ABSTRACT

STEVENSON, KATHRYN TATE. Building of Environmental Literacy among Middle School Students: The Role of In-School, Out of School, and Psychological Factors. (Under the direction of M. Nils Peterson).

Solving environmental challenges will require an environmentally literate citizenry, equipped with ecological knowledge, pro-environmental attitudes, problem-solving skills, and motivation toward environmentally responsible behaviors. This dissertation addresses three approaches to building environmental literacy (EL) among middle school students: through schools (Chapter 1), through activities outside of school (Chapter 2), and through understanding psychological factors that affect environmental perceptions (Chapter 3).

Chapter 1. This study examined school-wide EE programs among middle schools in North Carolina, including the use of published EE curricula and time outdoors while controlling for teacher education level and experience, student demographics, and school attributes. Our sample included an EE group selected from schools with registered school-wide EE programs, and a control group randomly selected from NC middle schools that were not registered as EE schools. Students were given an EL survey at the beginning and end of the spring 2012 semester. Use of published EE curricula, time outdoors, and having teachers with advanced degrees and mid-level teaching experience (between 3 and 5 years) were positively related with EL whereas minority status (Hispanic and black) was negatively related with EL. Results suggest that though school-wide EE programs may vary in effectiveness, the use of published EE curricula paired with time outdoors represents a promising strategy. Further, investments in both new and veteran teachers to build and maintain enthusiasm for EE may help to boost student EL levels. Middle school represents a pivotal time for influencing EL, as improvement was slower among older students.

Differences in EL levels based on gender suggest boys and girls may possess complementary skills sets when approaching environmental issues. Our findings suggest ethnicity related disparities in EL levels may be mitigated by time spent in nature, especially among black and Hispanic students.

Chapter 2. Significant life experience (SLE) research suggests 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.

Chapter 3. Though many climate literacy efforts attempt to communicate climate change as a risk, these strategies may be ineffective because among adults, worldview rather than scientific understanding largely drives climate change risk perceptions. Further, increased science literacy may polarize worldview-driven perceptions, making some climate literacy efforts counterproductive among skeptics. Because worldviews are still forming in the teenage years, adolescents may represent a more receptive audience. This study examined how worldview and climate change knowledge related to acceptance of anthropogenic global warming (AGW) and in turn, climate change risk perception among

middle school students. We found respondents with individualistic worldviews were 16.1 percentage points less likely to accept AGW than communitarian respondents at median knowledge levels, mirroring findings in similar studies among adults. The interaction between knowledge and worldview, however, was opposite from previous studies among adults, because increased climate change knowledge was positively related to acceptance of AGW among both groups, and had a stronger positive relationship among individualists. Thus, education efforts specific to climate change may counteract divisions based on worldviews among adolescents, versus polarize them as among adults.

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Building of Environmental Literacy among Middle School Students: The Role of In-School,
Out of School, and Psychological Factors

by
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DEDICATION

To all who taught me love of land, water, and creatures.

For all who will inherit them.

BIOGRAPHY

Kathryn Stevenson is a North Carolina native and grew up in Hickory. Seeds for her interest in environmental education were planted early, through camping trips with her family and many summers at the Green River Preserve, a camp set on 3,500 wooded acres in Western North Carolina. One of Kathryn's first teaching experiences was working as a camp counselor at Green River, leading daily hikes, afternoon activities like canoeing and rock climbing, and weekend backpacking trips.

Kathryn continued to develop her commitment to environmental education at Davidson College, where she earned a Bachelors of Science in Biology and minor in Spanish. She spent several terms abroad, studying wildlife management with the School for Field Studies in Kenya, interning at Hammond Ranch in Zimbabwe, and studying comparative tropical ecology and Spanish in Ecuador. On campus, she worked in Mike Dorcas's Herpetology Lab, where she started an outreach program for local schools; taking lab animals to classrooms, setting up cover board monitoring on elementary school campuses, and bringing K-12 students to work in the field with herpetology lab staff. She also started EcoTeam at Davidson, which trains undergraduate students to teach environmental education programs in third grade classrooms.

After college, Kathryn headed to California and spent six years teaching as an outdoor educator and classroom teacher. She first moved to Catalina Island to work for the Catalina Island Marine Science Institute at Toyon Bay. As a marine science instructor, she taught marine biology and island ecology through snorkeling, kayaking, and hiking. After

two years on Catalina Island, she moved to San Francisco where she taught high school science at Drew School. Though she was in the classroom, she still got her students outside through nearly weekly local field trips and extended trips to North Carolina, Kenya and Tanzania, and the Galapagos Islands.

Although she thoroughly enjoyed living and working on the west coast, Kathryn moved back to North Carolina where taught high school Biology at Woods Charter School before starting graduate school at NC State. At Woods Charter, Kathryn started a field-based aquatic and marine biology course as well as an enrichments program, engaging students in experiential education each Friday afternoon. She also led student trips to the NC coast, the Florida Keys, and Costa Rica. After two years at Woods Charter, Kathryn left classroom teaching for graduate school to pursue environmental education research. While at NC State, she also helped with the development of NC Environmental Literacy Plan and currently sits on the board of the Environmental Educators of North Carolina. She plans to continue her research as a post-doctoral scholar at NC State and hopes to transition to a faculty position or a career in environmental education program development and evaluation.

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CHAPTER 1: Environmental, Institutional, and Demographic Predictors of Environmental Literacy among Middle School Children

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Abstract

Building environmental literacy (EL) in children and adolescents is critical to meeting current and emerging environmental challenges worldwide. Although environmental education (EE) efforts have begun to address this need, empirical research holistically evaluating drivers of EL is critical. This study begins to fill this gap with an examination of school-wide EE programs among middle schools in North Carolina, including the use of published EE curricula and time outdoors while controlling for teacher education level and experience, student attributes (age, gender, and ethnicity), and school attributes (socio-economic status, student-teacher ratio, and locale). Our sample included an EE group selected from schools with registered school-wide EE programs, and a control group randomly selected from NC middle schools that were not registered as EE schools. Students were given an EL survey at the beginning and end of the spring 2012 semester. Use of published EE curricula, time outdoors, and having teachers with advanced degrees and mid-level teaching experience (between 3 and 5 years) were positively related with EL whereas minority status (Hispanic and black) was negatively related with EL. Results suggest that school-wide EE programs were not associated with improved EL, but the use of published

EE curricula paired with time outdoors represents a strategy that may improve all key components of student EL. Further, investments in teacher development and efforts to maintain enthusiasm for EE among teachers with more than 5 years of experience may help to boost student EL levels. Middle school represents a pivotal time for influencing EL, as improvement was slower among older students. Differences in EL levels based on gender suggest boys and girls may possess complementary skills sets when approaching environmental issues. Our findings suggest ethnicity related disparities in EL levels may be mitigated by time spent in nature, especially among black and Hispanic students.

Introduction

Direct responses to global environmental crises can slow the tide of environmental degradation, but reversing the trend will require an environmentally literate citizenry. These direct responses have included converting nearly 12% of the earth's land base to protected areas, which has undoubtedly altered the trajectory of species extinction (Convention on Biological Diversity, 2010). Similarly, international climate change treaties guided by the UN Framework Convention on Climate Change (UNFCCC) and carbon markets represent the seeds of a response to global warming (Schreurs, 2012). Comparable initiatives are associated with marine protected areas (Agardy, 1994), water conservation and quality (Brezonik & Cooper, 1994), and erosion mitigation (Liu, Li, Ouyang, Tam, & Chen, 2008). The existence of these programs and development of future responses, however, depend entirely on publics who understand ecology, care about the environment, possess skills to assess environmental risk, and share a commitment to sustainability.

These four attributes of a citizenry capable of achieving sustainability are reflected by the four components of environmental literacy (EL): Knowledge, Affect, Cognitive Skills, and Behavior (Hollweg et al., 2011). The environmental education (EE) movement revolves around promoting EL. Precursors to environmental education included both nature study and outdoor education early in the 19th century, but environmental education as a field gained momentum in 1977 with the first intergovernmental conference on environmental education organized by the United Nations Education, Scientific, and Cultural Organization (UNESCO). The ensuing Tbilisi Declaration established EE objectives, and subsequent

collaborations between environmental literacy experts have focused the definition of environmental literacy on the following topics: ecological knowledge, environmental attitudes and sensitivity, issue and action skills, and verbal and actual commitment to proenvironmental behavior (Hollweg et al., 2011; McBeth, Hungerford, Marcinkowski, Volk, & Meyers, 2008).

Environmental literacy helps to create a citizenry equipped to tackle current and emerging environmental concerns worldwide (Bickford, Posa, Qie, Campos-Arceiz, & Kudavidanage, 2012), and each component of EL is critical to this goal. Lack of empirical ecological knowledge about problems like extinction and climate change makes the problems insurmountable. For instance, a 2011 national poll found that 63% of adults in the United States “think there is solid evidence that the earth is warming,” which was down from 71% who saw solid evidence in 2008 (The Pew Research Center for the People & the Press, 2011). If citizens do not accept overwhelming scientific evidence of warming trends, behavior to mitigate effects of global warming and support for government policies is highly unlikely (Tobler, Visschers, & Siegrist, 2012). Similarly, even an empirically aware public must care about the environment, have skills required to identify problems and solutions, and a willingness to act before the problems can be adequately addressed. That these components of EL are necessary to ensure pro-environmental behavior is both intuitive and supported by research. Hines, Hungerford, & Tomera (1987) found that knowledge together with pro-environmental attitudes are requisites to environmentally responsible behavior, and a model has been further refined that includes in-depth knowledge about issues, personal

investment in the environment, knowledge of and skill in using action strategies, and intention to act (Hungerford & Volk, 1990), all key components of EL (Hollweg et al., 2011).

Classroom activities have limited ability to change some components of EL, notably emotional connection to the environment (affect) and environmental behavior (Rickinson, 2001), and outdoor education has been promoted as a solution to this challenge. Time outdoors has been linked with the affective components of EL, a key predictor for proenvironmental behavior (Judith Chen-Hsuan Cheng & Monroe, 2010). Duerdon and Witt (2010) found that classroom activities were associated with improved environmental knowledge whereas field experiences were correlated with improved affect which indirectly improved behavior by activating knowledge. Skelly and Zajicek (1998) also found time outdoors was a key predictor of pro-environmental attitudes in their evaluation of a gardening program. In Louisiana, horticulture teachers found that students participating in a program with an outdoor component were more aware of their role in the environment than students who did not participate in the program (Karsh, Bush, Hinson, & Blanchard, 2009).

