

Promoting Environmental Education Through Digital Media: The Development of an Environmental Education App for Children

A senior honors thesis for the Department of Child Study and Human
Development

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Abstract

Active environmental learning opportunities for young children are on the decline. This is partially due to parental and societal concerns surrounding children's outdoor exploration and the development of new forms of mostly electronic entertainment in which so many children engage. This decline affects the new generations not only in their ability to be stewards of our natural world but also may contribute negatively to many aspects of their physical, cognitive, and social-emotional development. The review of the literature indicates a need for effective environmental education and identifies media as an applicable learning tool. This study was two-pronged. The purpose of the first phase was to identify best and worst practices in both environmental education and app development. To this end, educators, app developers, and leaders of environmental initiatives were interviewed and asked a series of open-ended questions. Results indicated the need for the creation of effective, developmentally appropriate environmental learning tools and identified concerns that current digital tools are developed without adequate consideration of the educational and developmental needs of students. The second phase of this study applied the information obtained to design a pilot environmental education app for children.

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Chapter 1: Introduction

Problem Statement and Significance:

Rachel Carson once said, “Those who contemplate the beauty of earth find reserves of strength that will endure as long as life lasts.” (Carson et al., 1962). Exploration and interaction with the natural world has proven to have a variety of benefits, or offer many reserves of strength, for young children. Not only do opportunities for natural exploration and outdoor free play afford children a greater sense of environmental competence but it also allows children to develop a stronger sense of purpose, self-worth, self-efficacy, and resilience. As children navigate their environment, making and managing risky decisions, they are able to develop decision-making skills that will prove critical later on in life. Denied the opportunity to explore nature freely, children experience shortfalls in these areas, along with other emotional, physical, and intellectual deficits.

One of the most important advantages of providing outdoor play opportunities or other natural experiences early on is that it fosters a love and interest in nature. Nature exists everywhere, and these outdoor experiences can be encouraged in all settings – rural, suburban, or urban. Environmental programs such as nature preschools and forest kindergartens provide hands-on natural interaction encompassed in a school curriculum. Similar programs in schools, camps, youth organizations, and nature centers have been implemented in cities to allow children living in urban areas to explore natural systems. These programs have proven to be effective in instilling a passion for the environment and aiding in the development of a more active environmental understanding. Given the current state of our environment, it is becoming increasingly important to care about our

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natural world. It will be up to these children, and future generations, to solve issues such as climate change, pollution, and other environmental disasters. In order to ensure that these children will be interested in these problems in the future, and have a desire to fix them, it is crucial to begin fostering an interest and passion in the natural world early on through effective nature education such as programs like these.

However, despite the benefits of outdoor exploration, the time children spend outside is diminishing rapidly (Brussoni et al., 2012; Malone, 2007; Copeland et al., 2012; Staempfli, 2009; Carver et al., 2008; Brown & Kaye, 2017). Exploration was once a source of freedom and wonder, but now we as a society have grown overly cautious and fearful of the great outdoors. Anxious parents and caregivers are restricting their children's ability to explore the outdoors freely due to environmental threats such as poison ivy but also physical threats such as crime and neighborhood safety. It is also important to consider the expansion of media, which has contributed to the decline of individual interest in a variety of forms of entertainment including outdoor play. Much of the literature suggests that children are more likely to spend time interacting with digital media than engaging in outdoor activities (Brussoni et al., 2012; Malone et al., 2007; Brown & Kaye, 2017). Similar to children, adults have experienced a decline in their own interest in the natural world due to other forms of entertainment. By modeling this trepidation and lack of interest in natural exploration, adults can pass these anxieties onto their children. This fear and disinterest will continue to be passed on from generation to generation unless we can think of a way to harness a passion and interest for the natural world early on. This cycle will have dangerous ramifications for a wide array of environmental problems such as climate

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change, pollution, and waste management that if left unsolved, can threaten not only the security of our natural world but our own existence as well.

In order to reconcile the fears of adults and children, they should be introduced to an environmental curriculum that is comfortable and manageable for all individuals. Successful environmental education programs such as nature preschools and forest kindergartens can be adapted and implemented in homes, neighborhoods, and backyards. Through the use of an environmental education app, children will be able to experience similar hands-on, active exploration that has proven to be effective in schools. While the ubiquity of media plays a role in the decline of outdoor play, mindful, meaningful educational media such as this app can provide and enhance opportunities for natural interaction.

Without a successful and impactful nature education to help children, including potential future scientists and researchers, formulate a desire for taking care of the environment, I worry that children will not be able to play and explore the outdoors freely because of the way our environment is rapidly deteriorating. It is critical that we think creatively about the potential for digital media to enhance our relationship with the environment. By developing an environmental education app that will mediate individual concerns with outdoor exploration, implement an effective environmental curriculum, and reach a wide demographic of children we can take steps to protect our natural world and the natural experiences of future generations.

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Purpose:

This thesis provides an overview of the importance of environmental education, an evaluation of successful environmental curriculums, and an investigation of successful educational app development. Ultimately, I will conclude my project by proposing an environmental education app that incorporates effective aspects of environmental education programs. Free play, for my purpose, will refer to child-directed play in which limited restrictions are imposed on the child by an adult. However, this does not mean that an adult cannot be present for free play to occur. Adults can serve to supervise, guide, and enhance this free play but they should not hinder outdoor exploration as a result of their own overly cautious behavior. The demographic under consideration is school-aged children from the ages of 6-9 although I am interested in effective environmental education programs for all ages, as there is a potential for adapting certain activities and lessons for my specific demographic. This thesis seeks to address the causes and effects of young generations minimal outdoor experiences, and how these can be mediated by the development of an environmental education app for children.

Research Questions:

This thesis seeks to address the following questions:

1. How are parental and societal concerns impacting the way in which children interact with nature and how can these concerns be eased?
2. Knowing what we know about how children learn and how environmental education can foster an interest in nature, what different methods are environmental educators using to teach children about the natural world?

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3. How can effective environmental education methods be adapted to, or enhanced by, the development of a digital app or game?

Overview:

Chapter Two reveals the relevant literature surrounding the causes and effects of children's limited outdoor play opportunities and the benefits of educational media. It will also cover literature that explores how the development of an environmental education app can offer a potential solution to these issues. Chapter Three will cover interviews with several environmental educators, digital app developers, and parents in order to provide a better understanding of best and worst practices for developing an environmental education app for children. In Chapter Four, I synthesize the information from the previous chapters and address limitations and directions for further research in my conclusion and discussion sections. Finally, in Chapter Five, combining and applying the research from both Chapter Two and Three, I propose my premise and design for the app.

Methodology:

For this study, I gathered information from environmental educators and app developers to address these research questions and to aid in the design of an app to engage and educate children about nature. Once the project was completed, the participants of this study were invited to view and experience the app proposal.

Participants

For this study, environmental educators and digital app developers were interviewed. An email describing the study and asking for volunteers was sent to

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educators at local elementary schools and environmental organizations such as Massachusetts Audubon Society. A similar email blast was sent to individuals at Tufts University and WGBH with experience in the development of digital apps. A sample size of five to seven participants total was desired.

Instruments

Open-ended qualitative interviews with environmental educators and digital app developers were employed to gather data for this study. Individual interviews were conducted remotely or in person. Additionally, group interviews were arranged if it was easier for participants. These interviews were designed to assess how education about nature is handled in both the classroom and home setting. Educators were asked to delineate which types of activities they find the most successful and least successful when trying to engage their students with nature. The following questions were asked: What nature activities have you tried with your students in the past? Have they been effective? Why or why not? How involved are the parents of your students in your child's environmental education? During the interview, they were also asked their opinions on additional methods other educators have recommended or advised against although participants were not informed of who the other educators were. A close look was also taken at the curricula these educators use and how they chose to teach this material in the classroom setting.

Digital app developers were asked questions about what needs to be considered when developing an app for children. I asked them questions such as: How have you introduced educational topics digitally to children? How have children responded to this form of education? How do parents respond to educational media? I also presented them

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with some of my ideas and asked their opinion on how to incorporate these ideas into a digital platform.

Participants who happened to be parents were also asked about their experiences exploring the natural world with their own children. They were asked the following questions: How often do you play outside with your child? How often does your child play outside alone? How engaged are you when you play outside with your child?

