ABSTRACT

SZCZYTKO, RACHEL. Promoting Environmental Behaviors Among Children: Tools to Measure Environmental Literacy and Pathways to Develop Connection to Nature. (Under the direction of Kathryn Stevenson)

Most environmental problems affecting the world today require strategies that extend beyond technical solutions and include social commitment to environmentally responsible behaviors. Although encouraging environmental behavior is complex and difficult, children are particularly good candidates for these efforts. Environmental education has focused on fostering environmental behaviors and their precursors (e.g., environmental knowledge) in children for four decades; however, key challenges remain. There are not adequate measurement tools for evaluation, and the field lacks a holistic understanding of drivers of environmental behaviors among children. Through two studies, this thesis contributes to the measurement of environmental behaviors among children and the development of a more nuanced understanding of strategies to encourage environmental behaviors among children. The first study validates a concise environmental literacy tool for adolescents and tests several conceptual models of environmental literacy (i.e., environmental knowledge, affect, skills, and behaviors). The second study analyzes how outdoor activity type, frequency, and socialization level interact with demographic factors to predict connection to nature. Findings from these studies suggest that (1) environmental hope; knowledge; the interaction between hope and knowledge; and cognitive skills are important precursors to environmental behavior and (2) frequent solitary outdoor activities paired with consistent social outdoor activities together support connection to nature, and likely, environmental behaviors. These results not only add to theories on environmental behaviors among children but also provide practical
tools that can be used in the field to promote environmentally responsible behaviors in the next generation.
Promoting Environmental Behaviors Among Children: Tools to Measure Environmental Literacy and Pathways to Develop Connection to Nature

by
Rachel Szczytko

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APPROVED BY:

Dr. M. Nils Peterson

Dr. Sarah Carrier

Dr. Kathryn Stevenson
Committee Chair
BIOGRAPHY

Hailing from the Great Lakes’ state, I came to North Carolina State University in the winter of 2016 to pursue a graduate degree focusing on environmental education research. I not only completed two manuscripts for this Master’s thesis in my two years at NC State, but I also finished a comprehensive program evaluation of the Muddy Sneakers’ environmental education program. My passion for environmental education and my dedication to learning about the research process stems from a life-long infatuation with the outdoors and a desire to motivate the next generation to love, respect, and protect it as I do.

After graduating from the University of Michigan in 2014 with a focus on Terrestrial Ecology, I pursued environmental education positions in Southern California and New Hampshire where I taught in camp, park, and school settings. These experiences were extremely gratifying, but I wanted to know if, how, and why these programs were working. I desired to understand the education techniques that I utilized and the research that informed them. I presents this thesis not only as part of the lessons I have learned here at NC State but also as my contribution to the environmental education field. I hope that this thesis will serve researchers and practitioners for years to come as we seek to improve the field of environmental education and connect all children with nature.
ACKNOWLEDGMENTS

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I would like to thank my advisor, Dr. Kathryn Stevenson, and my committee members, Drs. Sarah Carrier and M. Nils Peterson, for their guidance and patience during my tenure at NC State.

I also thank my co-authors on the manuscripts in my thesis: Dr. John Nietfeld for his guidance on cognitive skills and educational psychology in manuscript one; Dr. Howard Bondell for his statistical feedback on classification trees in manuscript two; and Renee Strnad for her valuable feedback on my entire thesis and the environmental education profession in general.

I deeply thank all of the teachers and students for taking the surveys for this thesis. This would not be possible without their input, and I hope this thesis can serve them in their professions and lives.

I would like to especially thank my partner - Richard, my family, and my friends for supporting me throughout this thesis process and listening to my lamentations on working indoors.
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Chapter 1. Introduction

There are a number of persistent and complex environmental problems affecting the world today (UNEP, 2016). Some of these issues, such as water quality, have been at the forefront of a global environmental agenda decades (Federal Water Pollution Control Act, 1948; United Nations, 1977). Others, like climate change, have only gained mainstream attention within the past two decades (United Nations, 1992). While there have been small victories addressing these challenges, such as increased regulations on water and air quality (Federal Water Pollution Control Act, 1972; Clean Air Act, 1970), existing solutions have proven far from adequate. For instance, while government regulations can be effective, they can be undone and their enforcement depends on people. The creation and success of collective solutions, ultimately, rely on individuals. Because of this, the public must be capable of analyzing and acting on environmental issues.

Simply put, tackling current environmental issues requires individuals to engage in environmentally responsible behaviors. Environmentally responsible behaviors are those that are “intended to have a positive impact on the environment by targeting problems and issues, as well as those that actually have a positive environmental consequence” (Hollweg et al 2011, p. 3-1). Although environmentally responsible behaviors, or environmental behavior, have been defined, analyzed, and researched from many perspectives (Heimlich & Ardoin, 2008; Islam, Moore, & Cosco, 2014; Kollmus & Agyeman, 2002), there is not yet a consistent way to produce lasting environmental behaviors among adults. Much of this difficulty may stem from engrained worldviews which hinder them from acting in an
environmentally conscious way, despite having more environmental knowledge (Kahan et al, 2012).

While it is difficult to motivate environmental behaviors among adults (Kollmuss & Agyeman, 2002), children are particularly good candidates to learn environmental behaviors. First, children are at a stage of development where they are naturally learning and forming life-long traits (Ormrod, 2016). This is why we have individuals in schools during their developmental years. Second, children have not yet established ingrained habits, identities, or frameworks which shape their behaviors (Stevenson et al, 2014). By promoting environmental behavior at a young age, children can be set on life-long trajectories and develop the intrinsic motivation necessary to sustain environmental behaviors (Pink, 2009). Third, children already learn about civic engagement in schools; environmental behaviors, such as properly dealing with waste and practicing water conservation techniques, fall into the category of civic engagement (Schneller, 2008).

Environmental education has instilled environmental behaviors and its precursors (e.g., environmental knowledge) in children since the 1970s (UNESCO-UNEP, 1977). Despite over 45 years of experience, environmental education has failed in some ways (Blumstein & Saylan, 2007), particularly in fostering persistent environmental behaviors in the next generation. The goal of this thesis is to (1) generate useful tools and information for the environmental education field, so that it can better instill environmental behaviors in today’s youth and to (2) add to a diverse body of research on environmental behaviors across two broad paradigms: environmental literacy and environmental psychology/sociology.
1.1 Background

Due to the complex nature of environmental behaviors, researchers have analyzed them from multiple paradigms (Bamburg & Moser, 2007). For this reason, this thesis is drawing from two different paradigms to understand environmental behaviors: environmental literacy and environmental psychology and sociology.

1.1.1 Environmental literacy

Environmental literacy as a paradigm has its roots in education; it involves learning and the developing of skills to be able to address environmental issues. Environmental literacy is the goal of environmental education (EPA, 2017; NAAEE, 2017). Environmental literacy stems from the foundation of the field of environmental education through the Tbilisi Declaration (UNEP-UNESCEO, 1977). This document noted five objectives of environmental education - awareness, knowledge, attitudes, skills, and participations – which became the basis of environmental literacy. Environmental literacy was seen as a continuum where meeting one objective (e.g., awareness) was necessary before proceeding to the next (e.g., knowledge). Environmental literacy has evolved over the past four decades to focus on four components: knowledge, affect, cognitive skills, and behavior (Hollweg et al, 2011; NAAEE, 2017). These are all seen as necessary traits of an environmentally literate citizen, and no one trait is seen as necessary to come before the others.

Despite this evolution, much about environmental literacy remains unknown, particularly around measurement and theoretical development. There is not an empirically tested model of environmental literacy nor is there a formal theory. And, despite environmental literacy being the goal of environmental education, there has been little consistent measurement of the construct. In particular, there is a need for a practical
measurement tool that can be used in formal and informal settings and that can generate mass data on environmental literacy.

1.1.2 Environmental psychology and sociology

Environmental psychology and sociology are broad paradigms that cover a range of factors that influence environmental behaviors. Environmental psychology focuses on the role of the self in affecting environmental behaviors such as inherent motives, personality, traits, and self-efficacy (Steg, van den Berg, & de Groot, 2013). Environmental sociology, on the other hand, focuses on factors outside of the self, such as contextual factors and social group (Lockie, 2015). In this thesis, environmental psychology and environmental sociology will be considered under one psycho-social lens for two reasons. First, when considering environmental behaviors, such as recycling, they naturally combine both self-interest (e.g., monetary reward) and concern for others (e.g., less pollution in the environment; Bamberg & Moser, 2007). Thus, environmental behaviors are inherently psycho-social. Second, psycho-social constructs have typically been grouped together in meta-analyses (Bamberg & Moser, 2007; Hines, Hungerford, & Tomera, 1987). Despite the significant progress that has been made in each of these respective fields, there is a lack of research on the environmental psycho-social factors of children.

1.2 Study objectives

Two overarching research questions drive this study and connect the second and first manuscript. The first is: How can we better understand the development of environmental behaviors in children? The second draws from the first to ask: How can we utilize this information to aid practitioners? To answer these questions, this thesis has two manuscripts
which focus on two different perspectives for promoting environmental behaviors. The first manuscript draws from the educational theoretical perspective and highlights environmental literacy, while the second manuscript analyzes connection to nature - a part of the psycho-social theoretical perspective.

1.2.1 Manuscript one: Development and validation of the environmental literacy instrument for adolescents

Manuscript one focuses on the development and validation of a practical environmental literacy tool for teachers and practitioners. To better understand the development of environmental behaviors in youth, we test several conceptual models of environmental literacy in the manuscript. This model development aids in building the theory of environmental literacy, as well as adds to the body of research on environmental behaviors. To address research question two, we will use the study and its results to aid in program evaluation and add to the pool of data on environmental literacy. These efforts could spark increased funding and credibility for the environmental education field.