The dire need for EL has spurred legislation in several nations as well as attention at international conferences. In the United States, the Environmental Education Act of 1970 was one of the first major pieces of EE legislation and established the US Office of Environmental Education. Internationally, both the 1975 Belgrade Charter out of an International Workshop on Environmental Education hosted by the United Nations Environmental Program (UNEP) and Educational, Scientific and Cultural Organization (UNESCO), as well as the 1977 Tbilisi Declaration, brought international attention to the

field of environmental education. Legislation stemming from these conferences included resolutions of the European Union Council of Environmental Education in 1988, the 1995 National Environment Statute in Uganda (Palmer, 1998), and the Environmental Education Act of 1990 in the United States, which reestablished the Office of Environmental Education after its elimination in the 1980s (Palmer, 1998). Most recently, a groundswell of support for connecting children to nature spurred the No Child Left Inside Act of 2011 (NCLII) in the United States, which would have provided \$100 million in funding for state EE efforts if passed. Though much of the aforementioned legislation supported specific programs, this act emphasized the role of outdoor education, integrated EE into formal schooling, and required the development of state EE standards, assessment, and teacher training through state-wide EL plans adopted by state boards of education (H.R. 2547, 2011).

Given the potential role of EL in addressing global environmental crises and the rapid expansion of EE around the world, there is surprisingly little empirical research addressing how EL is formed (Keene & Blumstein, 2010). Further, even less research utilizes before-after, treatment-control designs. Blumstein and Saylan (2007) suggest a “bunker mentality” within the environmental community may explain the reluctance to more formally evaluate the drivers of EL. Whatever the cause for limited evaluation, research addressing the drivers of EL is critical (Palmer, 1999). Although many studies examine factors contributing to at least one component of EL, (Bradley, Waliczek, & Zajicek, 1999; Karsh et al., 2009; Lisowski & Disinger, 1991), few if any address all four components or evaluate a broad suite of drivers. Efforts to standardize the way programs target and measure progress in all four

elements include the National Environmental Literacy Assessment (NELA) project (McBeth, Hungerford, Marcinkowski, Volk, & Cifranick, 2011; McBeth et al., 2008) and the 2011 Framework for Environmental Literacy Assessment (Hollweg et al., 2011). The NELA team developed the first major assessment tool for middle school students in the United States and the Framework project established guidelines for use in developing future assessment tools worldwide. Although these latest efforts have made progress in standardizing and measuring EL, no studies we are aware of have controlled for confounding factors including ethnicity, socio-economic background, school quality, and teacher training or addressed the degree to which specific EE efforts are effective in a school setting.

This study begins to fill the gap in EE research with an examination of participation in school-wide EE programs and how time spent in nature relates to EL in North Carolina, USA middle schools. We also accounted for use of published EE curricula; student attributes of gender, age, and ethnicity; teacher attributes of education level and years of experience; and school attributes of economic status, urban status, school type (charter or private vs. traditional public) and student-teacher ratio. We hypothesized that students' EL scores would be: (1) positively related to participation in school-wide EE programs and use of published EE curricula, (2) positively related to class time spent in nature, (3) positively related to teacher development, measured by both having an advanced degree and years of teaching experience, (4) negatively related to student attributes historically associated with low academic performance (e.g., interest and performance in science wanes with student age (Fouad & Smith, 1996), girls score lower than boys in science (Neathery, 1997), and

minority students score lower than white students in other academic areas (Osborne, 2001)), and (5) negatively related to student-teacher ratios and enrollment in lower-income schools.

Materials and Methods

Ethics statement

The North Carolina State University institutional review board (IRB # 2212) approved this study. All participants provided written informed consent. Students and their parents/guardians were given either a Passive Consent form or an Active Consent form, per the preference of the teacher and/or school. The Passive Consent form was only signed and returned if the parents/students did not want to participate. The Active Consent form was signed and returned to indicate consent to participate in the study.

Sample selection

We targeted 6th and 8th grade students because middle school students are developing cognitive abilities linked to the goals of EL and represent the latest and prime stage for influencing how students engage in society as citizens and environmental decision makers (McBeth et al., 2008). Additionally, we chose 6th and 8th graders so we could compare our results with the only other large scale assessment of EL available at the time that our study was conducted – Phase 1 of the National Environmental Literacy Assessment Project (McBeth et al., 2008).

Sampling occurred in three stages: schools, teachers, and classrooms. We followed the three stage sampling model for two groups – an EE group randomly selected from schools registered with the NC Office of Environmental Education as having school-wide EE

programs, and a control group randomly selected from 6th and 8th grade science classes in North Carolina that were not registered with the Office of Environmental Education. We generated the first stage of the EE sample from a list of all schools registered with the NC Office of EE ($n = 40$). We generated the first stage of the control sample from a list of all 665 middle schools in North Carolina. We omitted the 40 schools already included in the EE group and then randomly selected 40 schools for the control group from the remaining 625 schools.

From the two lists of 40 schools, we generated a list of 6th and 8th grade science teachers at each school. This process resulted in 135 teachers in the control group and 95 teachers in the EE group. We randomly selected 85 teachers from each group to recruit for the study and e-mailed each a letter of introduction and a brief recruitment survey. We sent up to four survey reminders to each teacher in 4–7 day increments. Of the 170 teachers contacted, 59 (34.7%) responded, and of these, 21 declined to participate and 38 consented, representing 20 members of the control group and 18 members of the EE group. Two teachers from each group later withdrew from the study. The 64% compliance rate among teachers who we successfully contacted could allow for bias if participating teachers were more environmentally oriented than other teachers. Because evaluating drivers of EL was more important than extrapolating findings to general assessments of EL in NC, this potential bias should not be problematic. Further, we measured teachers' environmental orientations using the New Ecological Paradigm scale (Dunlap, Liere, Mertig, & Jones, 2000) and their scores were not related to student scores on the MSELs ($r = -0.0186$, $p = 0.614$), so if

participating teachers were more environmentally oriented than others it should not bias student scores. Entering the pretest, we had 18 teachers participating from the control group (ten 6th grade and eight 8th grade teachers) and 16 teachers participating in the EE group (four 6th grade teachers and twelve 8th grade teachers). Though we contacted equal numbers of teachers in the control and EE groups and in 6th and 8th grades, differential teacher response rates prevented equal classroom numbers. If a teacher taught more than one 6th or 8th grade class, we asked them to flip a coin to randomly select one class for participation.

Survey instrument

All students in the study were given the Middle School Environmental Literacy Survey (MSELS) developed by the NELA team (McBeth et al., 2011, 2008). The MSELS consists of eight sections that contribute to an overall environmental literacy score (Table 1). The MSELS was based on four instruments that reported established high validity and reliability – the Middle School Environmental Literacy Instrument (Bluhm, Hungerford, McBeth, & Volk, 1995), Children’s Environmental Attitude and Knowledge Scale (Leeming, Dwyer, & Bracken, 1995), the Secondary School Environmental Literacy Assessment Instrument (Marcinkowski & Rehrig, 1995), and the Ecology Attitude Inventory (Maloney, Ward, & Braucht, 1975). In the 2008 national survey using the MSELS, the Chronbach alpha coefficients for each component of the MSELS fell between 0.701 and 0.869 with the exception of a three-item Issue Identification scale with an alpha coefficient of 0.389. The total reliability for the MSELS in this 2008 study was 0.82 (McBeth et al., 2008). Teachers were given a separate survey that asked about their use of EE, the degree to which they take

their students outside, and their own training. Key questions included whether they use a published EE curriculum (e.g. Project WET, Project WILD, Project Learning Tree), if they visit natural areas during class time, and their experience in education and EE.

Data collection

In January of 2012, we visited all 34 classrooms. We administered the MSELs to the students and asked each teacher to complete the teacher survey. From April 11 to June 6, 2012, we returned to the same classrooms and administered the post-test (using the MSELs again) to the students. While visiting each classroom for the post-test, we also asked teachers to complete a shorter follow-up survey that asked about the time they spent outdoors with the participating class, their use of EE, and any further EE training they had received since the pretest.

We surveyed 856 students during the pretest and 846 during the post-test. We eliminated students who were absent during either the pretest or the post-test from the pre/post-test comparison yielding 739 students in the comparison. Use of published EE curricula and time spent outdoors were reported by the teachers in the teacher surveys at the time of the pretest and confirmed by the follow-up survey at the time of the post-test. Teacher attributes of higher education and years teaching experience were self-reported as questions in the teacher survey. Student attributes of age, gender, and ethnicity were self-reported as questions within the MSELs. For school attributes of locale, school-level socioeconomic status (SES) measured by Title I status, student/teacher ratios, and charter or private school designation, we used data from the National Center for Education Statistics.

The Title I program is authorized by the Elementary and Secondary Schools Act to give additional funding to schools with high percentages of low-income students (107th Congress, 2002), and Title I status can be used as a measure of school-level SES. 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 (National Center for Education Statistics [NCES], 2006). We collapsed these categories into urban (including all size cities and suburbs) and rural (including all size towns and rural areas).

Data analysis

We analyzed data using STATA software, version 12.1. Multiple linear regression analysis was used to model component scores for the pretest and the difference between the post-test and pretest as a function of membership in the EE group, spending time outdoors as reported by the teacher at the end of the study, use of published EE curriculum, teacher education level (Master's degree or higher), years teaching experience, student attributes (age, gender, ethnicity) and school attributes (student/teacher ratio and Title I program). We also controlled for school locale and type of school (private or charter vs. traditional public) in all models. To account for the fact that students within the same classroom also are exposed to the same teacher and school attributes, we included a random effect for class. This approach captures the likelihood that students within the same classroom may have similar EL levels as opposed to independent random deviations of student scores.

Additionally, we calculated robust standard errors to account for the possibility of unequal variances between individual students (Stock & Watson, 2007).

For each analysis (pretest and difference in scores), we modeled each component of the MSELs (Knowledge, Affect, Cognitive Skills, and Behavior) as well as Overall EL using the aforementioned independent variables. We calculated each of these scores according to the guidelines listed in the Phase One NELA study (McBeth et al., 2008). This method weighted the four components in the MSELs to contribute equally to the Overall EL score. When modeling the change in MSELs scores, we also included the pretest score as a predictor to control for the fact that students scoring high in the pretest had less potential for improvement in the post-test.

Modeling both pretest scores and modeling how scores changed between the pretest and post-test was necessary because pretest scores reflected EL levels when students entered the study in January, half way through the school year. Spring testing was conducted to facilitate comparisons with other studies using the MSELs (McBeth et al., 2011, 2008). This meant that students had already been in their respective classes for several months – with the same teacher, often employing the same curricular strategies including use of environmental and outdoor education. Some variables may predict pretest scores and not change in EL, because the impact of that particular variable was exerted during first semester of the school year. Thus the pretest models allow assessment of variables with relatively rapid impacts whereas the change model allows assessment of the variables that may not have exerted a discernible effect during the first semester.

Results

Descriptive statistics

There were 415 students in the control group (240 6th graders and 175 8th graders) and 324 students in the EE group (70 6th graders and 254 8th graders). Almost half (49.1%) of the students in the study spent some class time outdoors and 42.1% were exposed to published EE curricula. The average student age was 12.7 years, and there were slightly more females (53.1%) than males. The students were primarily white (70.6%) and black (14.6%), with smaller percentages of Hispanic students (8.2%), Asian students (3.4%) and Native American/Alaskan students (3.3%). Half (50.0%) of the teachers in the study held Masters degrees, and the average experience level was 9.2 years teaching. Over half of the students were from schools with Title I programs (56.3%), and from rural communities (66.0%). The average school-wide student-teacher ratio was 14.6, and 26.8% of the students in the study were enrolled in Charter or private schools. Average pretest Cognitive Skills were considerably lower than the other three components measured in the MSELs (Table 1.1).