Design:

While the qualitative data collected from these interviews does not lend itself to statistical analysis, the trends and innovative ideas discussed in these interviews aided in the creation and development of the prototypical app.

Chapter 2: Literature Review

For the majority of children in modern western culture, opportunities to explore and learn about the natural world are limited despite the fact that exploration of the natural world has been shown to play a significant role in physical, emotional, and social development (Brussoni et al., 2012; Malone, 2007; Copeland et al., 2012; Brown & Kaye, 2017; Kellert, 2015; Moss, 2012; Audley & Stein, 2017). Additionally, both experience with the natural world and education about the environment have proven crucial to helping future generations develop a passion for and motivation to protect a natural world under siege (Beery & Jørgensen, 2016; Cheng & Monroe, 2012; Fleer, 2013; Ogelman, 2012; Otto & Pensini, 2017). The following literature review offers an overview of the importance of environmental education and outdoor exploration for healthy development and explores the factors that impinge on children's opportunities to experience their natural world. I will discuss relevant learning theories and the use of these

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theories to inform environmental education, particularly as they relate to the use of digital media. Finally, implications for the design of an app for children will be addressed. This literature review demonstrates the potential power of new media and technologies to advance environmental education programs and enhance learning objectives among school-aged children.

Importance of Environmental Education and Outdoor Exploration:

Why are experiences outdoors being threatened?

The amount of time individuals, both children and adults, spend outside is declining rapidly (Brussoni et al., 2012; Malone, 2007; Copeland et al., 2012; Staempfli, 2009; Carver et al., 2008; Brown & Kaye, 2017). On average, children in the United States are six times more likely to spend their time engaging with digital media than they are to ride a bike but this trend can be seen outside of the United States as well (Brown & Kaye, 2017; Malone, 2007). With the expansion of media, individuals are becoming less inclined to engage in other forms of entertainment (Brown & Kaye, 2017). The ubiquity of media is only one factor in the decline of outdoor play. It is important to acknowledge the many other, perhaps more pervasive threats to a child's outdoor engagement.

As a culture, we have become overly cautious and fearful of the great outdoors, when the experience of being outdoors in nature was once a source of freedom and wonder (Malone, 2007; Copeland et al., 2012; Beyer et al., 2015). A major contributor to the decrease of environmental exploration is the fact that fearful parents and caregivers are greatly restricting their children's ability to roam and play outdoors (Brussoni et al., 2012; Malone, 2007; Staempfli, 2009; Carver et al., 2008; Shirani et al., 2012; Brown & Kaye, 2017; Wihardjo, 2017). Parents are afraid of certain physical threats such as poison ivy or sunburns but they are also frightened of crime and unsupervised play ("How to Help Families Feel Comfortable in the Outdoors," n.d.). Griffiths

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(2013) found that the outdoor radius that today's parents allow their children to explore freely has decreased by 90% since 1970. Carver et al. (2008) attribute this decline to increasing concerns about neighborhood safety. As a result, many children are denied the opportunity for free outdoor play and those that are encouraged to explore independently are often confined to small areas such as their own backyard (Carver et al., 2008).

This decline is representative of rural settings as well, although we as a society tend to assume children growing up in rural areas have more access to nature. Rural land has become increasingly privatized (Staempfli, 2009; Clements, 2004; Smith & Barker, 2001). Staempfli (2009) explains that while rural areas contain more open spaces, these spaces are often designated for public use and are frequently inaccessible for children to explore. When thinking of rural areas, we tend to picture the idyllic rural setting with sprawling land and grazing animals when in fact only a minority of children residents describes it as such. Instead, they explain that this "wide open" land we picture is actually broken up and protected by fences and signs warning against trespassers (Smith and Barker, 2001). Smith and Barker (2001) echo Staempfli's concerns. In addition, these authors observe that, like urban parents, rural parents place spatial restrictions on their children for fear of "global dangers." Valentine and McKendrick (1997) argue that children in rural areas experience 'double deprivation' as they endure both restrictions on spatial mobility and have limited outdoor play opportunities. These authors note that by comparison, children living in urban areas have greater access to locations and programs designed specifically to foster outdoor play.

Smith & Barker (2001) conducted interviews with parents, children, and designated "playworkers" to gather information about rural children's experiences in nature. One playworker articulates the misconception that rural children have greater access to the natural

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world than their urban counterparts. She states: *Everyone admits that urban children can have deprived lifestyles, there's a need for youth clubs and input. Round here, people think that they have the sea, they have the country, they have clean, fresh air, they don't need anything.* Much of the literature negates this common assumption that children in rural communities have more opportunity for outdoor play and natural experiences.

While the issues with outdoor play vary between urban and rural settings, both must be addressed so to ensure that children have the opportunity to maximize their natural experiences. It is apparent that adult trepidation limits children's opportunity to explore nature in both rural and urban settings. This trepidation also limits the adult's time outdoors as well. By modeling this sort of behavior, and restricting the outdoor experiences of both themselves and their children, parents can cause children to develop significant anxiety regarding their natural world. This fear will then be passed on to future generations, continuing the cycle (Beyer et al., 2015).

Why must we fight to preserve these experiences?

Developmental Perspective:

Research supports the fact that the ability to engage in outdoor play is crucial to the healthy development of children. In their article "Risky Play and Children's Safety: Balancing Priorities for Optimal Child Development," Brussoni and her co-authors (2012) argue that the opportunity to participate in risky outdoor play contributes to a child's ability to manage and learn from risks in ways they cannot experience in other types of play. Outdoor free play also affords children a greater sense of environmental competence, a stronger sense of purpose, social competence, self-worth, self-efficacy, and resilience (Malone, 2007; Brown & Kaye, 2017). When left to their own devices outdoors, children must make decisions and follow through with

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the repercussions of those decisions. This experience helps them to develop decision-making skills that will prove critical later in life (Brown & Kaye, 2017).

Other physical, emotional, and intellectual deficits have been shown to be associated with restriction of outdoor free play (Moss, 2012; Copeland et al., 2012). Staempfli (2009) argues that outdoor play in unstructured settings without adult interference is necessary for adequate physical, emotional, and intellectual development. Other researchers contend that there are benefits to parents' engagement in this realm. For example, it has been shown that the interaction between parents and children in the natural environment can actually improve students' environmental awareness and information retention (Wihardjo, 2017; White, 2015; Richert et al., 2011; Ogelman, 2012). It is likely that the opportunity for both experiences, with and without parental involvement, provide their own benefits. Given the increasing discomfort that both children and parents have with outdoor exploration and the developmental importance of these opportunities, it is clear that we must seek on a societal level to balance both of these concerns (Beyer et al., 2015).

Environmental Perspective:

The price of progress has come at a great cost to our natural world. It will be up to future generations to solve issues such as global warming, pollution, and a variety of other environmental disasters. And yet these issues remind us in no uncertain terms of the increasing and ever-lasting importance of our outside world (Fisher-Maltese, 2016; Treagust et al., 2016). The best way to ensure that these generations will care about environmental issues in the future is to foster a passion and interest in nature early on. Researchers have shown that children are more likely to engage in positive environmental behaviors as adults if an interest, love, and

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passion for nature is fostered early on through effective environmental education and engagement (Beery & Jørgensen, 2016; Cheng & Monroe, 2012; Flear, 2013; Ogelman, 2012; Otto & Pensini, 2017).

A significant body of research points to the association between developing a caring attitude toward the environment and a child's ability to explore nature freely. Parents or adults can guide this free play, but few limitations should be imposed as to avoid hindering the child's individual experience and exploration (Wihardjo, 2017; White, 2015; Richert et al., 2011; Ogelman, 2012). Exposure to nature has been correlated with a child's increasing emotional affinity for nature (Collado et al., 2013; Fisher-Maltese, 2016; Wihardjo, 2017; Tugurian & Carrier, 2017; Treagust et al., 2016; Beyer et al., 2015; Moore et al., 2012; Audley & Stein, 2017). Additional studies indicate that children have a stronger preference, understanding, and ability to empathize with situations they are more familiar with (Simmons, 1994; Beery & Jorgensen, 2016; Cheng & Monroe, 2012; Flear, 2013; Ogelman, 2012; Otto & Pensini, 2017). For example, after conducting pre/post-test interviews with children, Fisher-Maltese (2016) found that children developed a more empathetic view towards insects after studying them. These results point to a significant positive shift in children's environmental attitudes as a result of outdoor education programs. Other studies explore the persistence of this positive connection into adulthood. Audley and Stein (2017) argue that children's autobiographical memories form their childhood narratives as these memories are retold and given cultural meaning. Encouraging children to explore nature and develop memories of these experiences can shape a child's personal narrative, create a positive environmental identity, and contribute to a larger cultural narrative of environmental importance (Audley & Stein, 2017).

