker-than- expected relationship between time outdoors and pro-environmental behavior found in this study may reflect a new form of time outdoors focused more on organized sports and technology and less on interaction with natural environments. Our finding that spending time outdoors alone or with family was more influential on pro-environmental behavior than time outdoors with organized groups supports this assertion.

Just as the use of electronics may be at least partially to blame for eroding the benefits of spending time outdoors, watching television may be associated with decreased ecological understanding. Chawla (1999) cited indirect experiences with nature, such as reading nature books, as an SLE identified as promoting environmental activism in adulthood, but in this study neither reading books nor magazines predicted environmental knowledge and watching television about nature was negatively associated with environmental knowledge and the strongest relationship demonstrated by an SLE-related variable. Intuitively, nature-related television would promote environmental knowledge, and at least one study found watching nature programming improved pro-environmental attitudes (Eagles & Demare, 1999). Future research should address the possibility that students who watched more nature-related television also watched more programming overall, and the negative effects of increased screen time may have overwhelmed and even reversed any gains attributed to nature-related television. Globally, there appears to be a shift away from nature-based recreation (Pergams & Zaradic, 2008), and an increase in the amount of exposure children have to television (Larson et al., 2011). Similarly, these two events may be linked, suggesting that people are spending less time outdoors because they are watching television, playing video games, or using the internet (Pergams & Zaradic, 2006). Our findings of a negative association between television time, even nature-related programming, and environmental knowledge echoes the growing research body demonstrating that increased exposure to television and computers over nature is damaging children's connection to and engagement with the environment (Kahn & Kellert, 2002).

Our findings highlight the need for research along several avenues to isolate the contexts in which SLEs produce the large and important effects on pro-environmental behavior highlighted in previous qualitative studies (Chawla, 1999; Palmer, Suggate, Bajd, & Tsaliki, 1998). Such research should expand in focus from adult subjects (e.g. Chawla, 1999; Corcoran, 1999; Wells & Lekies, 2006) to include more focus on adolescents and children. Such a shift could help determine when SLE-related variables begin to have an impact, and the relationship between the repetition of SLE-related experiences and eventual outcomes. Although SLE-related variables may not predict environmental behavior or knowledge in general, they may predict specific behaviors

and knowledge. Research instruments matching specific types of environmental behaviors with specific types of SLEs (e.g., being an environmental activist with having an adult mentor who was) would likely find stronger relationships, and help clarify more precisely how SLE-related variables influence environmental behaviors. Any contexts where self-reported activities and experiences can be replaced with observations of actual ones would strengthen such studies (Corral-Verdugo, 1997). The instruments used in this study may be useful in these efforts, particularly if more precise measures like hours watching television or hours participating in outdoor activities (vs. enjoyment) were included, and possibly an expanded measure of knowledge to include issue-specific (e.g., climate change) questions. Because we found strong relationships between ethnicity, income, knowledge, and behavior, special attention should be paid to ensuring items in future research instruments are not biased toward culturally limited ways of understanding the environment.

The relative importance of school-related variables compared to SLE-related variables suggests that in addition to encouraging EE in classrooms, improving the basic quality of education and improving equity in schools should continue to be part of EE efforts. Though we found only weak evidence for impacts of out-of-school SLE-related variables on environmental knowledge and behavior, use of EE curriculum and time outdoors during class time does seem to have an impact on student learning (Carrier, 2009; Coyle, 2010; Stevenson et al., 2013). In addition, small class sizes and teacher training improve student achievement in math, science, and reading (Finn & Achilles, 1999; Harris & Sass, 2011; Krueger, 2003), and our data suggest these factors also foster environmental knowledge. Ethnicity and income are associated with persistent achievement gaps, with lower income and ethnic minority students falling behind other groups (Kao & Thompson, 2003; Sirin, 2005; Stevenson et al., 2013). Similarly, just as lower-income students underperform in classroom environments (Sirin, 2005), income seems to affect environmental knowledge and behavior more than SLE-related variables. However, with the exception of income, these relationships were limited to environmental knowledge and did not extend to behavior. Native American students actually reported higher levels of environmental behavior than Caucasian students. Although there is little research specifically on pro-environmental behavior among Native Americans, some research suggests that Native American populations may participate in more outdoor activities, which are positively related to pro-environmental behavior, than Caucasian populations (Burger, Gochfeld, Jeitner, & Pittfield, 2012). Education literature suggests that low income and ethnic minority students are being left behind due to poor school quality in their neighborhoods (Cook & Evans, 2000), cultural views of schooling (Ogbu & Simons, 1998), and expectation bias among educators (de Boer, Bosker, & van der Werf, 2010). As our results largely mirror the trends found in the broader education literature, EE professionals should remain engaged in efforts to close achievement gaps in classrooms because the same factors creating inequity there appear to affecting environmental knowledge.

CONCLUSION

This study suggests that SLE-related variables may not be as integral to building pro-environmental behavior as previous research suggested. However, our findings highlight a critical need to actively reach out to lower income and ethnic minority students and improve teacher and classroom quality. Though environmental education is often seen as peripheral to K–12 education (Jickling, 1997), EE and outdoor education efforts may be more fruitful when included

in a school setting with teachers (Stevenson et al., 2013) than in less formal outdoor contexts. Further, promoting equity and quality in schools may be as essential to achieving the goals of EE as promoting SLE type experiences such as outdoor activities. Time outdoors does seem to be at least weakly correlated to pro-environmental behavior, and considering our finding that watching nature related television was negatively related to environmental knowledge among students, efforts should be continued to promote outdoor activities that encourage direct interaction with nature.