EE and outdoor education

Our results partially support hypothesis 1 because attendance at EE schools often had either a non-significant or negative relationship with EL, but classroom engagement in published EE curriculum was positively related to EL. Students in the EE schools pretested lower in Affect and Behavior (Table 1.2) and changed in the same ways as the control group over the course of the semester (Table 1.3). Further, membership in the EE schools was the most important negative predictor of pretest scores for the Affect component (Table 1.2).

The explanatory power of the Affect and Behavior pretest models was low ($R^2 = 0.071$ and 0.054 , respectively), suggesting that although there was a negative relationship between school-wide EE programs and Affect and Behavior scores, important drivers of Affect and Behavior (e.g., behavioral norms, values (Stern, 2000), parental attributes, presence of a role model for environmental stewardship (Chawla, 1999)) were not accounted for in the models. Although all schools in the EE group were registered with the NC Office of Environmental Education as having EE programs, only four of the teachers in this group indicated that their students participated in a formal EE program. Similarly, none of the teachers in the control group were associated with schools registered with the Office of EE, but three reported their students participated in a formal EE program.

Students exposed to published EE curricula improved more than students who were not, especially with respect to Cognitive Skills. Four teachers in the control group and six teachers in the EE group reported use of a published EE curriculum. The most frequently used EE curriculum was Project WILD (29.1% of students exposed) followed by Project WET (28.2%) and Project Learning Tree (12.8%), although most teachers reported to using multiple curricula and at least 13 curricula were listed. Students whose teachers used at least one published EE curriculum entered the study pretesting higher on Overall EL (Table 1.2). Students engaged in a published EE curriculum also improved more than other students in the Cognitive Skills component and Overall (Table 1.3, Figure 1.1). The use of published EE curricula was the only positive predictor of the change in the Cognitive Skills component measured in this study (Table 1.3).

Both the pretest and change in EL models support hypothesis 2 by suggesting that taking students outside was positively related to EL. Spending time in nature was positively related to the pretest scores for all components except Cognitive Skills ($p=0.09$) and was the most important factor predicting the Affect pretest scores in terms of significance and magnitude (Table 1.2). Time outdoors was the most important positive predictor of change in the Behavior component along with whether the teacher had a Master's degree (Table 1.3).

Teacher attributes

Our results support hypothesis 3 by suggesting teacher development, primarily through advanced degrees, is associated with improved EL among students. Teachers with Master's degrees had students who pretested higher in all components of EL except for the Cognitive Skills component (Table 1.2), and those same students improved more than others in the Behavior component (Table 1.3). Of the teachers that had Master's degrees, most (75%) held a degree in education or science education. Advanced degrees for teachers had the most important positive relationship with the pretest of Knowledge in terms of magnitude and significance (Table 1.2). The relationships between student EL and teacher experience were mixed. Teachers with 3–5 years of teaching experience had students that outperformed those with fewer than 3 years of teaching experience in the pretest of Cognitive Skills and Overall EL (Table 1.2, Figure 1.1). Teachers with 6 or more years of experience had students that pretested lower in Behavior than teachers with fewer than three years of experience (Table 1.2). Students with teachers of 6–8 years teaching experience also did not improve as much in Affect as those with teachers with fewer than 3 years of experience.

Student attributes

Our results support hypothesis 4 in terms of ethnicity and age but are mixed with regards to student gender. Girls pretested lower than boys in Knowledge but higher in Affect and Cognitive Skills (Table 1.2), although they improved more than boys in Knowledge (Table 1.3). Older students performed the same as younger students in the pretest (Table 1.2) and improved less than younger ones in Behavior and Overall scores (Table 1.3, Figure 1.1). Minority students fell behind in several components of EL. Native American students pretested lower than white students in the Knowledge and Cognitive Skills components as well as Overall (Table 1.2, Figure 1.1) and improved more slowly than white students in Cognitive Skills during the semester (Table 1.3). Hispanic students followed the same pretest patterns as Native American students (Table 1.2, Figure 1.1), but improved as much as white students over the course of this study (Table 1.3). Black students entered the study behind white students in the same areas as Native American and Hispanic students (Table 1.2, Figure 1.1), however, they improved more slowly than white students in all three of these areas (Table 1.3). Students self-identifying as black compared to white was the most important negative predictor in Knowledge, Cognitive Skills, and Overall EL in terms of significance and magnitude (Table 1.3, Figure 1.1).

Because we saw pronounced differences in EL levels related to ethnicity (Table 1.2, Table 1.3), we also tested interaction terms between ethnicity and time outdoors. Though the full models were minimally impacted, several of the interaction terms between time outdoors and Hispanic ethnicity were significant. Specifically, these interaction terms were significant

in the pretest of Affect (Beta = 3.639, $p = 0.012$) and Behavior (Beta = 4.893, $p = 0.016$). Additionally, the interaction term between time outdoors and black ethnicity approached significance at the $\alpha = 0.05$ level (Beta = 1.412, $p = 0.099$) for the Behavior pretest. These findings suggest that time outdoors may impact some components of EL more for Hispanic and black students than for white students. The main effect of time outdoors approached significance (Beta = 0.667, $p = 0.058$) in the pretest Affect model with the inclusion of the interaction terms, suggesting that although the relationship is stronger among minority students, Affect scores are still positively associated with time outdoors among white students. The time outdoors main effect was not significant in the pretest Behavior scores, suggesting that time outdoors is positively related to Behavior scores among Hispanic students but not significantly among white students. None of the interaction terms were significant for the change in EL models.

School attributes

The type of school students attended was related to some areas of EL, supporting hypothesis 5. In the pretest, schools with a higher student/teacher ratio were behind in Knowledge, Title I schools were behind in Behavior, and Charter and Private schools outperformed public schools in Behavior (Table 1.2). None of these school attributes were significantly related to change in EL over the semester (Table 1.3). Urban and rural schools performed the same in the pretest, although students in urban schools improved more slowly than those in rural schools over the semester in Cognitive Skills (Table 1.3). Overall, school attributes had the weakest relationships with EL (Table 1.3, Figure 1.1).

Discussion

EE and outdoor education

The surprising relationship, or lack thereof, between EL and school-wide EE programs (hypothesis 1) may be explained by how EE programs are defined and operationalized. The EE schools were drawn from a list of school-wide EE programs maintained by the NC Office of Environmental Education. Although there are specific qualifications listed on the website, teachers can register their own school based on a personal assessment of their school's EE program (NC Office of Environmental Education, 2011). The low percentage of teachers in EE schools as well as similar percentage of teachers in control schools that stated their students participated in an EE program during the study suggests attendance at an EE school had limited impact on whether a given student was actually exposed to EE programming. Further, teachers may enroll their schools because they perceive deficiencies in EE programming. This may explain why we found a negative association between membership in the EE schools and pretest Affect and Behavior scores. Ultimately, we suspect our findings related to attendance at EE schools have less to do with the efficacy of school-wide EE programs than with how those programs are defined. School-wide EE efforts may in fact be highly effective at building EL and other skills (Ernst, 2007; State Education & Environment Roundtable [SEER], 2000), but our results suggest effective evaluations of school-wide EE programs will need to account for what is happening in individual classrooms.

Although there may be some confusion about what constitutes a school-wide EE program, the use of published EE curricula in classrooms is less ambiguous, and our results

suggest their use may improve EL. Use of EE curricula was the only variable that was significantly linked to both higher pretest scores and improved Overall EL over the semester. Most of this impact was in the Cognitive Skills component, which is not surprising as guidelines for K-12 EE curricula emphasize ecological knowledge and awareness as well as cognitive skill building (NAAEE, 2004). These skills focus on identifying and analyzing complex issues as well as action planning and forming solutions. While many EE programs are content-specific to wetlands (e.g., Project WET), wildlife (e.g., Project WILD), or forests (e.g., Project Learning Tree) (Eick, Carrier, Perez, & Keasal, 2010), the fostering of Cognitive Skills in all of these published EE curricula equip students to engage in and respond to more complex issues including climate change, biodiversity loss, and water quality problems. Studies through the State Education and Environment Roundtable suggest Cognitive Skills built through EL improve academic achievement in reading, writing, math, science, and social studies test scores (State Education & Environment Roundtable [SEER], 2000). Accordingly, use of published EE curricula may be an important tool for improving student achievement in key academic areas beyond EL.

Time spent outdoors complements the use of published EE curriculum by addressing all components of EE other than Cognitive Skills. The relationship with the Affect pretest is not surprising as time outdoors has been linked to improvement in environmental attitudes and intentions (J. C.-H. Cheng & Monroe, 2010). Although time outdoors did not predict a change in Affect, time students spent outside in the fall may have already impacted Affect scores. We did, however, see that time outdoors was associated with improvement in

Behavior scores. As improvement in attitudes is generally linked to pro-environmental behavior (Guagnano, Stern, & Dietz, 1995; Poortinga, Steg, & Vlek, 2004), our data may show that time outdoors fosters pro-environmental attitudes and higher levels of environmental sensitivity which over time leads to more environmentally friendly behavior. Time outdoors also correlated with higher pretest scores in the Knowledge component. Time outdoors can improve student attention in children (Taylor & Kuo, 2009) and is linked to elevated creativity and improved problem solving skills in adults (Atchley, Strayer, & Atchley, 2012), which may explain why contact with nature may improve the more purely academic areas of EL (i.e., Knowledge). Because time outdoors was positively correlated with all areas except Cognitive Skills, use of published EE curriculum and time outdoors together represent a potentially powerful strategy for increasing EL. Our results add to the growing chorus of support for taking kids outside by suggesting outdoor education can promote EL in addition to social (Burdette & Whitaker, 2006), mental (Wells & Evans, 2003), and physical health (Potwarka, Kaczynski, & Flack, 2008).

Teacher development

Teacher development may be more important than curriculum in terms of predicting EL and may influence EL faster than curriculum. Further, the benefits of teacher development (having a Master's and 3–5 years of experience) appear to have been largely expressed in the pretest after only one semester of the course. The recent focus on teacher effectiveness in education reform has resulted in numerous studies on how teacher development affects student performance, and the results are mixed. Advanced degrees in

education seem to have little or inconsistent effect on overall student performance (Goldhaber, 2002), although subject-specific degrees (e.g. a MS in Biology for science teachers) do seem to have significant impact in Math and Science (Goldhaber & Brewer, 1996). As most (75%) of the advanced degrees among the teachers in our study are in education or science education, it appears that our results may conflict with those suggesting training in education does not impact student learning (Rockoff, 2004). Our results suggest that a strong background in pedagogical theory and technique is associated with improved student EL.