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In contrast, children who are not permitted to engage in outdoor free play lose the opportunity to become familiar with the environment, and to become comfortable navigating the natural world. In addition, their ability to develop the passion and desire to protect the natural world is impeded (Beery & Jørgensen, 2016; Cheng & Monroe, 2012; Fleer, 2013; Ogelman, 2012; Otto & Pensini, 2017).

A Review of Selected Outdoor Education Programs:

As opportunities for free play in nature continue to decrease, the role of early education and daycare centers in promoting environmental education has become paramount (Brown & Kaye, 2017; Cheng & Monroe, 2012; Fisher-Maltese, 2016; Wihardjo, 2017; Treagust et al., 2016; Ogelman, 2012; Otto & Pensini, 2017; Beyer et al., 2015). The inclusion of an environmental education component in these settings would be one way to provide children with an opportunity to explore and experience nature in a safe, comfortable, and educational manner. In this section of the literature review, various environmental education programs will be investigated and the best and worst practices for allowing children to interact with the natural world will be identified.

Environmental programs that provide hands-on, experiential learning opportunities encompassed in school curricula, such as nature preschools and forest kindergartens, have proven to be effective in instilling an interest and passion for environmental education (Staempfli, 2009; Beery & Jørgensen, 2016; Melhuus, 2012; Moore et al., 2012). For example, Beery and Jørgensen (2009) observed and analyzed children's play and exploration in an outdoor kindergarten in Norway and conducted structured interviews with adults about their interaction with nature as children. They note that this outdoor kindergarten took a playful approach towards

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environmental exploration and that participating children were able to have an active, sensory experience. The authors argue that this sensory experience in childhood serves as a foundational marker in spurring the development of ecological ideas and a greater, more active environmental understanding.

The development of programs that focus on exploration and emphasize natural play rather than a didactic curriculum has been called for by other researchers (Staempfli, 2009; Melhuus, 2012; Ogelman, 2012; Sobel, 2015). Researchers and educators argue that the best way for children to learn about science or the environment is through hands-on and active learning (Sobel, 2015; Beery & Jørgensen, 2016; Ogelman, 2012; Melhuus, 2012, Staempfli, 2009). This recommendation is based on studies reporting that children are better able to make emotional connections between the natural world and the modern world through play (Melhuus, 2012). Similarly, programs that follow a subtle curriculum, with an emphasis on play and exploration rather than direct instruction, have proven to be strongly connected with a child's passion and interest in nature (Sobel, 2015; Beery & Jørgensen, 2016; Ogelman, 2012; Melhuus, 2012, Staempfli, 2009). In contrast, other more didactic forms of interaction with nature, such as typical school science classes and programs, have not been connected with children's emotional attachment to the natural world (Tugurian & Carrier, 2017).

A strong argument can be made for the implementation of environmental programming outside of a school setting as well. For example, extracurricular activities have proven to be successful in the development of conceptual structure (Demirbas, 2017; Waite, 2017). Hands-on environmental experiences need to be integrated into many aspects of children's lives, not simply in a school setting. This increases a child's affinity for the environment and his or her

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understanding of the natural world as a whole (Beery & Jørgensen, 2016; Fisher-Maltese, 2016; Wihardjo, 2017; Tugurian & Carrier, 2017; Moore et al., 2012).

Combining Education and Educational Media:

Call for Research of Educational Apps:

The incorporation of technologies and media in environmental education instruction must be tempered by the concern that the use of these technologies outdoors might have negative consequences on a child's connection to nature (Peffer et al., 2013; Chen et al., 2016).

Researchers warn against relying too heavily on digital media in a classroom (Peffer et al., 2013; Creasey, 2013). Creasey (2013) argues that digital media can be highly effective when used as a supplement to instructional learning, but not when used as a substitute. For this reason, it is important to develop apps that supplement other forms of learning as well as stand alone as useful, informational entities. While there are a great many "educational" apps available to students and parents, there are not enough resources to adequately evaluate each individual app as it enters the market, which causes most educational apps to be unregulated and inadequately tested (Hirsch-Pasek, 2015; Wartella, 2015). To be sure, there are very few agencies that provide guidelines for the design of an effective educational app, but those that do offer support in this area call for the app to promote cognitively-active, engaged, meaningful, socially-interactive, and goal-directed learning (Hirsch-Pasek, 2015; Wartella, 2015). However, many apps fail to meet all of these parameters. Some apps are able to meet some of these guidelines, but very few, if any, apps are able to effectively meet all parameters.

As digital media is unlikely to become less of a presence in our lives, we as a society need to focus on providing our children with mindful, meaningful digital media in order to

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ensure that they are able to reap the benefits of innovative and influential technology. We need to shift our focus from demanding that we reduce screen time and instead focus on how to maximize the effects of screen time. Media is only going to become more pervasive in our society, and it is imperative that we focus not on the quantity of media usage but instead on the quality of media we are producing as media has proven to offer a variety of developmental benefits if implemented correctly.

After using digital technology, students have actually been shown to perform better on assessments (Anderson et al., 2015). Due to the fact that children prefer the use of digital media over other forms of instruction in classrooms and have proven to perform well on assessments after learning subjects through media, teachers should be focusing on how to adapt to their students' learning styles in order to take advantage of the interests, hobbies, and strengths of their students (Bartholomew, 2017). Teachers and parents can use these apps to enhance learning objectives and keep their students interested (Castek & Beach, 2013). For example, one of these learning objectives is the development of the ability to observe, which is a major science skill. The development of this skill can be supported by encouraging children to capture and share photographs or videos of what they observe in nature ("How to Use Digital Tools to Enhance Outdoor Explorations," n.d.). Apps also help students share information with each other and open the door for unique online collaborations among peers (Castek & Beach, 2013; Kermish-Allen, 2016). Mapping tools such as GPS or Google Earth also can provide children with a sense of their larger environment and the contributions they can make ("How to Use Digital Tools to Enhance Outdoor Explorations," n.d.). While these are just a few of the many possibilities that can be provided by digital education tools, it is clear that these devices can offer a wide variety of affordances to students.

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Digital apps are more and more present in the lives of our children—indeed, they are often more readily available and more widely used than other forms of media. They are easy to access, easy to navigate and highly portable. The educational possibilities offered by digital apps are numerous provided they are developed and implemented responsibly, incorporating findings from educational and developmental disciplines. Further investigation on how to maximize the beneficial potential of apps is necessary.

Media as a viable option for children's education:

When taking a close look at our cultural behaviors, it is hard to deny the far-reaching influence of our various forms of media, impacting many areas of our lives from education to socialization. (Castek & Beach, 2013; Anderson et al., 2015; Zipke, 2017; Noorhidawati et al., 2015; Brown & Kaye, 2017; Kim & Smith, 2017; Richert et al., 2011; Pierce & Cleary, 2016; Kermish-Allen, 2016). The more we interact with our electronic screens, the less time we seem to have for the world around. Indeed, our increasing reliance on digital diversions has begun to creep its way into many aspects of our daily lives and it is becoming increasingly difficult to regulate the use of media. It is for this reason that we as a society must focus instead on the possible benefits of media and try to use these pervasive devices to our benefit.