1.2.2 Manuscript two: Predicting recreational pathways to connection to nature among youth

In manuscript two, we focus on how demographic information, participation in outdoor activities, activity socialization level, and frequency of participation in outdoor activities affects connection to nature, a predictor of environmental behavior (Cheng & Monroe, 2012). To address research question one, the study advances theory on connection to nature among children by (1) testing the results of retrospective studies with adults and (2) breaking down the importance of individual and collective activities in developing
connection to nature. To address research questions two, the results provide practitioners with knowledge on where to focus their efforts to help promote connection to nature. For example, practitioners can think in terms of program activity type and frequency (e.g., solitary, nature journaling weekly) to increase the connection to nature of program participants.
Chapter 2. Development and Validation of the Environmental Literacy Instrument for Adolescents

2.1 Introduction

Environmental challenges such as water conservation and quality (UNEP, 2016), climate change (IPCC, 2014), and biodiversity loss (Secretariat of the Convention on Biological Diversity, 2014) are becoming increasingly pressing. Addressing these issues requires a citizenry who understands ecology, cares about the environment, has the skills to analyze complex issues, and is motivated to act (Hollweg, et al., 2011). These attributes are associated with the four components of environmental literacy (EL): ecological knowledge, affect (pro-environmental attitudes, environmental sensitivity, self-efficacy), cognitive skills (issue analysis and problem solving), and environmental behavior (Hollweg, et al., 2011; Stevenson, Peterson, Bondell, Mertig, & Moore, 2013). The goal of environmental education (EE) is to build EL, and research suggests EE can effectively do so, especially when it includes educational time spent outdoors (North American Association for Environmental Education, 2010; Stevenson, et al., 2013; UNESCO-UNEP, 1977).

Encouragingly, there are growing numbers of EE programs, however, evaluation of these programs has been limited (Blumstein & Saylan, 2007; Carleton-Hug & Hug, 2010; Monroe, 2010). Heimlich (2010) notes that while EE has recently developed into a profession, the emphasis on EE evaluation is lagging. As such, most EE programs have not integrated systematic, rigorous evaluation into their efforts (Heimlich, 2010; Norris & Jacobson, 1998; O’Neil, 2007). O’Neil (2007) found only one-third of 37 EE projects reviewed had formal evaluations. In addition, some of these evaluations were of poor quality,
as indicated by evaluations that do not match the program’s long-term objectives (Stern, Powell, & Hill, 2013) or evaluations over the course of a short time frame (e.g., same day as the experience or a few days after; Carleton-Hug & Hug, 2010). Successful EE program evaluation faces multiple challenges. First, limited knowledge of contextual factors among program participants (e.g., socioeconomic status, cultural background) presents a barrier to EE evaluation because such factors can influence program outcomes and potentially confound EE assessments (Carleton-Hug & Hug, 2010). Second, many EE program providers do not have a strong background in program evaluation. Third, EE providers face time and budget constraints associated with using or developing EE evaluation tools (Carleton-Hug & Hug, 2010; Monroe, 2010; Powell, Stern, & Ardoin, 2006).

Developing, and even using, EE instruments often creates logistic hurdles EE practitioners cannot overcome (Carleton-Hug & Hug, 2010; Powell et al., 2006). Regardless of cost, many of the instruments that do exist were designed for measuring program objectives versus broader EL concepts, which has rendered comparison of programs challenging or impossible (Robelia & Murphy, 2012; Stern et al., 2013). Additionally, most instruments only focus on one or two components of EL which further complicates evaluation of programs aiming to contribute to EL as a whole (e.g., attitudes and knowledge in the Children’s Environmental Attitudes and Knowledge Scale [CHEAKS] (Leeming, Dwyer, & Bracken, 1995); attitudes in the Children’s Attitudes Towards the Environment Scale [CATES] (Musser & Diamond, 1994). The Middle School Environmental Literacy Survey (MSELS) is among the most comprehensive and well-known tools for EL evaluation (McBeth, Hungerford, Marcinkowski, Volk, & Cifranick, 2011) and, in late spring 2007, its developers pioneered a national survey of EL of U.S. middle school (11-14 year old) students
Although the MSELS has been utilized in a few EL studies (Stevenson et al., 2013), its length (45 minutes for administration; McBeth et al., 2008) makes its use challenging, particularly in informal and outdoor settings. Additional EL instruments have been developed for college undergraduates (Shephard et al., 2014) as well as elementary and secondary teachers (Liu, Yeh, Liang, Fang, & Tsai, 2015), but few instruments measure all components of EL among older adolescents.

High schoolers represent an understudied adolescent population that should be included in EL research. A study on wildlife perceptions by Kellert (1985) suggested that 8th to 11th graders (13-18 year olds) are the ideal candidates for encouraging ethical concern and ecological appreciation of the environment. Similarly, Sivek (2002) proposed that the environmental sensitivity of adults is formed in their teenage years. Additionally, early high school students (9-10th graders) possess both the cognitive ability to understand environmental issues coupled with attitudes and worldviews that have not been fully formed (Carnegie Council on Adolescent Development, 1989; DiEnno & Hilton, 2005; McBeth et al., 2008). Others suggest that environmental attitudes and behaviors tend to decline as children enter high school, (Gorey, 2001; McBeth et al., 2008; Stevenson et al., 2013) highlighting the need to identify strategies to keep students engaged as they transition out of middle school. The North American Association of Environmental Education’s (NAAEE) Guidelines for Excellence: K-12 Learning (2010) note that, in high school, EE ‘can promote active and responsible citizenship’ (p. 49) encouraging students to craft and apply skills, such as problem-solving and communication, in real-world situations. Although interventions with younger students may have long term impacts on environmental literacy (Farmer,
Knapp, & Benton, 2007; Stern, Powell, & Ardoin, 2008), addressing EL with high school students may ensure that older adolescents maintain trajectories toward an environmentally literate adulthood. Instruments addressing components of EL among high school students can build on previous studies measuring environmental sensitivity (Sivek, 2002), environmental attitudes (Bradley, Waliczek, & Zajicek, 1999; DiEnno & Hilton, 2005), and environmental knowledge (Gambro & Switzky, 1994). And, while the Secondary School Environmental Literacy Instrument (SSELI) addresses environmental literacy more broadly (Marcinkowski & Rehrig, 1995; Nowak, Wilke, Marcinkowski, Hungerford, & Mckeowan-Ice, 1995), its challenges match the similar MSELS, with the length (i.e., 60 minutes or more) and, particularly, accessibility (i.e., not currently widely available to practitioners) proving challenging in informal and outdoor settings characteristic of EE.

2.2 Conceptual framework and scale development process

In this paper, we present the development and validation of a comprehensive EL instrument for older adolescents (i.e., 14 to 19 year olds). This instrument is the first widely available EL instrument designed for older adolescents that we are aware of which is accessible and short enough for use in field applications. Our conceptual framework for the ELI-A (Environmental Literacy Instrument for Adolescents) was based on the definition of EL established in the Tbilisi Declaration’s (1977) goals and objectives which highlight four main components: knowledge, skills, affect, and behavior (UNESCO-UNEP, 1977). This framework is mirrored in U.S. national curriculum and policy, including the United States’ National Environmental Education Act of 1990 which requires the EPA to increase
environmental literacy, defined as: awareness and sensitivity, knowledge and understanding, attitudes, skills, and participation (EPA, 2017).

Most recently, Hollweg et al. (2011) grouped these components into knowledge, (e.g., knowledge of physical and ecological systems and social, cultural, and political systems), dispositions (e.g., sensitivity and locus of control/self-efficacy), competencies (e.g., can identity and analyze environmental issues), and environmentally responsible behavior (Figure 2.1), which are similar to components measured by existing comprehensive EL measures (knowledge, affect, cognitive skills, and behavior; McBeth et al., 2011; McBeth et al., 2008). Although the Hollweg et al. (2011) framework includes dispositions and competencies, we chose to focus on the four components used in most versions of EL to facilitate cross-study comparison as well as to minimize survey length, as shorter instruments lead to higher completion rates, lessen survey fatigue (Dillman, Smyth, & Christian, 2014), and are more feasible in outdoor and informal education contexts. These four EL components are knowledge, hope as a measure of affect, cognitive skills, and self-reported behavior. Among these, the affective dimension of EL is probably the least explicitly theorized and varies the most among conceptualizations of EL. This dimension has been treated as attitudes (Pe’er, Goldman, & Yavetz, 2007; Shephard et al., 2014), emotional connections or sensitivity (McBeth et al., 2008; Liu et al., 2015), willingness to act (McBeth et al., 2008), and self-efficacy (Hollweg et al., 2011; North American Association of Environmental Education, 2010). Determining the best articulation of affect is beyond the scope of this paper, but we chose to focus on a measure of self-efficacy or hope for two reasons: first, the construct is more directly tied to behavior than attitudes, emotions, or sensitivity (Meinhold & Malkus, 2005; Moè, Pazzaglia, & Ronconi, 2010); and, second, a concise and valid
A measure of hope exists, facilitating a shorter instrument (Stevenson & Peterson, 2016). Conceptualization of affect as environmental hope stemmed from a desire to emphasize a measure of self-efficacy, as this is a key disposition associated with EL (Hollweg et al., 2011). Similarly, Bandura’s work (1977, 1986) and more recent studies on self-efficacy (Monroe, 2003) highlight the key role of personal efficacy (a person’s confidence that they can act to achieve a desired outcome) in influencing behavior. Self-efficacy is also related to other drivers of environmental behavior outside of EL constructs, such as locus of control and perceived behavioral control (Monroe, 2003; McLeod, Hine, Please, & Driver, 2015; Zimmerman, 2000).

![Figure 2.1 Domains of environmental literacy (Hollweg, Taylor, Bybee, Marcinkowski, McBeth, Zoido, et al., 2011).](image)

Figure 2.1 Domains of environmental literacy (Hollweg, Taylor, Bybee, Marcinkowski, McBeth, Zoido, et al., 2011).
2.2.1 Knowledge

We conceptualized knowledge from Hollweg et al. (2011) definition, as well as the characterization of knowledge provided by NAAEE’s Guidelines for Excellence: K-12 Learning Excellence (2010), which includes ‘understanding the processes and systems that comprise the environment, including human systems and their influences’ (p. 5). To operationalize the knowledge scale for an adolescent audience, we included questions targeting a wide range of environmental concepts, as suggested by Hollweg et al. (2011), including physical and ecological systems. To create developmentally appropriate questions, we integrated items that required multilogical thinking† (Morrison & Free, 2001) appropriate for the 9-12 grade range. Four ecologists at North Carolina State University reviewed the first draft of questions to eliminate any potential factual errors, and we relied on the educational psychology expertise of J. Nietfeld (Professor, Educational Psychology, NCSU) to provide feedback on categorization of the difficulty of questions based on whether the question required monological versus multilogical thinking. Using this strategy, we developed 15 multiple-choice questions (Table 2.1). All questions had four possible responses and one correct answer.

† Multilogical thinking refers to “thinking that sympathetically enters, considers, and reasons within multiple points of view,” such as looking at an ecological problem from moral, political, and biological perspectives (Paul, 1995).
Table 2.1 Initial structure of ELI-A knowledge, hope, and behavior scales. Items related to lack of environmental despair on the hope scale are indicated by *.