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APPENDIX: ENVIRONMENTAL KNOWLEDGE AND BEHAVIOR SCALES

Environmental Knowledge Scale

We used the Ecological Knowledge component scale from the 2009 Middle School Environmental Literacy Assessment (McBeth et al., 2011) to measure environmental knowledge:

1. A flower with colorful petals and a sweet smell would most likely be pollinated by:
   a. Rain.
   b. Wind.
   c. A gardener.
   d. Insects.

2. A small bird eats a butterfly that has been eating some nectar from a flower. Then, the bird is eaten by a hawk. This is an example of:
   a. Mutualism.
   b. A food chain.
   c. Competition.
   d. Survival of the fittest.

3. Which of the following is a predator-prey relationship?
   a. A flea bites a dog.
   b. A robin eats a worm.
   c. A fish eats aquatic plants.
   d. A deer eats grass that has a grasshopper in it.

4. A fox dies. This creates a problem for:
   a. The fleas that were drinking the fox's blood.
   b. A rabbit that has a nest nearby.
   c. Another fox whose territory is nearby.
   d. An animal that hunts in the same area that the fox did.

5. Termites eat only wood; however they cannot digest it. Tiny organisms that live in termites' stomachs and intestines digest the wood. The relationship the tiny organisms and the termites have is:
   a. Helpful to one and has no effect on the other.
   b. Helpful to one and harmful to the other.
   c. Helpful to both of them.
   d. Helpful to neither of them.

6. A seagull and a raccoon are after the same dead fish lying on the shore. What is the relationship between the seagull and the raccoon?
   a. One is using the other but not harming.
   b. They are competing with each other.
   c. They are helping each other.
   d. One is trying to eat the other one.

7. If there were no decomposers on Earth, what would happen?
   a. Dead plants and animals wouldn't become part of the soil.
   b. Many human diseases would disappear.
   c. More meat would be available for humans to eat.
   d. Little would change.

8. A mangrove forest is destroyed by humans. What will most likely happen to the animals that lived in the mangroves?
   a. Most will leave or die.
   b. They would have more babies to survive.
   c. Those that lived in the mangrove forest would adapt.
   d. Many will pass on traits that would help their young survive in the new environments.

9. Some people started a program in a national forest to protect deer. They started killing wolves. Ten years later, there were no wolves in the forest. For a few years after the wolves were gone there were more deer than there had ever been. Then suddenly there were almost no deer. The people who wanted to protect the deer didn't know that:
   a. Deer only live to be a few years old.
   b. Fires would kill so many deer.
   c. Other animals would eat so much of the deer's food.
   d. The deer would eat all the food and that many would starve.

10. The original source of energy for almost all living things is
    a. the sun.
    b. water.
    c. the soil.
    d. plants.

11. A dead bird is decomposing. What happens to the energy that was stored in the bird's body?
    a. Nothing happens to it. Once the bird is dead the energy is lost.
    b. It passes through the organisms that decomposed the bird.
    c. It is destroyed by solar radiation.
    d. The bird used up its energy when it was alive.

12. A rabbit eats some corn. The energy from the corn goes into the rabbit. The next day a fox eats the rabbit. The fox gets very little of the energy that was in the corn. Why?
    a. A fox can't digest corn.
    b. The rabbit had already digested the corn.
    c. Corn doesn't have much energy.
    d. Most of the corn's energy was used by the rabbit.

13. Most of the oxygen in the atmosphere comes from:
    a. Insects.
    b. Plants.
    c. The soil.
    d. The sun.

14. Which of the following would give humans the most food energy from 10,000 pounds of plants?
    a. Feed the plants to insects, feed the insects to fish, and then humans eat the fish.
    b. Humans eat the plants.
    c. Feed the plants to cattle then humans eat the cattle.
    d. Feed the plants to fish then humans eat the fish.

15. After living things die, they decompose. As a result of this process nutrients are:
    a. Released back into the environment to be recycled.
    b. Destroyed by the bacteria of decay.
    c. Changed from nutrients to oxygen and water vapor.
    d. Evaporated due to the heat produced during decomposition.

16. Which of the following is a part of the water cycle?
    a. Erosion.
    b. Ocean tides.
    c. Evaporation.
    d. Decomposition.

17. A pollutant gets into an ecosystem and kills a large numbers of insects. How might this affect the ecosystem?
    a. Plants are not damaged so it doesn't affect the ecosystem.
    b. It damages part of the ecosystem so it may affect the whole ecosystem.
    c. It kills only insects so the other animals in the ecosystem stay healthy.
    d. Most animals eat plants so it doesn't affect the ecosystem much.

Behavior Scale

We used the Behavior component scale from the Middle School Environmental Literacy Survey (McBeth et al., 2011) to measure environmental behavior:

Students indicated whether each statement was:

a) Very true
b) Mostly true
c) Not sure
d) Mostly false
e) Very false

1.) I have **not** written someone about a pollution problem.
2.) I have talked with my parents about how to help with environmental problems.

3.) I turn off the water in the sink while I brush my teeth to conserve water.
4.) To save energy, I turn off lights at home when they are not in use.
5.) I have asked my parents not to buy products made from animal fur.
6.) I have asked my family to recycle some of the things we use.
7.) I have asked others what I can do to help reduce pollution.
8.) I often read stories that are mostly about the environment.
9.) I let a water faucet run only when it is necessary.
10.) I close the refrigerator door while I decide what to get out of it.
11.) I have put up a birdhouse or a bird feeder near my home.
12.) I do **not** separate things at home for recycling.