Some types of media, particularly the use of digital apps, have proven to be viable options for enhancing children's education (Zipke, 2017; Noorhidawati et al., 2015; Castek & Beach, 2013; Crawford et al., 2016; Anderson et al., 2015; Kim & Smith, 2017; Richert et al., 2011; Bartholomew, 2017; Pierce & Cleary, 2016; Kermish-Allen, 2016; Chen et al., 2016). The use of these apps has the potential to reduce achievement gaps and close the digital divide (Pierce & Cleary, 2016). Apps, which are typically experienced on mobile devices such as smart

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phones and tablets, allow for portability and interactivity in a way that makes them much more accessible and present in many aspects of these children's lives both in and outside the home (Castek & Beach, 2013; Kim & Smith, 2017; Judge et al., 2015). The ubiquity of media makes it increasingly important that we investigate how children can developmentally benefit from the use of these devices.

According to Mayer's Cognitive Theory of Multimedia Learning (2014), information that is presented through a combination of both visual and auditory stimuli, as opposed to one or the other, is more likely to be retained. New technologies offer the ability to fuse together these stimuli in order to create a collaborative, interactive learning experience. The use of these technologies requires students to think abstractly and creatively and optimize learning potential (Mayer, 2011). The Science of Learning Perspective, an alternate approach to children's learning, suggests the most effective educational materials are those that include an interactive component and encourage the active engagement of children with content that evokes their passions (Hirsch-Pasek et al., 2015). However, Mayer (2014) cautions that it is important to consider each child's unique cognitive capabilities when designing these programs. It is essential that designers carefully consider the developmental appropriateness of media so as to ensure that each child's learning experience will be maximized.

Piaget's (1971) Constructivist Theory of Child Development calls for inquiry-driven, project-based learning in which children learn through active participation. According to Piaget, students benefit from having an active role in their learning. In this model, teachers serve the function of facilitators there to provide assistance but do not instruct directly. Digital media provides the opportunity for student-centered projects in which students can work actively in accordance with Piaget's model and collaboratively designing innovative communities in which

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they share and interpret data (Kermish-Allen, 2016). Kermish-Allen (2016) explores the affordances of online citizen science communities that provide students with access to a wide range of data from a diverse population in order to enhance their learning experiences. Citizen science refers to the public's participation in scientific research. One example of an online citizen science community that Kermish-Allen (2016) analyzed closely was "Vital Signs" which is an online project designed to identify and track invasive plants in the Northeast United States. The online community began as a citizen science project intended for the K-12 classroom but has grown to include adults at environmental organizations. Students and other participants are encouraged to raise questions, design their own investigations, and share their results with other community members. These results are then confirmed by participating scientists and educators. "Vital Signs" is just one example of an online community that allows students to play an active and collaborative role in their learning. This learning experience, where teachers and experts act as facilitators of learning and children are given more control, aligns with Piaget's theory of constructivism.

Vygotsky's (1997) Sociocultural Theory of Cognitive Development suggests that children learn through interaction with their environment, particularly through their interaction with adults. Parents and other adults are able to guide children through scaffolding. Scaffolding refers to the support an adult, or another individual can lend to a child's learning by extending the difficulty level of stimulation beyond what a child might manage on his or her own (Vygotsky, 1997). However, scaffolding is certainly not limited to adults it can be provided by peers, siblings, or even inanimate materials. It has been shown that when interacting with digital media, such as apps, children actually prefer to use them independently, without the direct instruction of an adult (Zipke, 2017; Castek & Beach, 2013; Crawford et al., 2016; Anderson et

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al., 2015). While this can be seen as a challenge to a more traditional scaffolding process, many features of digital media offer the ability to provide support to children's learning as well similarly to the inanimate materials Vygotsky explores. These digital devices have proven to be user-friendly and children are easily able to explore them independently and interactively (Zipke, 2017; Kim & Smith, 2017; Castek & Beach, 2013; Crawford et al., 2016; Anderson et al., 2015). Scaffolding in media can occur through the incorporation of formal features that can be utilized to guide children's attention, focus, and understanding. For example, digital and game-based learning also provides the opportunity for level advancement, which is a form of scaffolding (Mostowfi et al., 2016; Waite, 2017; Bartholomew, 2017).

Children are also able to develop unique relationships with on-screen characters in which characters appear to be speaking directly to users (Wartella et al., 2000; Richert et al., 2011; Bond, 2018; Gleason et al., 2017; Chung & Cho, 2017). Over time, these characters can become digital role models and can serve as a source of guidance and encouragement. A prime example of this is the popular television show, *Blue's Clues*, in which creators use faux eye contact. They have their characters speak directly to the screen and establish parasocial relationships with child viewers. This engages the audience and increases the likelihood of learning (Richert et al., 2011). Previous research focused on parasocial relationships specifically defined in terms of friendship and attention, but recent research seeks to provide an understanding of how these bonds form and why (Bond, 2018; Gleason et al., 2017; Jennings & Alper, 2016; Chung & Cho, 2017). For example, Bond (2018) explores how relationships with digital role models can be particularly meaningful and helpful for children who struggle to make bonds in real-life social situations. Through interactions with digital characters, these children can develop a stronger social

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understanding. Research also states that children can differ in which characters they form these bonds with based on the child's gender, family background, and interests (Gleason et al., 2017).

Video games, a term that refers to any game with a user interface and a screen, have been proven to have the potential to promote civic-outcomes (Bers, 2010). Certain games that engage players in civically oriented experiences such as navigating social, moral, or ethical issues, helping and guiding others, learning about problems in society, and other civic acts can help children engage in civic behavior in real life (Bers, 2010). If executed thoughtfully, video games, and all forms of media in general, offer the potential to promote civic engagement and conversations and increase children's' pro-social behavior.

As previously stated, media offer children the opportunity to think abstractly, creatively, and collaboratively. Abstract, creative, and collaborative thinking are cognitive processes that have been shown to increase learning retention among individuals (Mayer, 2011; Hirsch-Pasek et al., 2015). Digital media provide a unique medium for the playful, active learning that has shown to be successful in the form of other environmental education programs while also meeting and surpassing many of its child users' developmental learning needs.

Implications for Designing Apps for Children:

The design and development of an interactive environmental app for children can face many obstacles, especially as we look to integrate mobile learning into the lives of children and young families. Judge et al. (2015) identify three major categories of mobile learning challenges: theoretical, social, and technological. In order to create a successful, educational app for children it is crucial the researchers behind the development consider these three areas of challenges carefully (Kim & Smith, 2017). This section of the literature review will focus on

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identifying these challenges and exploring various ways educators and app developers can overcome them.

The theoretical challenge suggests that there is no overall theory or guide to creating effective mobile learning environments (Kim & Smith, 2017). Perhaps the primary reason this area of educational digital production is under-researched and under-tested is that it is relatively new and constantly changing. Educators, researchers, and parents must turn their attention to the expansion of mobile learning in order to ensure that meaningful educational media is being researched, developed, and put into the marketplace. The literature expressing this need for research is discussed more in-depth in the above section: *Call for Research of Educational Apps* (page 7).

Social challenges stem from the hesitations of researchers, pediatricians, and caregivers who fear that too much time spent using media may restrain a child's ability to develop crucial social skills (Radesky et al., 2015). However, certain formal features of digital media, such as the ability engage in discussions with others or take notes on the screen, have been proven to support children's social development (Richert et al., 2011; Castek & Beach, 2013; Kermish-Allen, 2016; Brussoni et al., 2012; Malone, 2007; Copeland et al., 2012; Brown & Kaye, 2017; Kellert, 2015; Moss, 2012). Digital media can offer the ability to work collaboratively with a diverse population, which in turn can enhance a child's social learning (Kermish-Allen, 2016). Peer interaction and play among children has many social and educational benefits (Kim & Smith, 2017; Sobel, 2015; Beery & Jørgensen, 2016; Ogelman, 2012; Melhuus, 2012, Staempfli, 2009). Peer interaction can be simulated through digital media in a variety of ways, as in the building of online communities, the engagement of multi-player activities, and the facilitating of opportunities to share information with others (Kermish-Allen, 2016).

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However, these benefits are not limited to interaction with other children. Richert et al. (2012) explains that children's learning from digital media is linked not only to the relationships they develop with each other in the pursuit of play but also to the relationships they form with virtual, on-screen characters. In order to increase a child's likelihood of learning and enhance their social development, a socially interactive approach must be taken by creators. A socially interactive approach is one that invites children into a world where characters speak directly to the screen, create the appearance of eye contact, and establish parasocial relationships with users. Indeed, many television shows have successfully taken this approach, such as *Blues Clues* and *Dora the Explorer*, but this approach can also be applied to other forms of digital media. In their study, Westlund & Brezel (2015) demonstrated that children improved their language learning when interacting with a sociable robot that matches their language abilities. These findings indicate that in order to mediate concerns about digital media and social development, apps should be designed to include these personable characters and serve as an on-screen playmate in order to aid the development of social skills among child users (Kim & Smith, 2017).