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>Factor 1 loading</th>
<th>Unique variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>What would most likely pollinate a flower with red petals and no odor?</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Burning coal for energy creates problems by:</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Phosphates are harmful in rivers because they:</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Nitrogen enters the soil through:</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Ecology is the study of the relationship between:</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>A series of predictable changes that occur in a community over time is called:</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>To which population characteristic does this information refer?</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>What is the original sources of energy for all living things on earth’s surface?</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>What term refers to living organisms and their physical environment?</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>What process is missing in the blanks above?</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Based on the image above, which do you think is the best conclusion about these animals?</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>What important role do soil organisms such as worms, bacteria, and fungi play?</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>As the number of animals in an area approaches the carrying capacity, what will happen?</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>As nutritional energy passes through the food chain, energy...</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Which type of symbiotic relationships does this best illustrate?</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hope</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe people will be able to solve most environmental problems.</td>
<td>0.58</td>
<td>0.63</td>
</tr>
<tr>
<td>The actions I can take are too small to help solve most environmental problems.</td>
<td>0.20</td>
<td>0.55</td>
</tr>
<tr>
<td>I believe scientists will be able to find ways to solve environmental problems.</td>
<td>0.66</td>
<td>0.51</td>
</tr>
<tr>
<td>Even when some people give up, I know there will be people who will continue to try to solve environmental problems.</td>
<td>0.61</td>
<td>0.55</td>
</tr>
<tr>
<td>Environmental problems are out of my control.</td>
<td>0.37</td>
<td>0.48</td>
</tr>
<tr>
<td>Because people can learn from our mistakes, we will influence the environment in a positive direction.</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td>Every day, more people care about environmental problems.</td>
<td>0.43</td>
<td>0.79</td>
</tr>
<tr>
<td>If everyone works together, we can solve environmental problems.</td>
<td>0.72</td>
<td>0.43</td>
</tr>
<tr>
<td>At the present time, I am energetically pursuing ways to solve environmental problems.</td>
<td>0.33</td>
<td>0.87</td>
</tr>
<tr>
<td>Environmental problems are so complex, we will never be able to solve them.*</td>
<td>0.50</td>
<td>0.61</td>
</tr>
<tr>
<td>I know that there are many things that I can do to help solve environmental problems.</td>
<td>0.73</td>
<td>0.47</td>
</tr>
<tr>
<td>I feel helpless to solve environmental problems.*</td>
<td>0.32</td>
<td>0.54</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Behavior</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Choose an environmental topic when I can choose a topic for an assignment in school.</td>
<td>0.23</td>
<td>0.52</td>
</tr>
<tr>
<td>Turn off the lights at home when they are not in use</td>
<td>0.73</td>
<td>0.34</td>
</tr>
<tr>
<td>Pick up trash that I find outside</td>
<td>0.59</td>
<td>0.54</td>
</tr>
<tr>
<td>Ask others about things I can do about environmental problems.</td>
<td>0.08</td>
<td>0.34</td>
</tr>
<tr>
<td>Turn off the water when it is not in use</td>
<td>0.70</td>
<td>0.32</td>
</tr>
<tr>
<td>Close the refrigerator door while I decide what to get out of it</td>
<td>0.62</td>
<td>0.61</td>
</tr>
<tr>
<td>Recycle at home</td>
<td>0.52</td>
<td>0.68</td>
</tr>
</tbody>
</table>
2.2.2 Hope

We designed our hope scale using the Snyder et al. (1991) conceptualization of hope; combining agency and pathways thinking, that is, believing you can achieve a goal (i.e., personal self-efficacy) and seeing clear pathways to progress (i.e., solutions are possible). This conceptualization of hope has been utilized to study climate change hope among adolescents (Stevenson & Peterson, 2016; Li & Monroe, 2017). Expressions of climate change hope include both individual and collective agency (i.e., believing that I can make a difference and that society can make a difference), as well as lack of negative thinking or despair (Stevenson & Peterson, 2016; Li & Monroe, 2017). We adapted Stevenson and Peterson’s (2016) climate change hope and lack of climate change despair scales to align better with EL by focusing broadly on environmental topics. All questions had five possible choices: strongly disagree, disagree, neutral, agree, strongly agree.

2.2.3 Cognitive skills

The cognitive skills scale was conceptualized based on the NAAEE’s Guidelines for Excellence: K-12 Learning, applying ‘questioning, analysis and interpretation skills’ to ecological knowledge to make decisions (North American Association for Environmental Education, 2010). We defined cognitive skills as how well students can identify and analyze environmental issues. Cognitive skills have been studied in many contexts (Finn et al., 2014; Taatgen, 2013) in addition to EE (Bluhm, Hungerford, McBeth, & Volk, 1995; McBeth et al., 2011, 2008; Stevenson et al., 2013). This prior research influenced our conceptualization of cognitive skills. During in-person administration of the MSELS to 856 grade school students (Stevenson et al., 2013), we observed students with lower reading levels exhibiting frustration, skipping large blocks of text, randomly selecting answers to questions linked to
reading assignments several paragraphs long, and taking over one hour to complete the survey. Feedback from participants in previous studies conducted by the research team (Stevenson, Carrier, & Peterson, 2014; Stevenson et al., 2013) led us to prioritize a concise question format that reduced test time and reduced potential to inadvertently test reading comprehension rather than cognitive skills.

After reviewing scales on reasoning, problem solving, and cognitive skills, we determined the format of Rest’s (1979) Defining Issues Test (DIT) balanced parsimony with accurately assessing the ability to analyze complex scenarios. Rest used this format to focus on moral dilemmas (e.g., shoplifting) for which respondents ranked the importance of related issues (e.g., personal need) in light of the situation presented. For our study, the cognitive skill measure provides an environmental dilemma (i.e., collapse of a fishery) and a list of five questions which might help mitigate the dilemma. Students must rank the questions by their importance in addressing the fishery collapse. To develop this tool, we first consulted with a fisheries expert (J. Rice, Professor, Applied Ecology, Extension Fisheries Specialist, NCSU) to draft a scenario to describe an impaired fishery. Next, we asked five faculty members from the Fisheries, Wildlife, and Conservation Biology program and Applied Ecology Department to generate a list of the five most important questions to consider when deciding how to mitigate threats to the fishery, as well as five ‘red herring’ items, defined as non-issues, that might seem important to someone not utilizing cognitive skills. This process generated 15 novel questions, which we then asked the experts to rank from most to least important. Next, one item was selected from the top three ranked items, one from the next three ranked items, and so on, until we arrived at five items. Finally, we asked the experts to again rank the final set of five questions. This generated an average rank for each item,
against which we could score the student responses. For specific scoring procedures, please see the Methods section.

2.2.4 Behavior

We conceptualized behavior as the degree to which students reported engaging in pro-environmental behavior such as recycling or conserving water. The focal behaviors reflect those from other environmental behavior scales (Liu et al., 2015; McBeth et al., 2008). However, the final behavior scale was operationalized differently from those in similar published work (Dijkstra & Goedhart, 2012; Erdogan, Ok, & Marcinkowski, 2012; McBeth et al., 2008) by including frequency of behavior and having shorter question stems. Frequency of behavior reflects one’s repeated actions across time which are central to determining traits (i.e., behavior trends; Fleeson, 2004). Using this strategy, we developed seven questions to construct the scale. All questions had five possible choices: never, rarely, sometimes, often, and always.

2.3 Current study

In this paper, we present the development and validation of the ELI-A. We examine the theoretical foundation, development, construct validity, and reliability of four scales that together make up the ELI-A from a sample of students in an Agriculture Applications’ course in North Carolina, U.S.A. (n = 665). The Agriculture Applications’ course is fitting given that the curriculum aligns with many EL goals in both a broad sense, such as developing critical thinking and decision-making skills, and, more specifically, with focal content on ecology and the environment (e.g., identifying parts of a tree, their functions, and their uses). Much of the curriculum focuses on interacting with the natural world through studying
horticulture, farming practices, and natural resource management (National Council for Agricultural Education, 2009; NC Department of Public Instruction, 2013). Validation of an EL scale with the agricultural education community serves the dual purpose of capturing data on the EL of this understudied group and providing a tool that may be useful to study EL among adolescent audiences. Further, by examining how well our survey data fit with accepted models of EL, we empirically explored the theoretical relationships between components of EL. We compared the utility of several models based on the relationships presented in literature specific to EL.

2.4 Methods

2.4.1 Pilot testing

After developing a draft instrument in spring 2014, we piloted it with a convenience sample of high school students \( n = 20 \). Students were asked to give written and oral feedback on the instrument for items that were unclear or confusing. We examined the knowledge and cognitive skills items for normality of responses and used Cronbach’s alpha measures to test the reliability of the hope and behavior scales. See Table 2.2 for a summary of pilot instrument reliability.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Cronbach’s alpha</th>
<th>Interitem covariance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>0.64</td>
<td>0.02</td>
</tr>
<tr>
<td>Hope</td>
<td>0.33</td>
<td>0.05</td>
</tr>
<tr>
<td>Behavior</td>
<td>--</td>
<td>-0.03</td>
</tr>
</tbody>
</table>
2.4.2 Sample and data collection

To further test the reliability of the instrument and validate the scale, we recruited 14 high school agriculture teachers across North Carolina who were willing to include their students in the study. Because students are assigned to teachers independently from this study, self-selection among teachers did not bias selection of student participants. During the 2015-2016 school year, select high school agriculture teachers across North Carolina administered paper surveys to all students \( (n = 748) \) during the first several weeks of their Agriculture Applications classes. Because most high school classes last one semester, some students \( (n = 434) \) took the survey at the beginning of the fall semester (August 2015) and others \( (n = 314) \) took it at the start of the spring semester (January 2016). Teachers were responsible for survey administration. All classes contacted participated in the study.

2.4.3 Data preparation

As all scales were additive, item-level missing data would impact reliability and validity analysis. Further, structural equation modelling (SEM) excludes individuals that are missing data for any part of the model. Since SEM was a crucial part of our analysis, we ran listwise deletions to exclude any individual who did not answer all items within the hope, cognitive skills, and behavior sections. This accounted for 14 respondents (1.9%) in the hope section, 37 respondents (4.9%) in the cognitive skills section, and 56 respondents (7.5%) in the behavior sections; other EL studies have 3.6 - 18.3% missing data across similar sections (McBeth et al., 2008). Seventeen respondents had data missing in two or more sections. We used t-tests to compare the group of students who completed all items with those students who had items missing. We found no differences between students with missing data and students without missing data in terms of gender, ethnicity, or age. Missing data were coded
as incorrect answers for the knowledge scale (Tobler, Visschers, & Siegrist, 2012). This resulted in 665 usable surveys.