Interestingly, the relationship between teacher experience and student EL was non-linear. Education literature suggests teacher effectiveness, measured by student achievement, increases rapidly in the first three years of teaching, afterward plateauing for teachers who stay in the profession at least five years (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2008; Clotfelter, Ladd, & Vigdor, 2007). This trend is either attributed to the benefits of on-the-job training provided for early career teachers or the possibility that less-effective teachers leave the profession quickly while more-effective teachers continue teaching past the first few years (Henry, Bastian, & Fortner, 2011). Our results add to this research by suggesting that the relationship between teaching experience and student achievement in EL plateaus (e.g., for Cognitive Skills scores in the pretest) after reaching a threshold around 5 years. Specifically, moderately experienced teachers (3–5 years of experience) seem to be more effective at fostering EL, particularly Cognitive Skills, than new teachers, but this effect is not present when considering teachers with more than five years of experience. As

this finding parallels research related to teacher experience and other areas of student achievement, perhaps the similar factors of on-the-job training and attrition affect EL. With respect to the pretest of Behavior and change in Affect scores, however, teachers with more than 5 years of experience had students that underperformed those with new teachers. One explanation may be related to loss of idealism and increasing burnout associated with more years of teaching experience (Schamer & Jackson, 1996). Several studies have suggested inadequate administrative support poses a barrier to inclusion of EE (Ernst, 2009) and may contribute to waning enthusiasm and commitment to EE among teachers. Teachers can become increasingly discouraged when not given support to expand use of EE through training or curriculum development (May, 2000). Efforts to promote teacher enthusiasm among veteran EE teachers may be just as important as similar efforts in other disciplines (Rosenholtz, 2008), despite the enthusiasm demonstrated by many EE teachers.

Student attributes

Our results suggest student attributes have strong relationships with EL, and challenges associated with ethnicity and early education identified in general education research apply to EE efforts as well. Age was negatively related to the change in Behavior and Overall EL, but had no relationship to the pretest in EL, suggesting that while middle school students have similar EL levels among grade levels, older students are slowing down in terms of improvement. This trend is mirrored in research that suggests early education has more bearing on student achievement and even certain measures of life achievement than education efforts with older students (Gorey, 2001). Additionally, older students tend to

wane in their interest in science and math in the middle school years (Fouad & Smith, 1996), which could also explain the slower rate of EL improvement among eighth graders. These findings suggest middle school grades may include an age related tipping point where EE efforts start becoming less effective in promoting EL. We are not arguing that older students cannot benefit from these efforts; rather younger students may have the greatest capacity for learning. Further, the most readily available EE curricula may be more effective for 6th grade students than 8th grade students.

Gender was related to EL in complex ways. Although girls underperformed boys in the pretest for Knowledge, they outperformed them in Affect and Cognitive Skills and improved faster in Knowledge over the course of the semester. The gap in the Knowledge pretest is supported by similar gender trends in science (Ma, 2008). However, as girls entered the study with more pro-environmental attitudes and higher levels of Cognitive Skills, they were perhaps better positioned for improvement in Knowledge. Girls often underperform boys in the sciences (Ma, 2008), but numerous studies have shown that women and girls hold more positive environmental attitudes and greater levels of concern for the environment (Stern, Dietz, & Kalof, 1993; Zelezny, Chua, & Aldrich, 2000). Although overall EL did not differ based on gender, the internal differences associated with Knowledge, Affect, and Cognitive Skills suggest routes to more effective teaching. For example, teachers could use the differing strengths associated with gender to facilitate boys sharing their higher levels of Knowledge with girls while encouraging girls to express their pro-environmental attitudes and utilize their Cognitive Skills to help boys put their

Knowledge to use. This strategy could be particularly effective in problem-based group work simulating environmental decision-making.

Ethnicity related differences in EL seem to mirror general education trends; however, the implications may be more complex in EL contexts. Much attention has been paid to achievement gaps between minority students and white students in education literature, and most studies find that individual and school level socio-economic status (SES) are confounded with ethnicity (Alexander, Entwisle, & Olson, 2001; Freyer Jr. & Levitt, 2004; Kao & Thompson, 2003). These scholars suggest achievement differences are more an issue of poverty than culture. We controlled for school level SES (Title I status), but the differences in EL scores predicted by ethnicity may be at least partially explained by individual SES data. Other explanations for these achievement gaps range from how views of schooling fit into cultural narratives (Ogbu & Simons, 1998) to how teacher expectation bias affects student performance (Boer, Bosker, Werf, de Boer, & van der Werf, 2010).

Although it is possible that achievement gaps in EL are rooted in the same causes as those in other academic areas, differences in cultural perception of the outdoors and access to natural areas may also come into play. Minority groups experience more constraints to natural area access and can be culturally excluded from outdoor recreation (Finney, 2005; Shores, Scott, & Floyd, 2007). In considering outdoor recreation, safety is of particular concern to some minority groups, including blacks and Hispanics, which may lead to minority children spending less time outdoors than their white counterparts (Shores et al., 2007). Additionally, a disproportionately high exposure to environmental risk and decreased

availability of natural areas among minority children offers another explanation for the disparities in EL shown in our results (Strife & Downey, 2009). If minority students are exposed to the outdoors less than white students, it would follow that in-school outdoor experiences could have more impact on EL among minority students. Outdoor experiences and contact with nature can be particularly effective in closing gaps in environmental attitudes and awareness associated with ethnicity (Larson, Castleberry, & Green, 2010). The interaction between time outdoors and Hispanic and black students suggest that time outdoors was particularly important in predicting the pretest of Affect and Behavior components among Hispanics and the pretest of Affect among black students. Exposure to nature could help mitigate EL gaps associated with ethnicity, at least among Hispanic and black students. This relationship could be a fruitful area of future study, including the amount, type, or quality of outdoor experience and its impact on EL levels of minority students.

School attributes

School characteristics were related to EL in somewhat expected ways. Lower socio-economic status (SES) is generally associated with lower academic achievement (Freyer Jr. & Levitt, 2004), but we did not detect this relationship for any dimension of EL except Behavior. Generally, income has been positively associated with environmental behavior (Gamba & Oskamp, 1994; Straughan & Roberts, 1999). Schools with Title I programs have a higher proportion of lower-income students who, according to these studies, may be less inclined toward environmental concern and behavior. However, more recent literature shows

that the link between income and environmental concern is fading and is context dependent (Mainieri et al., 1997; Samdahl & Robertson, 1989), which may explain why we found no difference in most EL components associated with SES. In addition to lower SES, bigger class sizes are generally associated with lower academic performance (Darling-hammond, 1999; Schwarts, Schmitt, & Lose, 2012). Our results support this research with a weak negative association between student-teacher ratios and the Knowledge pretest. The relatively low importance of school attributes is encouraging, because curriculum and teacher development are more easily changed than poverty, school types (e.g. charter vs. traditional) or locales.

Conclusions

Achieving EL through K–12 education is a critical step to creating a public equipped to meet and solve environmental challenges. This study highlights key ways to ensure investments in EE promote EL and ultimately lead to a sustainable future. First, we suggest using published EE curricula and time outdoors in tandem because taken together they foster all four components of EL among middle school students. Published EE curricula including Project WILD, Project WET, and Project Learning Tree were particularly effective at building Cognitive Skills. Future research should address whether other curricular innovations (e.g., service learning) could better engage older students. Time outdoors is one of the only factors that significantly impacts Knowledge, Affect, and Behavior. School-wide EE programs will fail to achieve EL gains unless these programs include tangible changes to curricula in classrooms. Second, despite the informal and volunteer nature of many EE

efforts, advanced degrees and years teaching experience are as important in EE as they are in other academic disciplines. EE efforts may improve if advanced degrees among teachers are promoted and teachers are retained for longer periods. The stabilization or even decline in teacher effectiveness after 5 years of experience highlights the need for training, administrative, and structural support for teachers that maintains their enthusiasm and commitment to EE over the long run. Gender based differences in EL appear to complement one another (with each gender excelling in areas where the other does not), suggesting teachers have synergistic opportunities to raise EL levels among both boys and girls. The relationship between ethnicity and EL reveal that although time outdoors may be effective for all students, it may be especially effective for engaging black and Hispanic students.

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^a Used published environmental education curriculum (No = 0, Yes = 1)

^b Spent time in outdoors during class time (No = 0, Yes = 1)

^c Teacher holds Masters degree (No = 0, Yes = 1).

^d Reference group is teachers with 0-2 years teaching experience (0-2 years = 0, 3-5 years = 1, 6-8 years = 2, 9-11 years = 3, 12 or more years = 4)

^e Reference group for student ethnicity is white students.

Figure 1.1. Significant predictors of pretest and change in EL. Variables present represent the significant predictors of pretest and/or change in Overall environmental literacy from the full models represented in Table 1.2 and Table 1.3. Pretest scores represent total MSELs score at time of pretest and change in scores represents difference between pretest and post-test scores attributed to each variable independent of the others in the model.

Table 1.1. Summary of MSELs contents and average pretest scores (McBeth et al., 2008). The MSELs was organized into eight specific concept variables that were grouped into four environmental literacy concept component scores. Average pretest scores for the total sample are shown in raw score and percentage of maximum score for each component.

Environmental Literacy Concept	Specific Conceptual Variables	Sample question	# of Items	Maximum Score	Average pretest score	Average pretest score %
Ecological Knowledge (Multiple choice)	Ecological Knowledge	If there were no decomposers left on Earth, what would happen?	17	60	44.0	73.3%
Environmental Affect and Awareness (5-point Likert Scale)	Verbal Commitment (intention)	To save water, I would be willing to use less water when I bathe.	12	30	23.3	80.0%
	Environmental Sensitivity	To what extent do you spend time outdoors alone?	11	25	18.8	
	Environmental Feeling	I love the environment.	2	5	4.0	
Cognitive Skills (Multiple choice)	Issue Identification	These three sections involve reading a passage, identifying the issues at hand, analyzing what factors are at play, and planning a course of action.	3	20	8.0	41.0%
	Issue Analysis		6	20	10.5	
	Action Planning		1	20	8.2	
Behavior (5-point Likert Scale)	Actual Commitment	I do <u>not</u> separate things at home for recycling.	12	60	47.0	78.3%
Total Score				240	163.6	68.2%

Table 1.2 Pretest MSELs Scores. Each labeled column represents a separate multiple regression model for each section of the MSELs as well as total scores (N = 731). Metric coefficients and p-values are displayed. Each model includes random effects for classroom and all standard errors are robust.