The technological challenges of app development refer to the many technical burdens placed on developers as they create fully functional mobile apps. Perhaps the most difficult challenge for creators is the fact that media is constantly changing (Kim & Smith, 2017; Huynh & Ghimire, 2017). It is becoming increasingly important to design and develop programs that can run across a variety of platforms, and an array of different interfaces, in order to ensure that the app will continue to run and function well as new devices and software are introduced. The Browser App Approach to app development describes how to develop an app that is supported across platforms, uses open source standards, and adapts the "write-once-and-run-anywhere"

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concept to ensure that apps will be able to work on a variety of interfaces (Huynh & Ghimire, 2017).

Further, creators should construct an app that is accessible to both proficient and inexperienced media users (Kim & Smith, 2017). It is necessary that developers ensure that their apps will be user-friendly to a wide audience including both adults and children. It can be problematic when children are more proficient in the use of technology than their parents or caregivers as it can decrease the adult's interest or investment in the technology. For this reason, it is important that apps do not appear too complicated for users with little digital experience so as they are not deterred from downloading the app. When creating apps for young children, in particular, it is important that parents or caregivers feel comfortable troubleshooting any technical difficulties during activities (Kim & Smith, 2017).

As yet, research has failed to delineate all encompassing criteria by which to classify an app as "educational." However, a few key elements have been identified. To serve an educational function, apps must foster cognitively active and engaged learning. In addition, these learning experiences must be meaningful, socially interactive, and goal-directed (Hirsch-Pasek, 2015; Wartella, 2015). Wartella (2015) argues that while physical engagement can promote active learning, the act must be more complex than a simple swiping or tapping. She states that active learning must involve thinking, reflecting, and effortful mental activity. In order for the child to be fully engaged with the app, their attention must be focused and not distracted by their surroundings or other, non-educational elements of the app. In order to foster meaningful learning, the app should help children attach new knowledge to their existing knowledge by providing information that is relevant and purposeful (Wartella, 2015). The app should also promote high-quality social interaction between the user and others whether teacher, parent, or

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peer. Cooperative and collaborative learning environments have proven to be an important aspect when it comes to enhancing children's learning (Wartella, 2015; Kermish-Allen, 2016). Finally, Wartella (2015) states that it is essential that these objectives be fixed in an app that is educationally goal oriented in order to allow the child to further explore and discover this new information.

The theoretical, social, and technological challenges of digital media development need to be considered critically when developing an app. While all of these areas could benefit from further research, app developers need to consider existing research to ensure that the educational potential of digital apps is being maximized.

Potential for a Successful, Educational App to Promote Environmental Awareness:

These studies indicated a large gap in the existing literature, suggesting that the potential benefits for environmental education among children through the development of an environmental education app has not been adequately researched. While the literature reveals that there is a need to enhance environmental education among children, and demonstrates that educational media can be a viable option to improving education in general, there has been a notable shortfall in research on the ways digital media can enrich environmental education in particular.

As our society becomes more inverted, relying on digital devices for entertainment and discovery rather than outdoor exploration, we are forced to think of a way to combine these two necessary developmental pursuits and adapt them in an integrated way to the new inventions and trepidations of our culture. While some suggest that the use of digital media will subtract from natural experience it is important to think of the ways in which it can actually enhance these

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experiences that are so threatened by environmental disasters and our own timidity. Digital media have the potential to utilize the same environmental education programs that have proven to be successful in a physical setting, and to enhance them through virtual activities that are not only more entertaining but also possibly more informative, as media has been proven to be a viable option for children's education. These positive media-guided experiences in nature not only have the potential to increase a child's affinity for and awareness of the natural world but can also intensify his or her desire to preserve and protect it.

Some "educational media" have been developed to offer supplements to children's environmental education. For example, BrainPOP has released various movies on environmental topics. PLUMLANDING, a PBS show produced by WGBH is also centered on an environmental education curriculum. Both of these resources offer many creative, digital environmental education opportunities, however, they do not effectively appeal to the entertainment and education of each individual child. Many other environmental education apps in the market are similar to the resources released by BrainPOP, which focus on specific environmental topics such as pollution or animals. These resources are effective for children who are already interested in those specific topics but do little to encourage children to explore other, existing or not yet existing, environmental interests.

Other resources are broader, and fail to provide a personalized learning experience. For example, *Outdoor Family Fun with Plum* is a useful app that provides families with a variety of "missions" that range from counting, scavenger hunts, and photographing animals and environments ("Outdoor Family Fun with Plum," n.d.). While this app encourages families to explore the outdoors, it does little to mediate possible hindrances to outdoor exploration. Activities are not region specific, making it difficult for children to receive guidance on

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exploring their own environment. “Missions” are also not altered depending on time, season, and daily weather, which prevent children from using the app in certain conditions. The app is also specifically designed for family use outdoors, which is diminishing due to hectic schedules and a rise in alternative forms of entertainment. Apps and digital tools that involve games and scavenger hunt components, like *Outdoor Family Fun with Plum*, focus on a more generalizable population rather than activities for each individual learner in each individual location. *Monkey Spot Scavenger Hunt* and *Happy Snap* are similar apps focused on environmental scavenger hunts. *Monkey Spot Scavenger Hunt* allows children to pick from seven lists such as “Out to Eat” or “Backseat Driver” offering children items to keep their eyes peeled for in restaurants or when they are in the car. *Happy Snap*, on the other hand, is an augmented reality game, which sends kids on a basic scavenger hunt telling them to “look for something green” or “take a picture of something colorful,” and it is meant for children as young as four. These two apps are also designed to work for a broad population and fail to provide adequate educational resources for users looking to learn more about the environment. For these reasons, it is clear that the potential for digital media to enhance children’s environmental education needs to be further researched.

This thesis aims to contribute to this body of literature by investigating how environmental education can be strengthened by the incorporation of digital media, specifically through the development of an app. In order to further research how to develop a successful, educational app for children, we will need to focus on specific subjects or activities that have proven to be successful when engaging children with the environment and think critically about how these elements can be adapted to fit into our digital worlds.

Chapter 3: Results

Semi-structured interviews were conducted with twelve participants. A total of eighteen emails were sent out asking for volunteers and twelve responded. The participants consisted of six environmental educators employed at various Massachusetts Audubon Society sites and programs, one elementary science educator, two climate change advocates, one educational app producer, and two mechanical engineering professors interested in STEM education. For the purpose of result analysis, the participants were divided into two groups – environmental educators and app developers. The environmental educator group consists of the six Massachusetts Audubon employees, the science educator, and the climate change advocates. App developers consist of the app producer and the two mechanical engineering professors, although there is some overlap as these developers have a genuine interest in education as well. Each interview lasted about thirty minutes and they were either conducted over the phone or in person. Interviews were open-ended, allowing for a variety of subjects to be discussed, but only the most informative and important themes will be analyzed here.

App Developers:

Participating app developers reported that commercial interests often drive technological projects. In the rush to bring a creative idea to market, there is often inadequate attention paid to the design process. Many app creators fail to think critically about the platform in which they are using, and for that reason, many apps tend to fall short. In order to ensure that apps are being created to their full potential, these app developers warn, app creators must carefully consider the app development process.

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Participants explain that the first step of app development is creating an idea and considering your target demographic. When developing educational apps, it is important to study your target age group and ask yourself “What are they able to do at this age? What do they already know? What is the potential for them to know? What are their developmental needs?” One app developer explains this important concept further using the example of fractions, “What do children of this age know about fractions? What is the potential for them to know? What types of math problems can they handle? What’s too easy and what’s too hard?” When developing an idea or premise for an app, these questions are crucial in determining what your audience will be able to manage. It will also aid in the development of activities that are attainable and enjoyable for your audience.