2.4.4 Data analysis

We tested the reliability of each item within the knowledge, hope, and behavior scales using Cronbach’s alpha. We could not run reliability tests for the cognitive skills scale because of its ranking format. We tested the validity of the hope and behavior scales through principal component factor analysis. The primary analysis technique used to analyze the structure of the items was confirmatory factor analysis (CFA) via SEM. We used CFA rather than an exploratory approach to refine the EL scales because our analysis tested an existing four factor model of EL (Brown, 2006; Hollweg et al., 2011; Suhr, 2005). Additionally, CFA allowed us to account for measurement error (Brown, 2006). The first step was to assume all scales were single-factor and would lead to a four-factor model. In this model, environmental knowledge and hope both impact cognitive skills, which influences behavior, which reflects the framework developed by Hollweg et al. (2011; Figure 2.1). The initial factor analysis revealed that neither the hope nor the behavior scale were one factor (Table 2.1). We expected the hope scale to split into two factors along items associated with environmental hope and lack of environmental despair based on the scale we drew from (Stevenson & Peterson, 2016), and all but one did. We removed this one item (At the present time, I am energetically pursuing ways to solve environmental problems) from the hope scale because it had a factor loading below 0.400. We also removed two items with low factor loadings (< 0.400) from the behavior scale. The reduced behavior scale then conformed to a single factor,
and the hope scale conformed to two factors containing environmental hope and lack of environmental despair items, respectively (Table 2.3).

To test the validity of the cognitive skills scale, we relied on correlation testing between the cognitive skills and knowledge section, a typical approach for validating ranking-type questions (Schlaefli, Rest, & Thoma, 1985). For the validity of the knowledge scale, we did not attempt to use factor analysis or make the knowledge scale one factor since factor analysis assumes items have the same frequency distribution for the latent trait (i.e., difficulty; van Schuur, 2003). The items on the knowledge scale, however, vary in difficulty. The scale items were binary with one correct answer, and items differed in their influence on the latent trait. We instead chose to use item response theory because it is a standard theoretical approach underlying standardized testing today, such as the GRE (Embretson & Reise, 2013), which also utilizes binary correct/incorrect answers. Item response theory analyzes scores using assumptions about the mathematical relationship between abilities (e.g., ecological knowledge level) and item responses (Baker, 2004). Thus, it takes difficulty of items into account when computing the latent trait.
Table 2.3 Final structure and factor loadings of hope and behavior scales

Items related to lack of environmental despair on the hope scale are indicated by *.

<table>
<thead>
<tr>
<th>Hope</th>
<th>Factor 1 loading</th>
<th>Factor 2 loading</th>
<th>Unique variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe people will be able to solve most environmental problems.</td>
<td>0.60</td>
<td>--</td>
<td>0.63</td>
</tr>
<tr>
<td>The actions I can take are too small to help solve most environmental problems.</td>
<td>--</td>
<td>0.68</td>
<td>0.54</td>
</tr>
<tr>
<td>I believe scientists will be able to find ways to solve environmental problems.</td>
<td>0.70</td>
<td>--</td>
<td>0.51</td>
</tr>
<tr>
<td>Even when some people give up, I know there will be people who will continue to try to solve environmental problems.</td>
<td>0.67</td>
<td>--</td>
<td>0.54</td>
</tr>
<tr>
<td>Environmental problems are out of my control.</td>
<td>--</td>
<td>0.71</td>
<td>0.48</td>
</tr>
<tr>
<td>Because people can learn from our mistakes, we will influence the environment in a positive direction.</td>
<td>0.65</td>
<td>--</td>
<td>0.58</td>
</tr>
<tr>
<td>Every day, more people care about environmental problems.</td>
<td>0.46</td>
<td>--</td>
<td>0.79</td>
</tr>
<tr>
<td>If everyone works together, we can solve environmental problems.</td>
<td>0.75</td>
<td>--</td>
<td>0.42</td>
</tr>
<tr>
<td>Environmental problems are so complex, we will never be able to solve them.</td>
<td>--</td>
<td>0.55</td>
<td>0.60</td>
</tr>
<tr>
<td>I know that there are many things that I can do to help solve environmental problems.</td>
<td>0.66</td>
<td>--</td>
<td>0.47</td>
</tr>
<tr>
<td>I feel helpless to solve environmental problems.</td>
<td>--</td>
<td>0.68</td>
<td>0.53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Factor 1 loading</th>
<th>Factor 2 loading</th>
<th>Unique variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn off the lights at home when they are not in use</td>
<td>0.77</td>
<td>--</td>
<td>0.42</td>
</tr>
<tr>
<td>Pick up trash that I find outside</td>
<td>0.55</td>
<td>--</td>
<td>0.70</td>
</tr>
<tr>
<td>Turn off the water when it is not in use</td>
<td>0.74</td>
<td>--</td>
<td>0.45</td>
</tr>
<tr>
<td>Close the refrigerator door while I decide what to get out of it at home</td>
<td>0.61</td>
<td>--</td>
<td>0.62</td>
</tr>
<tr>
<td>Recycle at home</td>
<td>0.49</td>
<td>--</td>
<td>0.76</td>
</tr>
</tbody>
</table>

2.5 Scoring and model fit

A cumulative score was generated for each scale. For the ecological knowledge scale, one point was given for each correct answer. For the hope scale, each item was worth five points. One point was given for ‘strongly disagree,’ and options increased by one point so that five points were given for ‘strongly agree.’ The cognitive skills scale had a maximum score of 12.8. Each item had an average expert ranking score. Students’ rank for each item were subtracted from the expert ranking to generate a difference (e.g., difference = expert ranking – student ranking). The absolute values of all the differences were subtracted from 12.8 to get the total cognitive skills score. The behavior scale was scored similarly to the hope scale. One point was given for ‘never,’ and options increased by one point so that five
points were given for ‘always.’ To generate a final score for EL, the sum of each scale was weighted equally to account for one quarter of the total score. The knowledge scale results were multiplied by 2.5, the hope scale by 0.45, and the cognitive skills scale by 1.95. The behavior scale was not changed because the maximum score is 25. The ELI-A scores ranged from 12 to 100.

We ran iterative SEMs and generated corresponding goodness-of-fit statistics to validate our instrument and empirically compare several competing models based on current EL theory. Early EE models of environmental behavior implied a linear relationship in which knowledge predicted attitudes, which predicted skills, which in turn predicted behaviors (Hungerford & Volk, 1990). Research suggests the relationships between antecedents to behavior are likely more nuanced, with interactions and feedback between knowledge, attitudes, and skills, which all predict behavior (Heimlich & Ardoin, 2008; Hollweg et al., 2011; Kollmuss & Agyeman, 2002). The Hollweg et al. (2011) model for EL represents this more nuanced view, in which knowledge is linked to dispositions, which are in turn linked to competencies, which are then linked to behaviors (Figure 2.1). Because these models have not been empirically tested, we compared the utility of several models based on the relationships presented in literature specific to EL (Dijkstra & Goedhart, 2012; Hollweg et al., 2011; Pe’er, Goldman, & Yavetz, 2007) and environmental behaviors (Heimlich & Ardoin, 2008; Kollmuss & Agyeman, 2002) using goodness of fit measures. In model one, all factors of EL are correlated and equally predict behavior (Figure 2.3). Models two and three reflect a progression supported by the literature (Hollweg et al., 2011, Heimlich & Ardoin, 2008; Kollmuss & Agyeman, 2002) in which knowledge and affect interact to predict behavior, but are mediated by cognitive skills. The relationship between
knowledge and affect has been theorized as correlative (Bamberg & Möser, 2007; Kollmuss & Agyeman, 2002; Roczen, Kaiser, Bogner, & Wilson, 2014) and interactive (Hines, Hungerford, & Tomera, 1987; Hollweg et al., 2011), but not empirically tested. We tested both correlative and interacting relationships between these factors in model two (Figure 2.4) and three (Figure 2.5), respectively.

To assess the utility of our competing models, we compared several fit statistics. SEM combines factor analysis and regression models to allow structural relationships among latent variables (e.g., ecological knowledge, hope, behavior). We report on Satorra-Bentler (S-B) Scaled Chi-Square (S-B $\chi^2$); S-B Comparative Fit Index (S-B CFI); Standardized Root Mean Square Residual (SRMR); the S-B Robust Root Mean Square Error of Approximation (S-B RMSEA), its probability of close fit (pclose) value, and its associated 90% confidence interval; and the coefficient of determination (CD). We use the S-B $\chi^2$, S-B RMSEA, and S-B CFI in lieu of $\chi^2$, RMSEA, and CFI because the S-B tests account for the degree of kurtosis in the data (Satorra & Bentler, 1994). The CFI is used as an incremental fit index to measure fit, it has a penalty for adding parameters. The RMSEA is an absolute measure of fit where 0.01 indicates excellent fit and 0.08 indicates mediocre fit (MacCallum, Browne, & Sugawara, 1996). Additionally, the smaller its associated confidence interval, the better the fit. The pclose value indicates the probability that RMSEA is less than 0.05. This can be interpreted as the probability that the fit of the model for the sample is close to the fit of the model for the population. If pclose > 0.05, the fit of the model for the sample is close to the population model. The SRMR is an absolute measure of fit, like RMSEA, and is the standard difference between the observed and predicted correlation. If SRMR = 0, the fit is perfect and if SRMR < 0.08 the fit is good (Hu & Bentler, 1999). The CD (i.e., $R^2$) is
conceptualized as the proportion of variance explained by the entire model (Nagelkerke, 1991). If the model has a perfect fit, the CD is 1 (i.e., 100% of variance is explained by the model). We ran a SEM on each of our competing models.

2.6 Results

There were 665 useable student questionnaires in the 2015-16 school year; 368 in the fall 2015 semester and 297 in the spring 2016 semester. Of the total 665 students, 41% were female, 50% were male, and 9% did not respond. Students’ ages ranged from 14 or younger to 18 or older, with a median age of 15. Grades ranged from 9th to 12th with 53% reporting 9th grade, 29% reporting 10th grade, 11% reporting 11th grade, and 7% reporting 12th grade. Fifty-five percent of students reported themselves as White, 23% Black or African American, 4% Asian/Pacific Islander, 12% Hispanic or Latino, 7% other, and 1% did not respond.