Variable	<u>Knowledge^a</u>		<u>Affect</u>		<u>Cognitive Skills^a</u>		<u>Behavior</u>		<u>Overall MSELs Score^a</u>	
	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>
EE Group ^b	1.871	0.058	-1.782***	<0.001	4.497	0.079	-1.328**	0.004	3.092	0.309
Use of Published EE Curriculum ^c	0.647	0.540	0.281	0.419	4.095	0.055	-0.123	0.752	4.801*	0.045
Time in Natural Areas ^d	2.366*	0.020	1.188***	<0.001	2.65	0.090	0.725*	0.035	6.935**	0.001
Teacher Has Masters ^e	5.259***	<0.001	1.054**	0.010	2.469	0.224	1.362***	<0.001	10.248***	<0.001
Years Teaching ^f										
3-5 Years	3.320	0.200	0.345	0.656	9.685***	<0.001	-0.522	0.32	11.995**	0.004
6-8 years	0.199	0.911	0.001	0.998	3.418	0.122	-1.980***	<0.001	1.081	0.732
9-11 years	-0.809	0.683	-0.635	0.375	5.05	0.155	-1.602**	0.004	1.362	0.780
12 or more years	0.278	0.869	0.813	0.229	5.441	0.145	-1.870**	0.005	4.505	0.248
Student Age (in years)	-0.483	0.477	-0.150	0.414	-0.344	0.645	0.249	0.270	-0.272	0.845
Student Gender (Female) ^g	-1.936**	0.001	1.234**	0.001	2.208**	0.009	0.391	0.360	1.766	0.151

Table 1.2 Continued

Variable	<u>Knowledge^a</u>		<u>Affect</u>		<u>Cognitive Skills^a</u>		<u>Behavior</u>		<u>Overall MSELs Score^a</u>	
	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>
Student Ethnicity ^h										
<i>American Indian</i>	-7.311***	<0.001	0.426	0.661	-5.683*	0.018	1.812	0.165	-11.041**	0.001
<i>Asian</i>	2.132	0.147	1.081	0.155	1.969	0.493	0.495	0.686	5.986	0.108
<i>Hispanic</i>	-5.611***	<0.001	0.115	0.892	-4.179*	0.044	-0.264	0.822	-10.183**	0.001
<i>Black</i>	-5.307***	<0.001	0.018	0.970	-5.865**	0.003	0.500	0.384	-10.441***	0.001
Student/Teacher Ratio ⁱ	-0.561*	0.020	0.007	0.947	-0.336	0.491	0.166	0.066	-0.686	0.285
Non-public School ^j	0.482	0.712	0.449	0.263	-0.268	0.928	1.362**	0.002	1.837	0.565
Title I Program ^k	-1.388	0.100	-0.626	0.152	0.401	0.838	-1.958***	0	-3.823	0.149
Urban ^l	0.703	0.452	-0.111	0.754	3.31	0.109	0.332	0.387	4.338	0.119
Constant	50.692***	<0.001	45.213***	<0.001	20.480**	0.004	45.294***	<0.001	160.509***	<0.001
Adjusted R ²	0.219		0.071		0.168		0.045		0.217	
Rho	0.045		0.010		0.124		0.000		0.078	

^a Random effect is significant (non-zero), and rho is the proportion of residual variance explained by the within classroom effect.

^b EE group membership (No = 0, Yes = 1)

^c Used published environmental education curriculum (No = 0, Yes = 1)

^d Spent time in outdoors during class time (No = 0, Yes = 1)

^e Teacher holds Master's degree (No = 0, Yes = 1)

^f Reference group is teachers with 0-2 years teaching experience (0-2 years = 0, 3-5 years = 1, 6-8 years = 2, 9-11 years = 3, 12 or more years = 4)

^g Student gender (Male = 0, Female = 1)

^h Reference group for student ethnicity is white students.

ⁱ School-wide average student/teacher ratio

^j School is either a charter school or private school (No = 0, Yes = 1)

^k School has a Title I program (No = 0, Yes = 1)

^l School categorized as urban (No = 0, Yes = 1)

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 1.3. Difference in MSELs Scores between pretest and posttest. Each labeled column represents a separate multiple regression model for each section of the MSELs as well as total scores (N = 378). Metric coefficients and p-values are displayed. Each model includes random effects for classroom and all standard errors are robust.

Variable	<u>Knowledge^a</u>		<u>Affect</u>		<u>Cognitive Skills^a</u>		<u>Behavior</u>		<u>Overall MSELs Score^a</u>	
	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>
EE Group ^b	1.594	0.278	-0.114	0.711	-0.245	0.858	-0.364	0.415	0.257	0.917
Use of Published EE Curriculum ^c	1.316	0.195	0.021	0.911	3.549**	0.004	0.273	0.516	4.349*	0.024
Time in Natural Areas ^d	1.64	0.18	0.041	0.858	0.621	0.591	1.292**	0.001	3.235	0.13
Teacher Has Masters ^e	1.525	0.289	0.119	0.636	2.1	0.117	1.428***	0.001	4.06	0.109
Years Teaching ^f										
3-5 Years	1.873	0.476	0.123	0.569	-0.083	0.972	2.027	0.098	2.345	0.676
6-8 years	-1.143	0.665	-0.624**	0.003	0.468	0.837	0.391	0.747	-0.708	0.901
9-11 years	-1.714	0.515	-0.681	0.062	0.307	0.897	0.571	0.587	-1.389	0.794
12 or more years	-0.798	0.75	-0.097	0.714	0.713	0.763	0.35	0.734	-0.101	0.984
Student Age (in years)	-0.712	0.218	-0.032	0.781	-0.585	0.219	-0.614*	0.034	-2.027*	0.032
Student Gender (Female) ^g	1.377*	0.019	0.062	0.745	0.705	0.418	0.087	0.813	1.701	0.211

Table 1.3 Continued

Variable	<u>Knowledge^a</u>		<u>Affect</u>		<u>Cognitive Skills^a</u>		<u>Behavior</u>		<u>Overall MSELs Score^a</u>	
	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>
Student Ethnicity ^h										
<i>American Indian</i>	-0.151	0.947	0.203	0.641	-5.572**	0.002	-0.71	0.576	-6.443	0.137
<i>Asian</i>	0.405	0.746	<0.001	0.999	-0.296	0.918	0.378	0.66	-0.259	0.941
<i>Hispanic</i>	-2.125	0.125	-0.282	0.624	2.415	0.148	-0.565	0.5	0.44	0.885
<i>Black</i>	-4.341***	<0.001	0.042	0.890	-3.699**	0.002	0.274	0.651	-7.146***	<0.001
Student/Teacher Ratio ⁱ	-0.096	0.744	0.082	0.117	-0.355	0.289	-0.072	0.606	-0.382	0.532
Non-public School ^j	1.37	0.329	-0.151	0.543	2.589	0.108	0.451	0.44	3.723	0.166
Title I Program ^k	-1.608	0.142	0.05	0.819	0.225	0.882	-0.657	0.122	-1.773	0.435
Urban ^l	-0.848	0.513	0.274	0.109	-2.966*	0.046	0.153	0.741	-4.442	0.064
Pretest Score	-0.373***	<0.001	-0.205***	<0.001	-0.490***	<0.001	-0.589***	<0.001	-0.311***	<0.001
Constant	18.426***	<0.001	8.457***	<0.001	17.895***	<0.001	27.848***	<0.001	58.447***	<0.001
Adjusted R ²	0.156		0.145		0.269		0.308		0.153	
Rho	0.065		0.000		0.087		0.034		0.041	

^a Random effect is significant (non-zero), and rho is the proportion of residual variance explained by the within classroom effect.

^b EE group membership (No = 0, Yes = 1)

^c Used published environmental education curriculum (No = 0, Yes = 1)

^d Spent time in outdoors during class time (No = 0, Yes = 1)

^e Teacher holds Master's degree (No = 0, Yes = 1)

^f Reference group is teachers with 0-2 years teaching experience (0-2 years = 0, 3-5 years = 1, 6-8 years = 2, 9-11 years = 3, 12 or more years = 4)

^g Student gender (Male = 0, Female = 1)

^h Reference group for student ethnicity is white students.

ⁱ School-wide average student/teacher ratio

^j School is either a charter school or private school (No = 0, Yes = 1)

^k School has a Title I program (No = 0, Yes = 1)

^l School categorized as urban (No = 0, Yes = 1)

* $p < .05$ ** $p < .01$ *** $p < .001$

CHAPTER 2: Role of significant life experiences in building environmental knowledge and behavior among middle school students

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Abstract

Significant life experience (SLE) research suggests 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.

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 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 (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 a type of citizen 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 period of 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 & 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: (1) positively related to time spent outdoors alone, in groups, and with family; (2) positively related to the presence of an adult role model for pro-environmental behavior; and (3) positively related to indirect experiences with nature.

Methods

Sampling

We focused on students in the 6th and 8th 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 6th and/or 8th grades. Next, we identified all 6th and 8th 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 6th grade classes (234 students) and eight 8th 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 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 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 US Census website (US Census Bureau, 2010) and classification of the school's locale from the National Center for Education Statistics (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). Additionally, 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, $p = 0.89$). 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 2.2). 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 2.2). We found evidence contrary to hypothesis three, with time watching nature-related television being a negative predictor of environmental knowledge (Table 2.2).

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 2.2). Minority students (American Indian, Hispanic, and African American) scored significantly lower than Caucasian students in environmental knowledge (Table 2.2). 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 2.2). Median county income was positively related to environmental knowledge and behavior and was the most important predictor of pro-environmental behavior (Table 2.2). 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.

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 & 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 & 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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Tables and Figures

Table 2.1. Questions measuring SLE exposure among students. 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 ($n = 407$).

Variable	Question	Mean Score
Time outdoors		
<i>Alone</i>	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)
<i>In groups</i>	To what extent do you go camping with youth groups or organizations (Boy Scouts, 4-H, Girls Club, etc.)	4.14 (1.17)
<i>With family</i>	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		
<i>Books and magazines</i>	To what extent do you enjoy reading books or magazines about nature and the environment?	3.66 (1.27)
<i>TV and movies</i>	To what extent do you enjoy watching television shows videos, CDs, or DVDs about nature and the environment?	3.65 (1.18)

Table 2.2. Regression models predicting environmental knowledge and behavior. Random effects are significant (non-zero) in both models (N = 405).

Variable	<u>Knowledge</u>			<u>Behavior</u>		
	<i>B</i>	β	<i>p</i>	<i>B</i>	β	<i>p</i>
Significant Life Experiences						
Time outdoors with family	0.718	0.069	0.130	0.517	0.099	0.053
Time outdoors in groups	0.838	0.087	0.050	0.139	0.029	0.563
Time outdoors alone	0.388	0.037	0.424	0.472	0.090	0.084
Read nature books or magazines	-0.406	-0.046	0.348	0.093	0.021	0.704
Watch TV about nature	-1.062*	-0.111	0.024	0.281	0.058	0.289
Have a role model for environmental sensitivity	-0.326	-0.034	0.464	0.468	0.096	0.062
Student Demographics						
Grade ^a	-0.964	-0.043	0.409	-0.012	-0.001	0.986
Gender ^b	-1.139	-0.051	0.255	0.734	0.065	0.192
Ethnicity ^c						
American Indian	-5.490*	-0.101	0.024	2.694*	0.098	0.050
Asian	3.476	0.055	0.222	1.056	0.033	0.509
Hispanic	-6.374***	-0.166	0.000	-0.482	-0.025	0.625
African American	-5.686***	-0.197	0.000	0.652	0.045	0.398
School Demographics						
Median Income of the County ^d	0.148**	0.144	0.004	0.065*	0.125	0.025
Urban ^e	-1.806	-0.078	0.187	-0.253	-0.022	0.743
Student/Teacher Ratio	-1.285***	-0.230	0.000	-0.205	-0.073	0.31
Teacher has Masters ^f	4.545***	0.186	0.000	0.171	0.014	0.792
Intercept	55.230***		0.000	39.185***		0.000
Adjusted R ²	0.236			0.095		

^a 0 = 6th Grade, 1 = 8th Grade

^b 0 = Male, 1 = Female

^c Reference category is Caucasian students

^d The unit for median county income is \$10,000.