Another important aspect of formative research is conducting what these app developers call landscape research. Using the same example of fractions, an app developer explains that in order to conduct landscape research you “...go into the app store, download as many apps about fractions that you can find. Go online and look for games about fractions and think about the best and worst aspects of them.” During this process, app developers are able to survey the field. They look into a variety of platforms and investigate what has already been created relating to their topic. They assess as many products as they can that relate to their general idea, and ask themselves “What has been done? What is effective? What is ineffective? What are they missing?” These questions allow app developers to explore the paths others with similar ideas have taken and improve upon them. They also allow app developers to get a deeper understanding of what has already been done. While a developer can have a great idea, it is quite possible somebody else has already attempted a similar idea before and this process is crucial in forming an

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understanding the best and worst practices, as well as what may not be possible given that it has previously been done. During this phase, developers also have to ask themselves what their specific design can contribute to the field knowing what currently exists.

Once the general idea has been developed, educational app developers take their concepts into schools, camps, or after-school programs. One of the app developers interviewed says that her company collaborates with schools, although other companies may conduct research with children in other capacities. This type of research allows the developers to cultivate an even deeper understanding of what is successful with their particular demographic. At times the developers are measuring for content while at other times they are looking to assess mechanics. One particular participating app developer reported that her company typically conducts this portion of research with individuals. They are either done in a one-on-one or two-on-one format, with one developer working with the child and the other taking notes. This allows developers to gain a deeper understanding of each child's experience, which is difficult to attain from larger group interviews.

The developers then begin working on designing a prototype and working towards the alpha and beta stages of development. One participant emphasized that each project has a different trajectory, so there are various stages of prototype development. For some projects, the beginning prototype can be coded and contain illustrations, while others can simply be paper prototypes. While there is no set framework for how to develop a prototype, or when to move on to the beta stage, this app developer emphasizes how important it is to set timelines and stages in which you plan on reflecting on your design and perhaps conducting more research if necessary.

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Once the app is fully developed, the final step for the app developer is to disseminate their creation. Depending on your platform and design, the app developer must implement an effective marketing plan and strategy to ensure that their creation will reach their desired demographic.

While the app design process will not be executed fully in this thesis, this framework for app development will be crucial in informing my approach to developing a proposal for an environmental education app for children.

Environmental Educators:

A variety of repeating themes were found across interviews with environmental educators. The first and perhaps the most important theme is the idea of safety. Participating educators declared that there is a need address the potential dangers of the outside world. It is most effective for the message of safety to be delivered in a way that is empowering, instead of frightening. When these messages are delivered in the form of warnings or alerts, children can become afraid of the natural world and decide to avoid natural interactions altogether. Perhaps if the topic were introduced through a game or activity, a child would not be made to fear the potential danger but instead develop the confidence and knowledge to conquer it. One contributing educator used the example of poison ivy; a child should not be made to fear poison ivy, but rather be given the tools to identify and avoid it. One environmental educator explains, "There could be something like 'don't forget your bug spray! Or, 'this is what poison ivy looks like! You know, just to introduce these reminders in a positive and empowering way. Sort of a, 'Yes this is out there, but you can handle it!'" By approaching safety concerns in this way, the child will be

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made to feel confident, ready, and eager to explore nature rather than discouraged by potential threats.

These educators consistently stressed the need for hands-on active play. Each participating educator offered advice and suggestions relating to hands-on activities, a few of which will be highlighted here. Many educators discussed the importance of engaging each of a child's senses when engaging in outdoor exploration. One educator suggests doing this by having the child respond to "I hear," "I see," "I smell," "I feel," or, if the activity permits, "I taste," statements. In this way, the child will be able to focus his or her attention and notice the way the natural world can activate different responses depending on his or her focus. Many educators encourage observational drawing as another effective method of active learning and functions as a secondary mechanism for tuning attention. One educator explains this concept more clearly, "If I'm looking at the skull of a cow, one of the ways I can study that is through a practice called observational drawing. To study this thing, I create a reproduction of it in a drawing. What that does is focus my attention in a kind of way where I start to see things and wonder things that if I were to just pick it up, look at it, and toss it away I never would experience." By guiding a child's attention and asking them to draw a specific observation, you are providing the child with the opportunity to experience their observations more deeply than if they just noticed them briefly. For example, if a child is observing a tree and is instructed to focus and draw one part of the tree such as a leaf, you are allowing the child to explore the leaf more fully. The child will be able to focus on each detail and think more critically about the functions and purpose of a leaf in the natural world. In this way, the child will be able to think of how their particular observation contributes to their greater worldview. Other popular subjects that lend themselves to

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hands-on, active, child-directed play include but are not limited to the topics of shadows, hibernation, migration, adaptation, seeds, bugs and insects. Another popular subject that was mentioned across the majority of interviews is building gnome or fairy homes. These homes are built out of only natural materials, such as sticks or pinecones, and meant to blend in with nature. Different seasons and regions provide children with access to different materials and allow children to think creatively about the project.

There are also several educational themes that must be considered when looking closely at children in the age range of six to nine years old. Many of the contributing educators explained that when dealing with this particular demographic, it is important to acknowledge their predilection for collection, identification, and categorization. These educators aim to design a curriculum that allows children to explore this interest through scavenger hunts and other activities where they can collect, identify, and categorize their findings. Educators emphasize how effective photographing findings can be for children. Similar to observational drawing, taking photographs allows children to pay attention to certain details they could have overlooked. However, photography is not the only tool to encourage children to collect, identify, and categorize items in nature. Many children enjoy grouping items into categories on their own by making lists or charts. Participating environmental educators feel that a variety of tools should be implemented in an effort to not only expose children to a variety of methods used for collection and observation, but also to allow them to find which tools work best depending on the material as well as their own personal learning styles.

Educators often use resources such as the Massachusetts Science Standards to determine what their students already know and what they should be learning at certain

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ages. While the standards are too extensive to be discussed here, several milestones are notable. According to the January 2016 Massachusetts Science Standards, kindergarteners begin to build on previous natural experiences and are capable of making more quantitative observations. They are then able to use these observations to identify why some changes occur. By the time they enter first grade, students have a more developed understanding of language, number sense, and inquiry skills which allows them to expand on their earlier observations and think critically about how these changes reflect certain patterns to make predictions about the natural world. This understanding is enhanced as children move onto second grade and can understand how their observations contribute to larger systems. Third grade marks the beginning of using the skills they have acquired to engage in more scientific learning and think critically about the way humans interact with the environment. While children within the age range vary greatly in their abilities and understandings, it is a crucial time to provide the basic structure and framework that will help children develop a positive relationship with the natural world and their own science education later on in life.

One educator in this cohort warns against taking a “deficit framework,” which is common among many parents and teachers. In this approach, adults tend to view children as empty voids that need to be filled with information. In reality, however, children have already have acquired vast funds of knowledge and a more effective way to educate them would be to provide them with opportunities to explore the knowledge and curiosities they already have. From this lens, the educator explains, a child’s desire to photograph what they observe can also provide them with a basic understanding of how to document and analyze their findings that will prove necessary as the child matures.

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The educators interviewed explain that for children of this age, acquiring information is not the most important part of learning. The popular educational model in which a teacher provides a student with information, and then later asks the student to memorize and recall said information is not effective, especially at this age. Instead, effective learning comes from providing children the opportunities to explore their own curiosities. One educator describes her curriculum, “A lot of the time, it consists of what we plan and then other times it is a sprinkling of whatever the children are interested in at the time, and then often we go off on tangents and follow whatever the children are doing that day. No two days look the same, especially when you throw the weather into the mix.” She implements this approach in her classroom, and begins each topic by asking her students, “What do you know about this topic? What do you wonder? What do you want to learn?” In this way, the educator ensures that the lesson does not simply provide information but reflects each student’s interest and passion as well. Although educators agree this approach can be frustrating, as it does not allow much room for structure and planning, they feel this flexibility is essential as it increases student engagement and interest.