Reliability of the knowledge, hope, and behavior scales was acceptable compared to results from other instruments (Bradley, Waliczek, & Zajicek, 1999; Leeming et al., 1995; McBeth et al., 2008). Cronbach’s alpha for the initial scales are reported in Table 2.2, and Cronbach’s alpha for the final scales are reported in Table 2.4. The results from the item response theory analyses revealed that the scale was of average difficulty with 50% of students scoring a 70% or higher (Figure 2.2). The correlation between the cognitive skills item and the knowledge scale ($r = 0.39, p < 0.001$) suggests our measure of cognitive skills was related to knowledge, as should be the case, but not confounded by it (Finn et al., 2014). Preliminary testing of the final instrument with adolescents in school ($n = 67$) took students from 4 to 15 minutes to complete ($M = 10.28, SD = 2.47$).
Table 2.4 Comparison of overall scale reliability of MSELS and ELI-A

<table>
<thead>
<tr>
<th>Scale</th>
<th>Cronbach’s alpha</th>
<th>Scale</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological Knowledge</td>
<td>0.79</td>
<td>Ecological Knowledge</td>
<td>0.71</td>
</tr>
<tr>
<td>Verbal Commitment</td>
<td>0.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td>0.76</td>
<td>Hope</td>
<td>0.75</td>
</tr>
<tr>
<td>Sensitivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Issue Identification</td>
<td>0.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Issue Analysis</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action Planning</td>
<td>0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Commitment</td>
<td>0.78</td>
<td>Behavior</td>
<td>0.62</td>
</tr>
<tr>
<td>Behavior</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.2 Test response function for ecological knowledge scale

Expected score of ecological knowledge scale represented on y-axis. Level of ecological knowledge on x-axis, with 0 representing average student ability.

The SEM for model one (Figure 2.3) had poor fit, explained 13.2% of the model’s variance (see Table 2.5 for goodness-of-fit statistics for all models) and had one non-
significant path (cognitive skills to behavior). Model two (Figure 2.4) had poor fit. The model explained 25.4% of the model’s variance, and one path was not significant (cognitive skills to behavior). Model three displayed excellent goodness-of-fit. All paths were significant, except for the path from cognitive skills to behavior, which was significant at the 0.10 alpha level \((p = 0.095)\). These results support model three (Figure 2.5) as an appropriate model of EL among adolescents. The goodness-of-fit results indicate an excellent fitting model for a complex data set, and the model explained 26.6% of variance in the data (Table 2.5).

Table 2.5 Comparison of goodness-of-fit statistics for all models

<table>
<thead>
<tr>
<th>Model</th>
<th>S-B (\chi^2)</th>
<th>(p &gt; \chi^2)</th>
<th>S-B CFI</th>
<th>SRMR</th>
<th>S-B RMSEA</th>
<th>pclose</th>
<th>CD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>0.000</td>
<td>--</td>
<td>1.000</td>
<td>0.000</td>
<td>1.000 (0.000 - 0.000)</td>
<td>1.000</td>
<td>0.132</td>
</tr>
<tr>
<td>Model 2</td>
<td>0.000</td>
<td>--</td>
<td>1.000</td>
<td>0.000</td>
<td>1.000 (0.000 - 0.000)</td>
<td>0.000</td>
<td>0.254</td>
</tr>
<tr>
<td>Model 3</td>
<td>0.340</td>
<td>0.560</td>
<td>1.000</td>
<td>0.001</td>
<td>0.000 (0.000 - 0.085)</td>
<td>0.794</td>
<td>0.266</td>
</tr>
</tbody>
</table>

Figure 2.3 Model one: Initial structural equation model of environmental literacy
Standardized path coefficients reported for single-headed arrows. Standardized covariance reported for double-headed arrows. All relationships significant at \(p < 0.01\), except for cognitive skills to behavior \((p = 0.113)\).
2.4 Model two: Structural equation model of environmental literacy
Standardized path coefficients reported. Standardized covariance reported for double-headed arrows. All relationships significant at p < 0.01, except for cognitive skills to behavior (p = 0.113; Hollweg, Taylor, Bybee, Marcinkowski, McBeth, Zoido, et al., 2011).

2.5 Model three: Final structural equation model of ELI-A
Standardized path coefficients reported. All relationships significant at p < 0.01, except for cognitive skills to behavior (p = 0.095).

2.7 Discussion
We present the ELI-A as a validated, concise EL instrument for use with high school students, including measures of ecological knowledge, hope, cognitive skills, and behavior. Results indicate that each subscale (i.e., knowledge, hope, cognitive skills, and behavior) is reliable and valid and that each construct relates to others in ways that build on current
models of EL and environmental behavior (Hollweg et al., 2011; Kollmuss & Agyeman, 2002). The final model suggests knowledge and hope predict cognitive skills which weakly predicts behavior, and the interaction between knowledge and hope also predict behavior.

We identify contributions to measurement related to the hope and cognitive skills components. This study is the first of which we are aware that utilizes environmental hope as a measure of environmental affect. Aligning with similar measures of hope in previous studies (Li & Monroe, 2017; Stevenson & Peterson, 2016), the environmental hope scale reduced to two factors, agency (individual and collective) and lack of despair. Environmental hope provided a parsimonious way of measuring key aspects of environmental affect in an EL context. We also present a new, concise method for measuring cognitive skills that may reduce the chance of confounding reading comprehension and cognitive skills. As in the use of environmental hope, this study represents the first case that we are aware of which utilizes question-ranking to analyze cognitive skills (Rest, 1979) in an EL context. Given this novel application, future research should continue to examine its utility. We encourage researchers and evaluators to test our cognitive skills measure, or similar, site-specific items, in a field setting and to examine whether the scale detects cognitive skills gains in association with EE programming known a priori to boost cognitive skills (e.g., published EE curriculum such as Project Learning Tree; Stevenson, et al., 2013).

This study advances EL theory by identifying an interaction between knowledge and hope that together predict self-reported behavior. This finding builds on learning theory indicating knowledge has the greatest impacts on behavior when tied to affective factors such as emotions or to past experiences (Ormrod, 2016a). Previous research suggests knowledge and forms of affect (e.g., emotions) likely interact to predict behavior (Duerden & Witt,
Our findings extend this research by offering hope as a useful affective variable interacting with knowledge to shape behavior, since the hope scale functioned well in our model. Additionally, our model captured a direct link from the interaction between knowledge and hope to behavior, suggesting that in addition to being mediated by cognitive skills, some behaviors are directly influenced by ecological knowledge and hope or, at least, the interaction between them. This is intuitive, given some environmental behaviors measured in our instrument, and in everyday life, do not require significant problem-solving ability to employ (e.g., turn off the lights at home when they are not in use). Further, the relationship is supported by research suggesting direct effects of emotions and memories on behavior (Carmi, Arnon, & Orion, 2015; Heimlich & Ardoin, 2008; Lincoln, Cooper, & Hauber, 2016; Ormrod, 2016a) as well as environmental knowledge and behavior when considering attitudes (Duerden & Witt, 2010; Hines et al., 1987; Roczen et al., 2014).

The weak relationship between cognitive skills and behavior is surprising, but likely points to the need for continued scale and theoretical development. In this study, we included only one ranking exercise. Further development of similar items may strengthen the measurement of this construct as well as its utility in an EL model. Other explanations for the weak relationship include developmental and theoretical underpinnings. It is possible that students who are still developing cognitively may not be able to fully utilize these skills in their decision-making processes (Ormrod, 2016b). Cognitive skills may also simply stand on its own in the EL model and not directly predict behaviors. Alternatively, the utility of cognitive skills may vary depending on the types of behaviors in question. Cognitive skills might not be a predictor of simple behaviors, such as recycling or turning off the lights, but
cognitive skills might predict more complex behaviors. The quick-decision behaviors that we measure in the ELI-A may be more likely to be impacted by structural barriers and social norms (Bamberg & Möser, 2007; Tanner, 1999) than critical thinking skills. Behaviors that require higher-level thinking and problem-solving skills may be more likely linked to cognitive skills. This presents a challenge for future research because behaviors that require problem solving skills such as developing a successful environmental advocacy campaign are more difficult to measure than quick-decision behaviors.

Although we feel the ELI-A provides a rigorous tool for EE evaluation in adolescent contexts, our results highlight several important areas for future improvements to individual scales. First, the majority of participants in our study were 14 to 16 years old, and future work could evaluate the efficacy among the younger and older adolescents (i.e., 12–14 and 17–19), as well as among differing academic abilities. The test response function (Figure 2.2) suggested the scale had more items that were easier (i.e., more appropriate for low-achieving students) since the average ability student would score close to 70% on the scale. We suggest that future research should test the scale among older and/or higher achieving students to ensure validity with more advanced groups. Second, knowledge and cognitive skills are best measured with locally relevant questions (Hollweg et al., 2011), so compiling a bank of locally relevant cognitive skills ranking scenarios and knowledge questions on EE websites that provide evaluation tools for practitioners such as through NAAEE’s eePro network (naaee.org/eepro) or My EE Evaluation Resource Assistant (MEERA; meera.snre.umich.edu) would help EE practitioners best utilize the instrument. Upon publication, we will submit the instrument in full to both of these resources and encourage other researchers and evaluators to add additional scenarios or feedback on the instruments. Similarly, although the cognitive
skills item presented here was reliable and valid, future research which develops new environmental scenarios (e.g., agricultural land management, sea level rise) could help researchers understand how students respond to a range of environmental issues that may be more polarizing to some students than others (e.g., climate change). Additional scenarios will also provide evaluators using the ELI-A a range of topics more likely to ensure a match with their programming objectives (e.g., habitat conservation for wildlife-focused program, forest management for terrestrial-focused program).

In addition to scale-level improvements, future research should continue to empirically test models of behavior change in EL contexts. Though our model does offer support for an interaction between knowledge and hope, a novel theoretical contribution, it only explained 26.6% of the variance in the sample and had a nonsignificant path from cognitive skills to behavior. We suspect that socio-cultural factors may have impacted the explained variance (Ormrod, 2016c) and that false reporting of behaviors may have affected the overall model, since self-reported behaviors can be swayed by social desirability (Collado & Corraliza, 2015; Hollweg et al., 2011). Future research should analyze how contextual factors, particularly norms (Leeuw, Valois, Ajzen, & Schmidt, 2015; Morgan & Chompreeda, 2015) and cultural context (Morren & Grinstein, 2016), affect self-reported behaviors in this scale. To account for unexplained variance and the nonsignificant path from cognitive skills to behavior, future studies could also consider scales that address subcomponents of EL (e.g., motivation as a component of affect) that have been important factors in both learning and self-reported environmental behaviors (Chawla & Cushing, 2007; Collado & Corraliza, 2015; Heimlich & Ardoin, 2008; Ormrod, 2016b) as well as scales that address behaviors requiring more problem-solving skills than the ones we include.
Finally, external structural factors, such as access to a recycling program, could have influenced self-reported behaviors. These unmeasured constraints could account for a large amount of variance in the model (Kollmuss & Agyeman, 2002).