^e 0 = Rural, 1 = Urban

^f 0 = no, 1 = yes

CHAPTER 3: Overcoming skepticism with education: Interacting influences of worldview and climate change knowledge on perceived climate change risk among adolescents

This article is in review in *Climatic Change*:

Stevenson, K. T., Peterson, M. N., Bondell, H. D., Moore, S. E., & Carrier, S. J. Overcoming skepticism with education: Interacting influences of worldview and climate change knowledge on perceived climate change risk among adolescents. *Climatic Change. In Review*.

Abstract

Though many climate literacy efforts attempt to communicate climate change as a risk, these strategies may be ineffective because among adults, worldview rather than scientific understanding largely drives climate change risk perceptions. Further, increased science literacy may polarize worldview-driven perceptions, making some climate literacy efforts counterproductive among skeptics. Because worldviews are still forming in the teenage years, adolescents may represent a more receptive audience. This study examined how worldview and climate change knowledge related to acceptance of anthropogenic global warming (AGW) and in turn, climate change risk perception among middle school students in North Carolina, USA ($n = 387$). We found respondents with individualistic worldviews were 16.1 percentage points less likely to accept AGW than communitarian respondents at median knowledge levels, mirroring findings in similar studies among adults. The interaction between knowledge and worldview, however, was opposite from previous studies among adults, because increased climate change knowledge was positively related to acceptance of AGW among both groups, and had a stronger positive relationship among individualists. Though individualists were 24.1 percentage points less likely to accept AGW

than communitarians at low levels (bottom decile) of climate change knowledge, there was no statistical difference in acceptance levels between individualists and communitarians at high levels of knowledge (top decile). Non-whites and females also demonstrated higher levels of AGW acceptance and climate change risk perception, respectively. Thus, education efforts specific to climate change may counteract divisions based on worldviews among adolescents, versus polarize them as among adults.

Introduction

The potential impacts of global climate change include serious ecological, economic, social, and health consequences, yet concern over the issue may be on the decline in the United States (Smith & Leiserowitz, 2012). This waning concern is particularly troubling because citizens will be more likely to act to address climate change if they believe it poses a risk. Research suggests this relationship applies to both collective (e.g., support for emissions regulations) and individual (e.g., driving less) actions (Alhakami & Slovic, 1994; O'Connor, Bord, & Fisher, 1999).

A growing body of literature suggests that this apparent apathy within the U.S. is largely a product of low climate literacy and successful media campaigns designed to foster skepticism (Jacques, Dunlap, & Freeman, 2008; McCright & Dunlap, 2011). Climate science includes complicated topics (e.g. the interaction between micro, regional, and global climates) which are associated with largely unfamiliar terms (e.g. solar vs. terrestrial radiation), making achieving climate literacy challenging. Further, many people hold misconceptions about climate change, such as attributing global warming to holes in the ozone layer or confusing weather and climate, that lead to misguided conclusions about the risk of climate change (Leiserowitz, 2012). For instance, some point to an unusually cold winter as evidence that global warming is not happening (Egan & Mullin, 2012). These misconceptions are strengthened by concentrated media campaigns that spread scientific-sounding but erroneous information in an effort to shroud climate change in doubt and controversy (McCright & Dunlap, 2003; UCS, 2007). As a counter to these efforts, some suggest that climate scientists should concentrate efforts on distributing sound science in

forums with considerable public reach (e.g. popular websites and social media) (Hamilton, 2011; Wibeck, 2013).

Though the need for climate literacy seems obvious, other studies suggest that increased climate literacy will have little impact on risk perception among adults because political ideology and worldviews have a larger influence over climate change risk perceptions than climate change knowledge. A clear partisan divide was identified among adults with Democrats significantly more likely than Republicans to acknowledge anthropogenic global climate change (Mayer, Adair, & Pfaff, 2013). Hamilton (2011) found that education level was both positively and negatively related to climate change concern depending on political affiliation. He attributed this trend to the increasing availability of websites and cable news shows that allow educated people to readily find ideologically compatible information for their views (Hamilton, 2011). Similarly, cultural cognition theory posits that individuals seek and integrate information that is congruent with their worldviews (Kahan, 2012). Worldviews are general ways of seeing the world and distinct from political ideology, although they are correlated with it (Dunlap, Liere, Mertig, & Jones, 2000). Kahan (2012) posits worldviews can be measured using two scales – one ranging from hierarchy to egalitarianism and another ranging from individualism to communitarianism. People who have egalitarian communitarian worldviews generally perceive climate change as higher risk while those who are hierarchical individualists perceive it as lower risk. Individualists purportedly downplay environmental risks because they want to avoid restrictions on individual choices including those associated with commerce, whereas hierarchists deemphasize risk because it would cast blame on social

elites (Kahan, 2012). Individuals scoring high on both scales incorporate both influences, and they tend to interpret new information on climate change in ways that support their existing beliefs (Kahan, 2012). A recent study among adults suggests that increased science literacy polarizes people's perceptions of climate change with hierarchical individualists becoming more skeptical and egalitarian communitarians becoming more alarmed as scientific literacy increases (Kahan et al., 2012). These findings imply that climate literacy efforts may only amplify levels of skepticism among hierarchical individualists.

Although science literacy appears to polarize and reinforce ideologically based perceptions of climate change among adults, the same relationship may not exist in the context of K-12 climate education. Worldviews are still forming during childhood and adolescence (Vollerberg, Iedema, & Raaijmakers, 2001), and may not dictate climate change risk perception among adolescents in the same way as among adults. Similarly, climate-specific literacy may not have the same polarizing effect as science literacy in general (Tobler, Visschers, & Siegrist, 2012). Given the interacting effects associated with science literacy (Kahan et al., 2012) or self-reported climate change understanding (Hamilton, 2011) with worldviews among adults, research is needed to investigate the potential implications among adolescents, especially as many current climate literacy efforts focus on building knowledge. If climate literacy only polarizes perceptions of climate change among adolescents as science literacy seems to among adults (Kahan et al., 2012), climate literacy efforts in K-12 contexts will not work unless they are framed to be compatible with student worldviews. Although some climate educators utilize framing to reach K-12 audiences (Fleischer, 2013), such framing efforts would presumably work more effectively if built on

an understanding of how worldview and knowledge interact to form climate risk perception among adolescents.

This study evaluated how worldviews and climate change knowledge affect climate change risk perception among adolescents with a case study of middle school students in coastal North Carolina, USA. We proposed a path model in which both climate change knowledge and worldview predicted acceptance of anthropogenic global warming (AGW), which in turn predicted climate change risk perception. We chose the phrase acceptance of “global warming” over “climate change” in this case for several reasons. Though the latter may facilitate more nuanced scientific understanding, the former has been used in previous studies with adolescents (Leiserowitz, Smith, & Marlon, 2011). Further, climate change was suggested as an alternative framing for AGW by political strategist Frank Luntz precisely because the public can interpret the phrase in multiple ways, many of which do not implicate humans or imply a global warming trend (Luntz, 2003). The more narrow, though emotive, understanding of AGW limits this subjectivity problem thereby allowing us to capture potential relationships between worldviews and acceptance. Because higher levels of climate change knowledge have been associated with higher climate change risk perceptions (Tobler et al. 2012), we predicted that 1) adolescents with higher levels of climate change knowledge would be more likely to accept AGW. Because worldviews play such a prominent role in shaping climate change risk perception among adults (Kahan et al., 2012; Smith & Leiserowitz, 2012), we hypothesized that 2) students who were hierarchical and individualistic would be less likely to accept AGW. Because worldviews are still developing during adolescence (Vollerberg et al. 2001), 3) we did not anticipate finding support for the

polarizing effect of knowledge on worldview found among adults (Kahan et al., 2012). In addition to testing these hypotheses, we controlled for student gender and ethnicity, as these have been associated with differing risk perception among adults (Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000; Sjöberg, 1999).

Methods

Theoretical Model

Because environmental risk perceptions among adolescents are poorly understood, our model is grounded in environmental behavior theory and integrates current understanding of how adolescents perceive the environment. The Value Belief Norm (VBN) theory of environmentally responsible behavior draws on several behavior theories to form a causal chain of variables: personal values, a set of beliefs about the environment, awareness of consequences, ascription of responsibility, and personal norms for environmental action (Stern, 2000). Slimak and Dietz (2006) propose that risk perception can be understood through the VBN framework as awareness of consequences; values help form beliefs which in turn influence risk perception (awareness of consequences). Their model explained 48.4% of the variance in predicting of global environmental risk perception (global warming, ozone depletion, population growth, and acid rain). Environmental education research employs a similar causal chain but also includes the role of scientific knowledge. Hungerford and Volk's (1990) oft-cited model suggests entry-level variables including environmental attitudes and knowledge influence ownership variables (e.g., knowledge of consequences) among adolescents. Similarly, environmental literacy frameworks suggest that environmental

knowledge and environmental attitudes influence understanding of issues (including inherent risks) (Hollweg et al., 2011).

Following Slimak & Dietz's (2006) application of the VBN framework to environmental risk perception and integrating current environmental education research, we propose a model for understanding how worldview and knowledge affect climate change risk perception among adolescents (Figure 1). Though the terms values, worldviews, beliefs, and attitudes are often used interchangeably in the literature (Slimak & Dietz, 2006), we see worldviews as they are discussed in relation to climate change risk perception (Kahan, 2012) as fitting into the values category of the VBN framework because they reflect "what is important to me?" (Slimak & Dietz, 2006). Because scientific understanding is an entry-level variable for pro-environmental behavior among children and adolescents (Hungerford & Volk, 1990) we place climate change knowledge among the first steps of the causal chain leading to climate change risk perception. As Slimak & Dietz (2006) conceptualize "belief" in the VBN context as "what is the general pattern of human influence on the environment?" we saw acceptance of AGW as fitting into this area of the framework. Before we can assess degree of concern over climate change, we must account for whether individuals accept AGW. For these reasons, we saw acceptance of AGW as a precursor to climate change risk perception and propose it mediates the effects of knowledge and worldview (Figure 3.1).

Sampling

We chose to focus on middle school students for this study as they represent an intersection of cognitive abilities necessary to understand complex environmental challenges and a prime stage for influencing how students engage as citizens (McBeth, Hungerford,

Marcinkowski, Volk, & Cifranick, 2011). Though we only collected data from students for this study, we sampled in two stages – teachers and students. We compiled a list of all middle school science teachers in the 20 coastal North Carolina counties by visiting each school website, collecting faculty rosters, and calling the schools to confirm the faculty rosters. We randomly selected 150 of the 353 teachers to recruit for the study. Two area school districts would not allow teachers to participate, which eliminated 27 of the 150 from consideration. Of the remaining selected teachers, 36 responded and 24 consented to participate. The resulting schools were representative of the state in terms of ratios of local and Title I status, and differences between the student sample and population was accounted for (see Data Analysis). The Title I program is authorized by the Elementary and Secondary Schools Act to give additional funding to schools with high percentages of low-income students (107th Congress, 2002) and Title I status can be used as a measure of school-level SES. Each participating teacher was asked to randomly select one class to include in the study by flipping a coin. Between March and May of 2013, we visited all 24 classrooms and surveyed students in person. Our sample included 90 sixth graders, 102 seventh graders, and 186 eighth graders with the majority spanning ages 11-14 (17 students were 15 years old). Most students completed the entire survey (81.8%). The majority of the 378 students in this sample were female (54.8%), and white (60.5%) with fewer African American (15.6%), Hispanic (7.3%), American Indian (1.3%) and Asian (1.0%) students. Some also identified as multi-racial (10.9%) or other (3.4%).