Permitting children to have such an active role in their own education enhances their personal relationship with the material. All educators agree that this relationship with their environmental education is crucial as it encourages children to become personally invested in the topic. This relationship with nature can also be encouraged by urging students to participate in projects from the beginning to end. Having children develop an idea for a project, execute the project, and then reflect on their work is a very important process as it encourages children to develop fuller conclusions, and a deeper understanding of a particular subject. For example, one environmental educator explains,

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“One of the things that’s important for kids to understand about nature and about science is that things do change over time and there are patterns. It is important to think about that and use that to draw conclusions.” By encouraging students to participate in projects from beginning to end specifically in environmental education, children will be able to identify these changes and patterns in order to develop a better understanding of environmental concepts and the consequences of what they are observing.

Another way to foster this unique relationship with their natural education is by encouraging children to find a special place in nature. One environmental educator explains an example of how to develop a special place, “With one of our groups, we have picked a tree that we always check in on. They come to notice the changes.” This continual relationship allows children to better observe the tree and also feel personally invested in its progression. Another educator says she has her students go to their “special place,” which can be a certain tree or spot in the yard, and do a variety of activities. Sometimes she instructs them to observe what they see which is similar to how the other environmental educator develops this relationship, but other times she simply encourages them to read a book. Each of these activities, she feels, encourages her students to develop an emotional connection with this natural place.

The two climate change advocates interviewed also emphasize the importance of fostering an emotional relationship between students and their natural world. One explains, “That is where the literature is - unless we get kids outside and in nature, they won’t understand how important it is to protect it. Especially as we move forward and live with climate change, unless you know what is lost you won’t even know that it is lost.” These climate change advocates suggest that the issues surrounding climate change are

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only going to grow more intense with each year. It will be the responsibility of these children to attempt to solve these issues, but we cannot expect them to have a genuine interest or understanding of the issues at hand without an effective environmental education in which they are encouraged to form a strong bond with the environment. When specifically looking to address the issue of climate change with children, these educators feel like effective hands-on activities include planting gardens, reading books, and even tracking and observing changes in climate for themselves.

Another major theme that came across when speaking with educators was how to address children of different ages, developmental levels, and with different preferred learning styles. In general, these educators feel that effective environmental education stems from generating positive experiences in nature. They are less focused on providing information, but instead much of their focus is on generating these positive experiences. For this reason, they feel that all types of learners and students should be able to explore the outside world in a way that maximizes each student's comfort. For example, one educator stated that she has some students in her class with poor fine motor skills. She allows those students to take photographs of their observations, record videos, and voice recordings, or type them on an iPad instead of writing in their nature journals like many of the other students do.

Other educators in the study explain that each of their students prefers different activities and lessons. For example, one educator argues for flexible outdoor activities, "I think it is important to create space for free play because you are just trying to have a positive experience. So, it can be imaginary. It doesn't have to be like 'do you know this bird?' I mean, some kids love that and they want to know the exact names of every rock or

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every bird but I think for kids who just want to go out and play in a pretend kitchen outside things should be more open for that.” Some students prefer to hear information, while others prefer to actively learn, through activities such as dramatic play, crafts, and experiments. A majority of the educators interviewed reported that a crucial part of designing activities is providing many different access points to each activity and lesson. Many of the participating educators use the example of Story Walks, which have proven to be successful in many parks and schools. During a Story Walk, children walk along a path and find different pages of a story along the way. As they explore, more of the story is revealed. This is effective in getting a wide range of students excited about nature, whether they simply want to read the story or observe nature as well. However, it is also important to note that student’s learning styles and activity preference can change frequently. Adaptable activities and curriculums ensure that educators will be able to accommodate students varying needs and desires. These educators suggest that by being flexible in this way, they can focus on creating positive natural experiences for their students without being distracted by the content, or their students lack of participation.

When asked about parent involvement or interest in their children’s environmental education, educators, some of which are parents themselves, gave a variety of responses. None of the educators assigned activities to be done at home, so it was difficult to get actual evidence of parent’s willingness to conduct these activities with their children. All educators at Massachusetts Audubon said the parents of their students are enthusiastic about their child’s environmental education. While one educator says, “some parents do not buy into it,” most respond well to the sheets of additional activities and resources they send home.

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However, other educators interviewed argue that they have felt some pushback from their students' parents. The participating climate change advocates, in particular, have said they have encountered parents with "different sciences" who do not feel climate change should be taught in schools. Some of the participating educators reported that their parents avoid instigating these activities or nature lessons because they are afraid they will not know the right answer. One environmental educator explains, "One of the things parents get worried about is that they should know the right answer. It is important to enforce that this is about exploration and discovery and seeing what you learn. You do not need to know the right answer. You can always look for the right answer, but that is not necessarily the goal." While these educators feel that giving the "right answer" is not important, they try to send home sheets and additional resources to parents in hopes that they will become more comfortable with the subject matter. Some of these educators asserted that parents do not respond well to these resources from teachers, but parents are eager to participate in activities that their children are excited about. One educator, not affiliated with Massachusetts Audubon, shared that very few parents attend their teacher-run conferences, but she started holding student-run conferences last year and all but two parents were able to attend. This rise in participation shows that parents are eager to support their children's interest, which would indicate that an effective environmental education for students could improve environmental awareness among adults as well.

Chapter 4: Discussion

The overarching goal of this thesis was to gain an understanding of both environmental education and app development in order to fuse the results into a cohesive

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proposal for an environmental education app for children ages six-nine. This study underlines the importance of effective environmental education and app development. While many critical aspects of both subjects were discussed, only the most crucial themes of effective environmental education and app development will be discussed here. The literature reviewed in this study was interpreted judiciously in order to ensure that the work was effective. One theme that has emerged from this thesis include the need to carry out the educational app development process fully, so as to ensure the most effective learning experience. Other themes include the need for hands-on, active learning opportunities, the need to think critically about the wide range of learning styles and developmental needs of children, and, finally, the need for parental involvement in their children's environmental education.

App Development Process:

Few agencies provide parameters for the development of an effective educational app, but those that do call for the app to foster cognitively-active, engaged, meaningful, socially-interactive, and goal-directed learning (Hirsch-Pasek, 2015; Wartella, 2015). Participants in this study expressed similar sentiments. This is largely because app design is intended to be accessible to a large population, and offer creative outlets for everyone regardless of their background. The literature suggests that because wide ranges of individuals are producing apps there is a surplus of "educational" apps in the market that are largely unregulated and inadequately tested (Hirsch-Pasek, 2015; Wartella, 2015). Many of the participating app developers argue that a shortened timeframe often precludes adequate attention to detail, which compromises the educational potential of an app.

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However, digital media that have been adequately tested have proven to be highly effective when used as a supplement to instructional learning (Creasey, 2013). While the scope of this project does not include the development of a physical app, it remains important to carefully consider the advantages and limitations of the platform. This project lays the groundwork for the development of an app in the future and being mindful of the app development process will maximize the app's effectiveness as a supplement to instructional learning.

The app development process, which was revealed through interviews with participating app developers and the literature, was described as relatively simple. Ideally, the process should include pairing a carefully considered idea with a well-articulated desired demographic. App developers should then carefully conduct formative and summative research to ensure that their idea is carried out successfully.

The creation of an effective, informative, environmental education app for children requires a thoughtful process with attention to detail and development. In addition to suggestions delineated in the literature, participating app developers argue that landscape research must be conducted in order to survey what this particular app can contribute to the field, after carefully assessing best and worst practices in already existing apps. Both the literature and the participating app developers agree that thorough formative and summative research must be conducted to ensure that an app produces the intended effect. For environmental education apps, in particular, it is crucial that research is conducted to ensure that the information and activities delivered in the app echoes what each student is learning in school to ensure that their instructional learning is enhanced. School curriculums must be assessed as well as students' developmental capabilities.

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As digital media become increasingly present in our lives and the lives of children, it is important to understand that it does offer the opportunity to enhance children's learning (Castek & Beach, 2013; Anderson et al., 2015; Kermish-Allen, 2016; Rideout, 2017). In a recent study released by Common Sense Media (2017), it was revealed that 42% of children now have their own tablet device and that mobile media has become increasingly popular among children across all demographics. While it is impossible to ignore how pervasive these digital devices are becoming in our homes, 67% of parents argue that it helps their child's learning and 57% say it helps their child's creativity (Rideout, 2017). However, participating educators, app developers, and the literature all agree that digital media can also subtract from children's learning if app developers and creative types fail to carry out the app development process thoughtfully. When looking at environmental education apps, in particular, participants emphasize that if the curriculum introduced in the app does not match the curriculum being taught in school, it is possible that the student can feel overwhelmed. Participating educators also stress that each activity included in the app must match students developmental level. If students are given an assignment that they are not capable of carrying out themselves, participating educators feel it can serve as a deterrent to a child's environmental education. For this reason, each piece of information delivered in an environmental education app must be carefully researched so as to ensure each child will be capable of absorbing it on their own or finding the additional resources to aid them in their understanding. If this research is not carried out thoughtfully, both the literature and participants fear that apps can discourage children in their learning.