2.8 Conclusion

We hope the ELI-A developed and validated in this study is useful to many environmental educators. The four scales, ecological knowledge, hope as affect, cognitive skills, and self-reported behaviors, represent key environmental literacy concepts that researchers (Hollweg et al. 2011), government agencies (EPA, 2017), and international organizations (North American Association for Environmental Education, 2010) have acknowledged as important outcomes for EE. We see the ELI-A as a starting point for open access instruments to encourage metric development, particularly in the cognitive domain. In as much as EE evaluation is hindered by access to valid, reliable scales (Crohn & Birnbaum, 2010; Heimlich, 2010; Monroe, 2010), we encourage practitioners, researchers, and evaluators to consider testing and modifying the ELI-A to advance EE research and evaluation, with particular attention to cross-comparison of programs (Stern et al., 2013).
Chapter 3. Manuscript Two: Predicting Recreational Pathways to Connection to Nature Among Youth

3.1 Introduction

Current generations of Americans may be less connected to nature than in the past (Kellert et al., 2017), which poses potential problems for human health and well-being, as well as environmental engagement. For instance, research has linked spikes in obesity and mental health disorders in children with less time outdoors (American Academy of Pediatrics, 2006; National Wildlife Federation, 2010), and children were found to be more likely to correctly identify Pokémon characters than native wildlife (Balmford, Clegg, Coulson, & Taylor, 2002). However, high connection to nature (CTN), defined as an affinity for and comfort in nature (Cheng & Monroe, 2012; Nisbet, Zelenski, & Murphy, 2009), can lead to increased motivation to care for it and increased environmental behaviors (Cheng & Monroe, 2012; Arendt & Matthes, 2016; Frantz & Mayer, 2014).

Spending time outdoors, and specifically time alone outdoors, may be one of the most critical factors in fostering CTN among children, potentially setting them on lifelong paths of environmental engagement. Research suggests that time in nature helps children build positive emotions and attitudes towards nature (Cachelin, Paisley, & Blanchard, 2009; Chawla, 2015; Cheng & Monroe, 2012), and studies have shown that time alone in nature is a particularly important part of fostering environmental behaviors. A host of retrospective studies have revealed the importance of solitary outdoor experiences in childhood for forming environmental behaviors as an adult (Chawla, 1999; Corcoran, 1999; Ewert et al., 2005; James, Bixler, & Vadala, 2010; Tanner, 1980). Retrospective research on significant
life experience research, in particular, has revealed the importance of alone time outdoors for environmental engagement. Although these retrospective findings broadly state the importance of alone time outdoors, there are several research areas that need to be expanded. First, in most research, alone time has not been isolated from other types of outdoor experiences, such as those with family or friends (Tanner, 1980; Chawla, 1999). Second, there have been limited studies on children’s alone time in nature. One study by Stevenson et al. (2014) did study the link between time alone in nature and children’s (11-13-years-old) environmental behaviors. Although this study found a weak positive relationship, little else has been done. Third, there is a lack of information on how solitary outdoor activities influence CTN, rather than environmental behaviors. Cheng & Monroe (2012) found that previous experiences in nature were related to high CTN in children, but this study did not differentiate between types of experiences (e.g., individual versus collective). These differences should be considered, as some studies have shown that location and type of play can lead to different outcomes. For instance, research has shown that childhood (i.e., less than 10 years old) play in wildlands increased environmental competencies, preferences, and outdoor activities as an adolescent (Bixler et al., 2002) and that childhood involvement in appreciative (e.g., bird-watching) or consumptive (e.g., foraging) outdoor activities increased environmental behaviors (Ewert et al., 2005). Collado et al. (2014) found similar results (i.e., frequent experiences in nature predict positive environmental attitudes) when differentiating across residential areas (rural mountain, rural agricultural, urban).

Although time in nature alone promotes environmental engagement and CTN, social interactions in natural settings may be important as well. Social practice theory suggests certain behaviors (e.g., outdoor recreation, environmental behaviors) emerge from
identification with a group and notes the importance of interactions within social groups for reinforcing lifelong commitment to behaviors (Kempton & Holland, 2003). Thus, participation in outdoor activities with others may reinforce or augment CTN among children. Retrospective studies additionally support this theory. For instance, significant life experience research suggests outdoor experiences with others, such as family, friends, or scouting groups, promote environmental behaviors (Chawla, 1999; Corcoran, 1999; Tanner, 1980). Research with young environmental activists (i.e., 18-35; Arnold, Cohen, & Warner, 2009) suggests peer socialization promotes CTN and subsequent environmental engagement. Bixler et al. (2002) found, through retrospective interviews with adolescents (ages 13-18), that nature play in early childhood (i.e., before the age of ten) predicted not only engagement in other outdoor recreation activities such as fishing and tent camping but also comfort in wilderness settings. These findings laid the groundwork for James, Bixler, and Vadala’s (2010) environmental socialization model wherein early childhood experiences in nature (e.g., fantasy play, collecting rocks) build CTN, and social experiences outdoors in adolescence and early adulthood (e.g., volunteering at nature centers) encourage persistence in outdoor recreation activities, development of new skills, and solidification of CTN and environmental engagement into adulthood (James, Bixler, & Vadala, 2010).

3.2 Current study

We build on this foundation of CTN studies by exploring the relative importance of time alone and with others in nature for building CTN. Specifically, we model how engagement in outdoor recreation activities (by activity type and frequency) lead to high CTN. We account for diverse outdoor activities and whether these occur individually or
collectively. This study builds on previous qualitative research focused on single recreational activities or groups of activities by quantitatively evaluating: (1) the impact of a variety of outdoor activities (e.g., hiking, playing sports, fishing) on CTN, (2) the significance of social versus alone time outdoors on CTN, (3) the relative importance of one activity over another for building CTN, and (4) the effects of race, ethnicity, and gender on CTN. We suggest that for elementary children, certain outdoor activities are more important that others for developing CTN. Based on past literature, we hypothesize that:

(1) alone time in nature is a critical driver for CTN; and
(2) time spent in a group in nature is a secondary support of high CTN.

3.2.1 Contributions

This study makes two critical contributions to research on CTN. First, we measure the relative importance of time alone and with others in nature in building CTN through an investigation of specific outdoor recreation activities. No studies that we are aware of analyze the impact of a range of outdoor activities (e.g., hiking, playing sports) on CTN or the relative importance of one activity over another. When studying how life-long environmental engagement develops in children, it is important to acknowledge their participation in wide range of activities. This allows for research on the interplay between activities and the relative importance of each. Further, some children’s activities have received limited attention in CTN and environmental affinity studies due to their traditional conflict with environmental values (Holland, 2003). In particular, consumptive wildlife recreation activities, such as fishing and hunting, have not been considered in association with CTN but may be important activities shaping CTN. For instance, hunting participation
predicts biodiversity knowledge among 10-11 year old children (Peterson et al., 2017), environmental behaviors of college students (Ewert et al., 2005) and environmental attitudes within households (Peterson et al., 2008). These outdoor recreation activities may also mediate the relationship between environmental attitudes and behaviors (Thapa, 2010).

Another study revealed that adult hunters were four times more likely to engage in conservation behaviors than non-wildlife recreationists (Cooper, Larson, Dayer, Stedman, & Decker, 2015).

Second, we focus on diverse youth in the last stages of middle childhood (i.e., 9-12 years old). Seminal CTN studies relied on retrospective studies where adults were questioned about their childhood (Tanner 1980; Chawla, 1999). However, studies with children help overcome self-assessment and recall bias-related limitations of retrospective studies (Golden, Wrangham, & Brashares, 2013) and avoid potentially confounding effects of cultural changes, including increases in technology and decreases in perceived safety of the outdoors (Gough, 1999). More recent research with children did not focus on an array of individual demographic (age, race, and gender) outcomes (Braun & Dierkes, 2016; Ernst & Theimer, 2011) or did not gather any demographic data (Cheng & Monroe, 2012).

3.3 Methods

3.3.1 Sampling

Our sample consisted of 1,285 fifth-grade students, ages 9 to 12 years old ($M = 10.5$, $SD = 0.65$), in North Carolina, U.S.A. We focused on fifth-grade students since they are in the late stages of middle childhood (6-12) and approaching adolescence (12-18), a critical period for developing ethical and ecological knowledge necessary for environmental
engagement (Kellert, 1985) and outdoor recreation interests (James et al., 2010). Teachers administered online surveys in school during September and October 2016. Although our analysis unit was students, the lack of an adequate sample frame required us to sample in two stages – teachers and students. Most teachers were recruited through an environmental education program in western North Carolina and upstate South Carolina (34 teachers, 896 students), and the remainder was randomly selected from the same geographic area (17 teachers, 387 students; Figure 3.1). We included a variable for whether students would participate in the environmental education program or would not (i.e., were in randomly selected classroom) in all analyses. Although self-selection bias may exist among teachers, the unit of analysis, students, should not be affected as students are assigned to teachers in schools regardless of their environmental views or recreation behaviors. We tested our sample versus the true United States’ population using z-tests for proportions to compare gender (i.e., male versus female) and a binary indicator of ethnicity (i.e., white versus non-white) and found no significant differences ($p = 0.71$ and $p = 0.70$, respectively; U.S. Department of Education, National Center for Education Statistics, & Common Core of Data, 2015). Fifty-percent were female. Fifty-two percent of students identified as white/Caucasian, 9% as black/African American, 12% as Hispanic/Latino, 2% as Asian/Pacific Islander, 7% as Native American, 8% as other, and 10% as two or more.
3.3.2 Instrument development

We measured CTN using a six-item, five-point, Likert-type scale adapted from published, previously validated, CTN scales that address environmental affinity and comfort in nature (Cheng & Monroe, 2012; Martin & Czellar, 2016). Responses ranged from “strongly disagree” (1) to “agree” (5). Pilot testing with 609 students in spring 2016 revealed the scale went to one factor and was reliable (α = 0.813). Frequency of outdoor activities were measured on a five-point scale ranging from “never” (1) to “once a week or more” (5). Outdoor activities included camping, fishing, hunting, hiking, playing sports, playing outside, and spending time outside with family, in a group, or alone. Outdoor activities were selected based upon three criteria: (1) had been used in past instruments (McBeth, Hungerford, Marcinkowski, Volk, & Meyers, 2008), (2) accounted for different socialization levels (e.g., alone versus in a group), cultural groups, and interests (e.g., hunting versus playing sports outside), or (3) identified in the pilot test as a common outdoor activity among our population.
(i.e., playing sports outside). Validity and reliability tests were not assessed for frequency of outdoor activities, since the items were not intended as a summative scale. See Table 3.1 for the CTN scale and Table 3.2 for the outdoor activity scale.