Instrument development

The lack of published studies measuring perceptions of climate change among

adolescents required us to pre-test multiple scales designed for adults. Our pre-test instrument included the full-length individualism-communitarianism and hierarchy-individualism scales used by Kahan (2012) and individualism-communitarianism and hierarchy-egalitarianism scales in the form of the Culture Orientation scale (Singelis, Triandis, Bhawuk, & Gelfand, 1995) and the Social Dominance Orientation scale (Pratto, Sidanius, Stallworth, & Malle, 1994), respectively. We included the Tobler et al. (2012) scale to measure climate change knowledge, which includes questions on knowledge of the science, causes, and potential impacts of climate change. To measure acceptance of AGW and climate change risk perception, we drew on individual questions from the only large-scale survey instrument on the topic designed for adolescents (Leiserowitz et al., 2011). AGW was measured by two questions – one asking whether students believed global warming was happening, and another asking whether they thought it was caused by humans.

The final instrument was based on several rounds of pretesting. First, we administered the draft instrument to two classes of middle school students ($n = 48$). We asked students to circle questions that were difficult to understand and make notes on how to make improvements. After making adjustments to the wording of several items, we administered a second draft version of the survey to an additional two classes of middle school students ($n = 44$) and asked for written feedback. Additionally, we completed cognitive interviews (Desimone & Le Floch, 2004) with nine students to gather general feedback and identify which individualism and hierarchy scales were easier to understand.

In addition to the qualitative pretesting of the scales, we tested each for normality of responses and reliability. Histograms revealed normal distributions for student responses to

each scale included in the instrument draft, consistent with a range of worldviews we would expect in a randomly selected population. Cronbach's alpha measurements indicate internal reliability, or the degree to which items within the scale measure the same construct (Gliem & Gliem, 2003). In general, alpha scores reaching 0.7 and above are considered acceptable, 0.8 and above considered good, and 0.9 and above are excellent (Gliem & Gliem, 2003).

Cronbach's alpha measurements indicated the Kahan (2012) individualism-communitarianism scale to be more reliable than the Singelis et al. (1995) Culture Orientation scale among adolescents ($\alpha = 0.81$ and 0.75 , respectively), but the Pratto et al. (1994) Social Dominance Orientation scale ($\alpha = 0.93$) was more reliable than the hierarchy-individualism scale used by Kahan (2012) ($\alpha = 0.80$). Risk perception reliability was lower than ideal ($\alpha = 0.59$) but on par with measures reported for other studies using a risk perception scale (Betz & Weber, 2002). The acceptance of AGW scale had an inter-item correlation of 0.77 . The final instrument consisted of modified climate change knowledge scale from Tobler et al. (2012), a hierarchy-egalitarianism scale modified from Kahan (2012), an individualism scale modified from Pratto et al. (1994), an acceptance of AGW scale, and the risk perception scale. For a final version of all scales included in the instrument, please see Appendix 2.

Data Analysis

Students self-reported gender and ethnicity at the end of the survey instrument. We included both of these demographic variables in analysis, and we collapsed ethnicity categories into white and non-white. We compared ethnicity and gender in our sample to values for the student population using data available through the North Carolina Department

of Public Instruction, and found the sample underrepresented males (44.5% in our sample vs. 51.0% in coastal NC; $t = 2.37$ $p = 0.018$). We weighted our sample to adjust for this difference.

We completed a path analysis with the SEM command in STATA version 12.1. Path analysis is an extension of multiple linear regressions that allows for the analysis of several regression equations simultaneously, testing the likelihood that observations fit proposed causal model (Garson, 2008). We examined the goodness of fit for the model using the standardized root mean square residual (SRMR) measure. A perfect fitting model would have an SRMR value of 0, and a value less than 0.08 is considered acceptable (Hancock & Mueller, 2006). We tested all hypotheses using SEM path estimates and p-values. To test for the interaction between climate change knowledge and worldview, we created two interaction terms – one between climate change knowledge and each of the worldview variables (hierarchy and individualism). We then included these interaction terms in the path model as predictors of acceptance of AGW. Only the interaction between climate change knowledge and individualism was significant, so it was included in the final model.

Ethics Statement

This study was approved by the North Carolina State University Institutional Review Board (IRB #2961, Assurance Number FW A000003429).

Results

Students in this study answered 74.7% of the knowledge questions correctly (mean = 12.7 out of a possible 17, SD = 2.75). Average scores on the worldview scales suggested students in the sample were slightly individualistic (mean = 56.9 out of a possible 90, SD = 10.3) and egalitarian (mean = 53.8 out of a possible 112, SD = 15.8). Chronbach's alpha scores suggested all scales in the instrument were reliable (hierarchy-egalitarianism $\alpha = 0.93$, individualism-communitarianism $\alpha = 0.81$, and Risk Perception $\alpha = 0.61$). The AGW scale had an inter-item covariance of 0.78.

Our results largely supported the theoretical model predicting climate change risk perception among adolescents (Figure 3.1). Specifically, an interaction between knowledge and worldview (individualism) predicted acceptance of AGW, which in turn predicted risk perception of climate change. This relationship was limited to individualism, as there was no direct or interacting relationship between hierarchy, acceptance of AGW, and climate change risk perception. Demographic differences among students also influenced acceptance of AGW and risk perceptions associated with climate change. Non-white students were more likely to accept AGW than white students, and girls perceived climate change as higher risk than boys (Figure 3.1). All other variables held constant, non-white students scored an average of 3.7 percentage points higher than white students on the AGW scale. Girls scored 7.6 percentage points higher than boys on the Risk Perception scale.

Increased climate change knowledge was positively associated with acceptance of AGW, and this relationship was stronger among individualists than among communitarians (Figure 3.1, Figure 3.2). For a student scoring in the 50th percentile on the individualism-

communitarianism scale, acceptance of AGW (expressed as a percentage of the maximum score on the acceptance scale) climbed from 68.0% of the maximum score on the acceptance scale at low levels of knowledge (10th percentile) to 76.9% at a medium knowledge level (50th percentile) and 84.7% at a high knowledge level (90th percentile). For a communitarian student (scoring at the 10th percentile on the individualism-communitarianism scale), acceptance of AGW began higher and also climbed, with 78.5% acceptance of AGW at a low knowledge level, 84.6% at a medium knowledge level, and 88.7% at a high knowledge level. For an individualist student (90th percentile the individualism-communitarianism scale), acceptance of AGW was lower at low levels of climate change knowledge (54.8%), but as knowledge increased, acceptance levels approached those of communitarians (68.4% for medium knowledge and 79.3% for high knowledge levels). Because the difference in acceptance levels was low at high levels of knowledge (Figure 3.2), we ran a post-estimation test to determine if this difference was statistically significant. We failed to reject the null hypothesis that the difference was zero ($p = 0.129$), meaning there was no statistical difference in acceptance levels between individualists and communitarians at high levels of climate change knowledge.

Discussion

The potential for climate literacy efforts to overcome skepticism among adolescents may reflect an age-related window for influence. For adults, worldviews are well entrenched (Schultz & Zelezny, 1999) and exert considerable influence over climate change risk perception (Smith & Leiserowitz, 2012). During the teenage years, however, worldviews are still forming (Vollerberg et al., 2001), and this plasticity may explain why climate change

knowledge overcomes skepticism among individualist adolescents as well as why hierarchy does not seem to factor into perceptions of climate change. Further, the individualism-communitarianism scale is heavily tied to American politics, suggesting that though adolescents may be already adopting political ideologies, these ideologies do not dictate perceptions of climate change as strongly as among adults (Hamilton, 2011). Overall, students in our study displayed low levels of climate change knowledge, similar to those reported in a national survey of teens (Leiserowitz et al., 2011). Almost 20% of teens in our study and 46% of teens in the national survey (Leiserowitz et al., 2011) either thought global warming was not happening or did not know if it was happening. Together, these results highlight an opportunity to build concern for climate change by addressing low levels of climate literacy among adolescents. Climate literacy efforts designed for adolescents may represent a critical strategy to overcoming climate change related challenges, given stable or declining concern among adults that is driven in part by entrenched worldviews (Smith & Leiserowitz, 2012).

Another explanation for the impact of climate change knowledge on risk perception among individualist-leaning adolescents may have more to do with the type of knowledge than the age of the learner. Previous research suggesting that scientific understanding polarizes worldview-driven risk perceptions measured scientific literacy and numeracy instead of knowledge specific to climate change (Kahan et al., 2012). Without education specific to climate change, adults may be unable to “connect the dots” provided through general science education. There is some evidence that climate change knowledge increases climate change risk perception among adults (Tobler et al., 2012), and future research should

explore whether this effect is especially pronounced among hierarchical individualists, as we found with individualist adolescents. Further, it is possible that adolescents are learning information about climate change from more reliable sources than adults. Adolescents spend a considerable amount of time in schools, perhaps increasing the likelihood that their climate knowledge is based on information reviewed by experts rather than from politically charged news and web sources that seem to be contributing heavily to skepticism among adults (Hamilton, 2011; UCS, 2007). This possibility underlines the importance of quality professional development for teachers as well as assurance that teachers have access to climate literacy materials based on sound science. Future research should address whether findings in this study represent an age-related tipping point for the potential influence of climate change education or point to the importance of reliable climate-specific education campaigns.

Although existing and expanded climate literacy efforts will likely be effective at raising climate change concern among adolescents, worldviews still deserve consideration in climate change education. Though increased climate change knowledge may bring students with different worldviews to similar levels of acceptance of AGW (Figure 2), individualist students with low levels of climate change knowledge enter the conversation more skeptical. The guiding document for climate education, *Climate Literacy: The Essential Principles of Climate Science*, acknowledges climate change as a “significant part of public discourse” (US GCRP, 2009) but it does not address how to encourage climate change communication among different worldviews. Similarly, less than 40% of earth science teachers surveyed

nationally reported addressing the controversy over climate change in the classroom (Johnson, 2012).