Table 3.1 Connection to nature scale statistics. Mean, standard deviation, Cronbach’s alpha, and factor loadings for upper/lower quartiles of CTN scale (n = 706). Answers range from strongly disagree (1) to strongly agree (5).

<table>
<thead>
<tr>
<th>Item</th>
<th>M</th>
<th>SD</th>
<th>Cronbach’s alpha</th>
<th>Factor loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel comfortable in nature</td>
<td>4.19</td>
<td>1.03</td>
<td>0.88</td>
<td>0.82</td>
</tr>
<tr>
<td>When I’m in nature, I pay close attention to different plants and animals</td>
<td>3.87</td>
<td>1.14</td>
<td>0.89</td>
<td>0.72</td>
</tr>
<tr>
<td>I’d rather play outside than inside</td>
<td>3.93</td>
<td>1.24</td>
<td>0.88</td>
<td>0.76</td>
</tr>
<tr>
<td>If I have free time, I like to be in nature</td>
<td>3.67</td>
<td>1.31</td>
<td>0.86</td>
<td>0.87</td>
</tr>
<tr>
<td>Being in nature makes me happy</td>
<td>4.00</td>
<td>1.15</td>
<td>0.87</td>
<td>0.86</td>
</tr>
<tr>
<td>Being in nature makes me feel peaceful</td>
<td>4.02</td>
<td>1.18</td>
<td>0.87</td>
<td>0.82</td>
</tr>
</tbody>
</table>

3.3.3 Variables

We modeled high CTN through a variety of explanatory variables using a classification tree analysis (see below). CTN was determined as high (score 27-30; represented by 1) or low (score 6-21; represented by 0) based upon the upper and lower quartiles, respectively (Table 3.3). We included six outdoor activity variables: camping, fishing, hiking, hunting, playing outside, and playing sports outside. We additionally included variables for level of socialization when spending time outdoors: spend time outside by myself, spend time outside with family, and spend time outside with a group. We chose to measure alone time and social time in nature in two complimentary ways. First, we included self-assessment questions measuring time in nature alone, with family, and with larger groups (Table 3.2). Second, we asked about participation in activities that logically promote
time alone (e.g., hunting) and time in larger groups (e.g., camping; Table 3.2, Figure 3.2). The latter measures may be more objective than self-assessments (Lew, Alwis, & Schmidt, 2009). We included demographic variables that may be associated with CTN, including race, gender, and age. Girls can have higher levels of CTN than males (Frantz & Mayer, 2014; Kollmuss & Agyeman, 2002), and children often have higher CTN that adults (Braun & Dierkes, 2016). Previous research also identified different levels of comfort and affinity in nature among ethnicities, notably low levels of comfort in the outdoors among African Americans (Carlone et al., 2015; Finney, 2005). All variables included in the analysis were discrete variables.

Table 3.2 Descriptive statistics of outdoor activities. Mean and standard deviation given for reported frequency of outdoor activities for fifth-grade students (n = 1,279). Frequency of activity reported from never (1) to once a week (5).

<table>
<thead>
<tr>
<th>Activity</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunt</td>
<td>1.91</td>
<td>1.39</td>
</tr>
<tr>
<td>Fish</td>
<td>2.73</td>
<td>1.43</td>
</tr>
<tr>
<td>Hike</td>
<td>2.73</td>
<td>1.43</td>
</tr>
<tr>
<td>Camp</td>
<td>2.22</td>
<td>1.22</td>
</tr>
<tr>
<td>Play outside</td>
<td>4.74</td>
<td>0.77</td>
</tr>
<tr>
<td>Play sports outside</td>
<td>4.34</td>
<td>1.25</td>
</tr>
<tr>
<td>Spend time outside by myself</td>
<td>3.74</td>
<td>1.62</td>
</tr>
<tr>
<td>Spend time outside with family</td>
<td>4.24</td>
<td>1.17</td>
</tr>
<tr>
<td>Spend time outside with a group</td>
<td>3.74</td>
<td>1.48</td>
</tr>
</tbody>
</table>
3.3.4 Classification tree analysis

We relied on classification tree analysis to assess our hypotheses. Classification trees iteratively divide a sample into binary responses, and with every division, the sub-samples are increasingly similar in terms of the outcome variable (e.g., in upper quartile of CTN; Breiman, Friedman, Olshen, & Stone, 1984; Ma, 2005). Classification trees have several advantages over traditional models. First, classification tree analysis provides a visual representation of how the data can be divided into smaller sub-groups with varying CTN levels based on frequency of outdoor activities (Davidson & Bush, 2016). Second, classification trees build a hierarchy of explanatory variables and avoids isolating a few variables to explain an outcome (Breiman et al., 1984).

To run a classification tree analysis, we utilized RPART in R software (Therneau, Atkinson, & Ripley, n.d.). RPART constructs a classification tree by continually splitting the sample into two groups to make the proportions as close to 0 and 1 as possible (that is, as close to all individuals being in either the lower or upper quartile). The software begins with
the entire sample (i.e., root node) and searches through each explanatory variable (i.e., outdoor activity and/or demographic variable) to find which one best splits the sample into two groups with different proportions of the outcome variable (i.e., in upper quartile of CTN). The criteria for choosing which variable best splits the sample is the Gini index, a node impurity criterion employed by the RPART software (Loh, 2014). The Gini index measures how often a randomly chosen data point (i.e., student) from the sample would be incorrectly categorized (e.g., not in upper quartile) if the data point was categorized according to its explanatory variables (i.e., activity frequency or demographic information). The explanatory variable (i.e., outdoor activity and/or demographic variable) that has the smallest Gini index† will split the sample first (Therneau & Atkinson, 2017). This split results in two child nodes that are very different in terms of the chosen explanatory variable (i.e., upper quartile of CTN). These two child nodes are then split again based on the node impurity criterion. This splitting continues until the impurity criterion is not met or until a chosen sample size is reached (Therneau & Atkinson, 2017). When this occurs, the splitting ends and the remaining sample is called a terminal node.

We ran a classification tree analysis on the upper and lower quartile of our sample (n = 706). The upper and lower CTN quartiles capture the extreme ends of the sample and help to highlight the activities, frequency of activities, and combination thereof, that lead to high and low CTN. For our study, the branches represent potential predictors of CTN (i.e., outdoor activities and/or demographic variables) while the nodes denote the proportion of the

† Therneau and Atkinson (2017) provide a detailed introduction to Gini index and recursive partitioning in RPART.
sample that were in the upper quartile of CTN (score above 26). Every node has a distinct path made up of one or more branches. We analyzed each branch and associated child node for every terminal node. We refer to terminal nodes with a large proportion of students in the upper CTN quartile as key terminal nodes. Key terminal nodes have more than 75% of the sample in the upper CTN quartile.

Table 3.3 Connection to nature descriptive statistics for high and low quartiles.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>range</th>
<th>M</th>
<th>SE</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low quartile</td>
<td>318</td>
<td>0-21</td>
<td>17.82</td>
<td>0.21</td>
<td>17.41-18.22</td>
</tr>
<tr>
<td>High quartile</td>
<td>391</td>
<td>27-30</td>
<td>28.34</td>
<td>0.06</td>
<td>28.23-28.26</td>
</tr>
</tbody>
</table>

3.4 Results

Students’ CTN scores ranged from 6 to 30 (M = 23.68, SD = 5.72). Upper and lower quartile (n = 706) statistics are provided in Table 3.3. Frequency of outdoor activities varied widely (Table 3.2). Hunting was the least frequent outdoor recreation activity and playing outside was the most frequent activity.

3.4.1 Description of classification tree

Figure 3 shows the classification tree analysis for frequency of outdoor activities channeling students into nodes based on proportion of high CTN. The root node was split according to time spent in nature alone (i.e., time alone in nature was most predictive of high CTN). The left child node (Node 1) contained 324 students who spent time in nature once a month or less (36% of sample in upper CTN quartile). The right child node (Node 2) contained 382 students who spent time in nature once a week or more; this sub-sample had 71% of students in the upper quartile. See Figure 3.3 for the full classification tree.
3.4.2 Description of child characteristics

We found support for hypothesis one, as the most predictive split was on time spent in nature alone. Children who spent time alone in nature weekly (Figure 3.3, Node 2) had 34.8% more students in the upper CTN quartile than those who spent time alone less frequently (Figure 3.3, Node 1). Further, Nodes 4 and 6 split the group into solitary activities, such as hunting and fishing, respectively. The proportion of children in the upper CTN quartile who spent time in nature alone once a week or more and fished three times a year or more (Figure 3.3, Node 6) was 24.3% higher than those who did not fish (Figure 3.3, Node 5). Children who spent time outside alone less frequently (once a month or less) but hunted...
Our results supported hypothesis two in several ways. First, the results reveal that time spent outside in social activities was a secondary predictor of CTN. Second, we found support in several nodes for group time in nature as a significant predictor of CTN. For instance, spending time outside with my family was found to be a significant predictive split for predicting high CTN. Children who spent time outside with their families once a month or more had 33.0% more students in the upper CTN quartile than those who spent time outside with their families four times a year or less. Similarly, we found that spending time outside with a group and several outdoor activities that are inherently group activities for children (e.g., camping) were found to be significant splits for predicting high CTN.

Because most terminal nodes reflected social activities in nature, the classification tree suggests alone time in nature by itself does not lead to a large proportion of students with CTN. Terminal nodes with the largest proportion of students in the upper CTN quartile (Figure 3.3, Node 12, 14, and 16) included paths through nodes with both solitary (e.g., hunting) and social activities (e.g., playing sports). For instance, 85.6% of the sample in node 12 had high CTN. Terminal node 12, camping once a year or more, also included fishing three times a year or more (Figure 3.3, Node 6) and spending time outside by myself once a week or more (Figure 3.3, Node 2). Likewise, terminal node 14 (78.1% percent of students in upper CTN quartile) also included solitary activities, hunting once a year or more (Figure 3.3, Node 4), and social activities, spending time outside with family (Figure 3.3, Node 8). Terminal node 16, playing sports outside once a month or more, had the largest proportion of high CTN of any node (88.9%). Node 16 included a solitary activity (spending time outside
by myself once a week or more), a social activity (playing sports outside), and a semi-social activity (hiking once a month or more) which falls in the middle of the range of social interaction for outdoor recreation activities (Figure 3.2).

3.5 Discussion

Our results suggest time alone may operate as the key determinant of CTN. Broadly, the results reinforce previous research findings on the importance of alone time in nature (Chawla, 1999; Palmer, 1993; Tanner, 1980). Particularly, our results align with research on significant life experience that indicates solitude is a formative influence for some environmentally engaged adults (Tanner, 1980). We add to significant life experience work and previous studies that emphasize the value of alone time outside in childhood (Hsu, 2009; Stevenson, et al., 2014) by documenting an effect independent from, and stronger than, social time and engagement with adult role models. Our results indicate that nonsocial or solitary activities may have greater impact than is apparent from retrospective interviews with adults.

James et al’s (2010) environmental socialization model may explain why the highest levels of CTN occur only when coupled with social activities, even those less obviously related to nature, such as playing sports. The environmental socialization model combines ideas from significant life experience research, child development models, and social practice theory. Environmental socialization posits that adult environmental engagement develops through a childhood and adolescence filled with various environmental activities occurring with a range of people (i.e., peer groups to solitary). This model mirrors concepts from social practice theory which asserts that individuals need to participate in environmental behaviors within a social group in order to make them environmentally engaged (Holland, 2003). Our
results suggest children need social support for developing environmental behaviors and strong CTN during middle childhood (6-12 years old), adding to literature suggesting the importance of such support even before adolescence, in establishing pro-environmental habits and lifelong CTN (James, Bixler, & Vadala, 2010; Kellert et al., 2017).

Our classification tree results suggest demographic variables may not influence CTN directly, rather, demographics may simply correlate with the degree to which children spend time alone in nature and participate in key outdoor recreation activities. Past work suggests gender and race influence environmental attitudes and recreation behaviors (Finney, 2005; Prévot, Clayton, & Mathevet, 2016). Our results, however, indicate gender and race may not be the cause of low environmental engagement but are an indicator of low exposure to consistent and varied outdoor activities (Bixler et al., 2011; Kellert et al., 2017). If children are given the same opportunities to recreate outdoors both in social and secluded settings, then, they will likely develop similar levels of CTN. This aligns with research that found varied leisure participation regardless of race or socioeconomic status (Floyd, Shinew, McGuire, & Noe, 1994) and varied outdoor recreation preferences regardless of race or gender (William, 2017). While gender and race may influence the outdoor recreation experience (Parker & Green, 2016; Shores, Scott, & Floyd, 2007), our findings indicate all children can develop similar levels of CTN despite these differences. Initiatives to reduce constraints to social and nonsocial outdoor recreation, such as the United States’ Every Kid in a Park campaign (US Department of the Interior, 2016), may help address these inequities.

Our results imply efforts to build CTN among children would benefit from programming supporting solitary (e.g., fishing, exploration, meditation) reinforced by social (e.g., playing sports, camping) activities outdoors. Programming for parks and recreation
providers as well as environmental and educational institutions are typically social (North American Association for Environmental Education, 1998). Although some studies have argued that solitude during play hinders child development (Bowker & Raja, 2011), others suggest nonsocial play aides childhood development and happiness (Goossens, 2014; Luckey & Fabes, 2006). There are several barriers to solitary outdoor activities that need to be overcome in order to facilitate high CTN development in children, including: competing priorities for time and attention (Kellert et al., 2017), increased tendency to see being in nature as risky (Kurka, et al., 2015; Rader et al., 2014), and urbanizing populations (Heilig, 2012; UNEP, 2016). These barriers are associated with children having less time outdoors overall, less time unsupervised by parents outdoors, and decreased access to outdoor spaces that facilitate alone time in nature, respectively (Kellert et al., 2017). Improving infrastructure (Kurka, et al., 2015), implementing community policing strategies (Rader, et al., 2014), and reducing perceived cost of outdoor recreation (Kellert et al., 2017) may provide general strategies for promoting CTN. Our results suggest strategies which may complement these efforts to build strong CTN among diverse youth in middle childhood: promoting alone time in nature, reinforcing lessons learned through alone time through social outdoor activities such as camping and hiking, encouraging hunting and fishing, and prioritizing engagement with underserved groups.
Chapter 4. Collective Conclusions

4.1 Introduction

Despite decades of effort (EPA, 2017; NAAEE, 2017), environmental education is largely failing to encourage environmental behaviors in future generations (Blumstein & Saylan, 2007). Although researchers have analyzed multiple factors which may affect this outcome, antecedents to environmental behaviors and environmental behavior itself among children is not adequately understood. Despite the fact that all people must act to help the environment, children are ideal candidates to learn environmental behaviors due to their cognitive developmental stage, their relative age compared to adults, and their role as learners of civic engagement. Thus, there is a genuine need to increase research in this area. Environmental behaviors have been, and need to continue to be, examined from multiple paradigms and taught to all peoples. The complexity, persistence, and global nature of environmental issues necessitate that we engage every individual. However, focusing on children could be the most critical way we can affect environmental issues now and in the future.

4.2 Summary of findings

This thesis has highlighted that there are no quick solutions to environmental problems nor to generating the environmental behaviors to tackle them. A variety of factors affect environmental behaviors, including connection to nature, environmental hope, ecological knowledge, and cognitive skills. These antecedents to environmental behavior can be generated and supported in a variety of ways, as well. But, practitioners have largely been focusing on factors, such as ecological knowledge and social activities, that are not the only
major drivers of environmental behavior. Thus, there is a need to improve methods in the environmental education field to reflect research, as well as a need for researchers to explore new strategies for environmental education. This thesis builds theory and research in regard to environmental behavior, but it also benefits environmental education practitioners and provides them with practical tools and methods to utilize to improve their programs and the field as a whole.

4.2.1 Manuscript one findings

Manuscript one conveyed the development and validation of a short instrument to measure environmental literacy among adolescents. The instrument included four novel scales. The cognitive skills scale, however, was particularly unique due to its ranking format, especially when compared to previous measures of cognitive skills. In addition to the instrument validation, the study had several findings related to environmental literacy model and theory development. First, the study presents hope as a parsimonious measure of affect that is predictive of behavior. Second, we found empirical support for an EL model in which knowledge and hope predict cognitive skills; knowledge and hope interact to predict behavior; and cognitive skills predicts behavior. Third, the study revealed an interaction between ecological knowledge and hope which significantly predicted environmental behavior. While this interaction had been suggested in several studies (Duerden & Witt, 2010; Heimlich & Ardoin, 2008), it had not been tested prior to this study.

4.2.2. Manuscript two findings

Manuscript two focused on the impacts of demographic information and participation in outdoor activities on the connection to nature of youth in middle childhood (e.g., 6-12
years old). Utilizing a classification tree analysis, we evaluated the importance of activity type; frequency; and socialization level as well as demographic information (gender, age, race) in predicting connection to nature. We found that (1) alone time outside is the most important predictor for connection to nature, (2) social activities in nature are an important secondary support for connection to nature, and (3) demographic information are not significant predictors of connection to nature.

4.3 Study connections

Connection to nature and environmental literacy both positively predict environmental behavior (Cheng & Monroe, 2012), but they could connect to be an even more powerful predictor of behavior. In the first manuscript, environmental literacy components (e.g., knowledge) only partially explained the variance in environmental behavior. Other analyses on environmental behaviors, particularly those on connection to nature, are also able to only explain part of the variance in environmental engagement (Cheng & Monroe, 2012). For this reason, environmental literacy and connection to nature should both be considered when determining environmental behaviors. Connection to nature has the potential to integrate into the environmental literacy framework in a few ways. First, connection to nature may be a predictor of environmental hope. The components of environmental hope (e.g., individual and collective agency) have parallels to the most predictive recreational pathways to connection to nature (i.e., alone time and social time in nature). Thus, alone time in nature may promote individual agency while social time in nature may promote collective agency. Second, connection to nature could be a parallel predictor of the affective component of environmental literacy, alongside environmental hope. In this way, connection to nature
relates to only affective components of environmental literacy. Third, connection to nature may be a foundation for environmental literacy as a whole, not simply affect. Connection to nature is developed through direct experiences in nature. This basic affinity for and comfort in nature may be a base factor for developing environmental literacy and sustained environmental behaviors. In particular, connection to nature may help intrinsically motivate individuals to pursue and maintain environmental literacy overall.

4.4 Insights for future research and practice

4.4.1 Research

There are several areas for future research that are unique to each manuscript. However, there is an overall need for more research on environmental behaviors with children. For manuscript one, future research can assess the efficacy of the environmental literacy model with other contexts (e.g., age groups, informal programs). There should also be further testing of the instrument as a whole, in addition to examining different iterations of the cognitive skills questions (i.e., different topics beside fisheries). Manuscript two also created avenues for new research. First, the study can be replicated with other age groups in different locations. Second, the survey can include other activities that may better reflect the samples’ interest (e.g., surfing for sample sites close to the ocean). Third, researchers should reproduce the study with larger sample sizes (i.e., 3,000 individuals or more) that are more typical of decision tree analyses.

4.4.2 Practice

This thesis was grounded in developing tools and methods that could be useful for practice. Manuscript one provides a practical tool that can easily be used in field settings
(e.g., 4-15 minutes to complete instrument). Additionally, the tool will be open-access, so it can be easily distributed for states to use in their Environmental Literacy Plans. Further, the study revealed the importance of hope in environmental literacy and suggested that programs should focus on increasing environmental hope in students. Our findings from manuscript two also indicated that programs should focus on providing consistent access to varied outdoor activities for youth. In particular, formal and informal programs alike should focus on increasing the amount of and frequency of solitary activities for children. Lastly, programs should consider the importance of consumptive, solitary outdoor recreation, such as hunting, to foster connection to nature among youth.
REFERENCES


Federal Water Pollution Control Act (1972).

Federal Water Pollution Control Act (1948).