In addition, ethnicity and gender should be considered as climate literacy efforts are developed. Our findings extend previous research in adult populations that suggest non-whites perceive climate change as a higher risk than whites (Smith & Leiserowitz, 2012). Some have explained this difference by noting that some non-white populations are disproportionately exposed to the negative effects of climate change as minority populations are more likely to live in inner cities affected by air pollution and heat-island effects (Younger, Morrow-Almeida, Vindigni, & Dannenberg, 2008) or in areas more prone to sea-level rise and storm surges (Kleinosky, Yarnal, & Fisher, 2006), risks which are projected to be exacerbated by climate change (Michener, Blood, Bildstein, Brinson, & Gradner, 1997; Younger et al., 2008). As individuals who personally experience adverse effects of a specific threat are more likely to perceive that threat as high risk (Slovic & Weber, 2002), similar factors may partially explain why non-white adolescents in our study appear more likely to accept AGW. However, as these effects have not been previously documented among adolescents more research is needed. The higher levels of climate change risk perceptions we identified among girls reflects findings in numerous studies where women perceive climate change and a host of other environmental threats as higher risk than men (Finucane et al., 2000; McCright, 2010; Smith & Leiserowitz, 2012; Zia & Todd, 2010). McCright (2010) suggested gender differences may stem from differing socialization experiences between men and women, which can lead to differing levels of environmental concern or trust in science. Finucane et al. (2000) suggest that as women and minorities often hold positions of less

power than white males, cultural socializations make both these groups more likely to assign higher levels of risk in a host of contexts. It is possible that our results extend these findings associated with gender and ethnicity socialization to adolescents. Future research could address the degree to which parents, peers, and other socialization mechanisms influence gender and ethnicity differences in perceptions of climate change, particularly among adolescents.

If educators want to engage all students in discussing climate change, they will need to employ strategies to reach students who are less likely to accept AGW. Among adults, reframing discussions of climate change mitigation efforts as economic improvement measures boosted the likelihood that climate change deniers would support those efforts (Bain, Hornsey, Bongiorno, & Jeffries, 2012). Similar framing efforts should be fruitful for adolescents given education and worldviews interact to reduce rather than exacerbate divisions in acceptance of AGW and perception of risk associated with climate change. Researchers participating in a conference on K-14 climate change education suggested treating controversy as a teachable moment, using inquiry-based pedagogy, inviting outside speakers, and discussing solutions to specific climate change problems as strategies for including all students in climate change discussions regardless of their level of belief or risk perception (Beatty, 2012). Another recent study suggested reframing the climate discussion away from factuality and toward analyzing mitigation strategies (Feldpausch-Parker, O'Byrne, Endres, & Peterson, 2013). Although these strategies may not impact risk perception directly, they may offer ways to overcome barriers to engagement in climate change solutions associated with worldviews.

Overcoming challenges associated with climate change will require a public that is informed and concerned about the issue, and our results suggest that efforts should focus on adolescents. Despite an overwhelming consensus among the scientific community that global warming is happening and caused by humans (Cook & Evans, 2000), skepticism among adults is stable or on the rise (Smith & Leiserowitz, 2012), and this skepticism is driven in part by hierarchical-individualist worldviews (Kahan, 2012). Climate literacy efforts can overcome, rather than exacerbate, worldview-driven skepticism among adolescents, making them a receptive audience for building climate change concern. Future research should explore whether climate change perceptions formed in childhood persist as worldviews become more stable. As the scales we used in this study displayed high levels of reliability, they may be helpful in these efforts. Also, more insight is needed into the congruency and relative influence of climate literacy, scientific literacy and numeracy as well as the source of climate change information on climate change risk perception among all age groups. Finally, we should identify strategies to engage students regardless of their level of acceptance of AGW or risk perception, paying special attention to the specific perspectives of adolescent populations. Building concern about climate change is critical to spurring individual and collective action. Although perceptions of climate change are complex and likely influenced by several factors, building climate literacy is an essential tool for ensuring future generations are fully engaged in adapting to and mitigating the effects of climate change.

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Figures

Figure 3.1. Path diagram model for climate change risk perceptions among adolescents. Path coefficients displayed are standardized. We weighted our sample to reflect the population of coastal North Carolina before analysis ($n = 378$). Paths from each demographic variable to each endogenous variable were included in the analysis, but only the statistically significant paths are shown. Model goodness of fit statistics are as follows: SRMR = 0.010 and overall $R^2 = 0.278$. For ethnicity, 0 = white and 1 = non-white. For gender, 0 = male and 1 = female.

Figure 3.2. Effect of increased climate change knowledge on acceptance of anthropogenic global warming among students with differing worldviews. Both regression lines predicting acceptance of anthropogenic global warming (AGW) ($n = 378$) were generated from the regression equation implied by Figure 1 where climate change knowledge, worldview, and demographic variables predict acceptance of AGW. Predicted values and 95% confidence intervals (represented by error bars) of acceptance of AGW have been converted to percentages of maximum scale score (max = 13). Communitarians and individualists are represented by individualism-communitarianism scale scores in the 10th and 90th percentiles, respectively. Similarly, low knowledge is represented by a 10th percentile score and high knowledge as a 90th percentile score. Error bars represent a 95% confidence interval.

APPENDICES

Appendix 1: Environmental Knowledge and Behavior Scales (Chapter 2)

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 it:
 - 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 fox can't digest corn.
 - The rabbit had already digested the corn.
 - Corn doesn't have much energy.
 - Most of the corn's energy was used by the rabbit.
13. Most of the oxygen in the atmosphere comes from:
- Insects.
 - Plants.
 - The soil.
 - The sun.
14. Which of the following would give humans the most food energy from 10,000 pounds of plants?
- Feed the plants to insects, feed the insects to fish, and then humans eat the fish.
 - Humans eat the plants.
 - Feed the plants to cattle then humans eat the cattle.
 - Feed the plants to fish then humans eat the fish.
15. After living things die, they decompose. A result of this process nutrients are:
- Released back into the environment to be recycled.
 - Destroyed by the bacteria of decay.
 - Changed from nutrients to oxygen and water vapor.
 - Evaporated due to the heat produced during decomposition.
16. Which of the following is a part of the water cycle?
- Erosion.
 - Ocean tides.
 - Evaporation.
 - Decomposition.
17. A pollutant gets into an ecosystem and kills a large numbers of insects. How might this affect the ecosystem?
- Plants are not damaged so it doesn't affect the ecosystem.
 - It damages part of the ecosystem so it may affect the whole ecosystem.
 - It kills only insects so the other animals in the ecosystem stay healthy.
 - 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.

Appendix 2: Scales and Reliability Measures (Chapter 3)

Table A2.1 Climate change knowledge scale. We drew these questions from Tobler et al. (2012) and modified questions based on pretesting with middle school students ($n = 92$). Percentage correct represents the percentage of respondents whose answers reflect current scientific understanding ($n = 378$)

Topic	Item wording	% Correct
Climate Change Science	Burning oil, among other things, produces carbon dioxide (CO ₂)	81.8
	Carbon dioxide (CO ₂) is a greenhouse gas.	72.2
	Greenhouse gasses partly keep the Earth's heat from escaping into space.	55.6
	Carbon dioxide (CO ₂) is harmful to plants	72.7
	The ozone hole is the main cause of the greenhouse effect.	50.4
	At the same quantity, carbon dioxide (CO ₂) is more harmful to the climate than methane.	62.9
Climate Change Causes	The global carbon dioxide (CO ₂) concentration in the atmosphere has increased during the past 250 years.	79.2
	The increase of greenhouse gasses is mainly caused by human activities	76.6
	With a high probability, the increase of carbon dioxide (CO ₂) is the main cause of climate change.	55.6
	Climate change is mainly caused by natural variations (such as changes in solar radiation and volcanic eruptions)	50.1
	The last century's global increase in temperature was the largest during the past 1000 years.	63.1
	The decade from 2000 to 2009 was warmer than any other decade since 1850.	69.9
	The amount of (CO ₂) in the atmosphere has reached the same levels within the past 650,000 years.	68.1
Change Impacts Climate	For the next few decades, the majority of climate scientists expect...	
	... an increase in extreme events, such as droughts, floods, and storms	77.1
	... a warmer climate to increase the melting of polar ice, which will lead to an overall rise of the sea level.	78.4
	... a cooling-down of the climate	74.3
	... a warmer climate to increase water evaporation, which will lead to an overall decrease of the sea level.	62.3
	... the climate to change evenly all over the world.	66.5
	... a precipitation increase in every region worldwide.	54.0

Table A2.2. Individualism scales adapted from Kahan (2012). We modified the wording of the original questions slightly based on results from pretesting with middle school students ($n = 92$). Individualism was a six-point Likert scale ranging from strongly disagree to strongly agree.

Item	Wording
1	The government (at any level) interferes far too much in our everyday lives.
2	Sometimes the government needs to make laws that keep people from hurting themselves.
3	It's not the government's business to try to protect people from themselves.
4	The government should stop telling people how to live their lives.
5	The government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.
6	Government should put limits on the choices individuals can make so they don't get in the way of what's good for society.
7	It's society's responsibility to make sure everyone's basic needs such as food, housing, and healthcare are met.
8	It's a mistake to ask society to help every person in need.
9	People should be able to rely on the government for help when they need it.
10	Individuals should take responsibility for their own lives without anyone telling them what to do.
11	Our government tries to do too many things for too many people. We should just let people take care of themselves.
12	If the government spent less time trying to fix everyone's problems, we'd all be a lot better off.
13	People who make money in business have a right to enjoy their money however they want.
14	Hard work and competition – not government programs – are the best way to supply people with the things they need.
15	Making money is why people work hard.

Table A2.3. Hierarchy scale adapted from Pratto et al (1994). We modified the wording of the original questions slightly based on results from pretesting with middle school students ($n = 92$). Hierarchy was a seven-point Likert scale ranging from strongly disagree to strongly agree.

Item	Wording
1	Some groups of people are simply inferior to other groups.
2	In getting what you want, it is sometimes necessary to use force against other groups.
3	It's OK if some groups have more of a chance in life than others.
4	To get ahead in life, it is sometimes necessary to step on other groups.
5	If certain groups stayed in their place, we would have fewer problems.
6	It's probably a good thing that certain groups are at the top and other groups are at the bottom.
7	Inferior groups should stay in their place.
8	Sometimes other groups must be kept in their place.
9	It would be good if groups could be equal.
10	Group equality should be our idea.
11	All groups should be given an equal chance in life.
12	We should do what we can to equalize conditions for different groups.
13	Increased social equality is beneficial to society
14	We would have fewer problems if we treated people more equally.
15	We should strive to make incomes as equal as possible.
16	No group should dominate in society.

Recently, you may have noticed that global warming has been getting some attention in the news. Global warming refers to the idea that the world's average temperature has been increasing over the past 150 years, may be increasing more in the future, and that the world's climate may change as a result.

What do you think? Do you think that global warming is happening?

Yes....

- a. ... and I'm extremely sure
- b. ... and I'm very sure
- c. ... and I'm somewhat sure
- d. ... but I'm not at all sure.

No....

- e. ... and I'm extremely sure
- f. ... and I'm very sure
- g. ... and I'm somewhat sure
- h. ... but I'm not at all sure.

Or...

- i. ... I don't know.

Assuming global warming is happening, do you think it is...

- a. Caused mostly by human activities
- b. Caused by both human activities and natural changes.
- c. Caused mostly by natural changes in the environment
- d. None of the above because global warming isn't happening
- e. Other

Figure A2.1. Acceptance of AGW scale. Items were taken from the only available large-scale climate change survey for teenagers (Leiserowitz et al. 2011).