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Activities:

Both the literature and participating environmental educators argue that the most effective environmental education stems from hands-on, active learning. Various environmental programs have been observed, and those that have been the most effective are the ones that allow children to learn about the environment in an active, experiential manner. However, the concept of active learning does not simply refer to a child swiping or tapping on an app but rather learning that encourages the child to think, reflect, and exert active mental activity (Wartella, 2015). Wartella (2015) explains the need for this active learning in order for all “educational apps” to earn this label. While she may not be referring specifically to environmental education apps in her writing, participating educators have also echoed her concerns. They stress that this active learning is not only necessary for children to retain information but in doing so these apps provide children with a better understanding of the natural world and increase their affinity for the environment.

Participating environmental educators in this analysis concurred with the literature explaining that their students have both enjoyed and learned the most from activities in which they were permitted to have an active role. These environmental educators offered a plethora of examples of hands-on activities that have been successful in their classrooms and programs. These educators suggest that shadows, hibernation, adaptation, migration, engineering, seeds, bugs and insects, weather patterns, wildlife, and fauna are subjects that lend themselves well to hands-on activities.

According to participating educators, children learn best when genuinely interested in a topic. These educators advocate for a flexible curriculum in which the teacher provides

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a general topic while the students guide the classroom's specific focus. This observation goes hand in hand with what the literature states about providing children with active learning experiences that will enhance their knowledge and understanding of the natural world. However, both the literature and participating educators also argued that transmitting information is not what is important so our focus should not only be on how efficiently students learn. Instead, the literature and participating educators argue that it is most important to simply generate positive natural experiences to encourage children to form a bond with the environment.

These positive natural experiences, participating educators argue, are crucial in effective environmental education. They stress that we as a society cannot expect children to understand the magnitude of environmental issues such as global warming unless they are aware of what is being changed. With the future of our natural world in question, it will be up to these students to solve and inform others about these various environmental disasters. For this reason, it is imperative that a bond between children and the natural world is fostered early on. Without the knowledge and understanding provided through effective environmental education, participating educators fear that these students will not feel the desire to protect the natural world. Effective environmental education in a variety of settings, including in schools and digital media platforms, can help students develop into the environmental stewards they will need to be in the future.

Different Developmental Levels and Ages:

Another important theme that came across in the study is the fact that each individual child is unique, and differs in their preferred learning style and developmental

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capabilities. This is a typical issue for educators, as they are required to develop a curriculum that works for a variety of learners on multiple levels. As the goal of environmental education is to generate positive experiences, it is important that activities are designed to maximize positive experiences across all students – regardless of the activity’s specific goal. While this point was not stressed in the literature reviewed for this project, each participating educator mentioned how important overcoming this obstacle is in environmental education. For example, one educator says she combats this by allowing her students to take their time on outdoor explorations. She frequently gives her students an endpoint on a trail and explains that once everybody arrives at the point they will do an activity. For some students, they take this as an opportunity to run ahead. One teacher accompanies those students and allows them to play freely once they arrive. Another teacher accompanies those students who take the opportunity to observe what is around them and walk leisurely. In this way, the educators try to appeal to the many different personality types and interests of their students. However, one environmental educator warns against being too accommodating of different styles and interests. If we do not push children to try different types of activities, she fears students will become too reliant on their preferred learning style and be unable to adapt later on in life.

Parental Involvement and Societal Concerns:

Much of the literature argues that opportunities for children’s natural experiences are declining due to parental and societal concerns (Brussoni et al., 2012; Malone, 2007; Copeland et al., 2012; Staempfli, 2009; Carver et al, 2008; Brown & Kaye, 2017; Shirani et al., 2012; Beyer et al., 2015). The literature also emphasizes how important these natural

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experiences are for a child's intellectual, physical, creative, and social-emotional development (Brussoni et al., 2012; Malone, 2007; Copeland et al., 2012; Brown & Kaye, 2017; Kellert, 2015; Moss, 2012). Another prevailing theme in children's educational media asserts that joint media engagement, or digital engagement alongside a parent, can enhance various educational goals and maximize the potential developmental benefits of media use (Wartella, 2015; Richert et al., 2011; Kim & Smith, 2017). Interaction between parents and children in nature has also been proven to enhance the developmental benefits of environmental education (Wihardjo, 2017; White, 2015; Ogelman, 2012).

While all participating environmental educators agreed that opportunities for outdoor exploration and natural play are crucial for healthy development, they differed in their opinions on how parental and societal concerns were contributing to the decline. Those interviewed who work with the Massachusetts Audubon Society all argued that the parents they work with are extremely enthusiastic and eager to implement environmental activities at home. The other participating environmental educators all contended that their students' parents are eager to support their child's interest, but they are not interested in pushing environmental education activities without prior encouragement from their child. Participating environmental educators state that this may be because these parents were not brought up with an effective environmental education, highlighting the fact that this cycle of indifference to the natural world will not end unless an interest in nature is fostered early on.

This observation highlights the fact that parents who enroll their children in a Massachusetts Audubon program are not representative of the larger population of parents. For a parent to enroll their child in such an environmentally centered program,

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they must already be interested in environmental initiatives and feel it is a worthy opportunity for their child. For this reason, it would make sense that parents of children at Massachusetts Audubon programs would be interested in encouraging these activities at home too. However, it is important to consider the fact that not all parents maintain this interest. For parents outside of the Massachusetts Audubon Society, environmental education may not be a preexisting interest of theirs. For this reason, they only hear of environmental activities or programs from their child and while they may be eager to encourage their child's interest and passion in the natural world, it simply may just not be brought to their attention.

Participating educators also felt that a major deterrent for parents could be that they do not feel comfortable with environmental education material, which the literature supports ("How to Help Families Feel Comfortable in the Outdoors," n.d.; Brussoni et al., 2012; Malone, 2007; Staempfli, 2009; Carver et al., 2008; Shirani et al., 2012; Brown & Kaye, 2017; Wihardjo, 2017). Children do ask questions, and often parents feel it is their responsibility to have the answer to each of these questions. All participating educators assert that this is not the case. They argue that the parents' responsibility is not to provide a correct answer, but rather encourage their child's curiosity and search for the answer with their child. Participating educators assert that parents should be provided with additional resources and suggestions so that parents feel comfortable introducing environmental education in the home. Some of the educators interviewed feel that parents have not been responsive to didactic handouts, but have responded more to books and movies on certain topics.

Limitations and Directions for Future Research:

While this research was largely qualitative in nature, I hope that future research examines the effects of digital media on environmental education more closely. For the purpose of this thesis, an idea and potential solution for bringing environmental education into the home was proposed but this process was not carried out fully. In order to obtain an accurate understanding of the effects of this particular educational app and others, formative and summative research must be conducted in order to improve users experience with the platform. The proposal put forth by this thesis was based on effective environmental curriculums that have been observed in classrooms, but further modification may be necessary to allow this curriculum to fit a digital platform.

Another major limitation of this study was that the majority of environmental educators were employees of the Massachusetts Audubon Society. While this cohort of participants is very knowledgeable on the topic of environmental education, as they lead a variety of programs, workshops, and initiatives, it is important to understand that they are not necessarily representative of the greater population of schools, parents, and children. For the most part, parents who enroll their children in Massachusetts Audubon programs already feel effective environmental education is important. For this reason, it is not surprising that each of these educators reported that their parents have a high level of investment in their children's environmental education and are enthusiastic about continuing this education at home. This is not always the case among parents and guardians that have not already taken the initiative of enrolling their child in an environmentally focused program. In order to gain insight into the parental involvement of

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a greater population, researchers will need to investigate parental involvement in other programs and schools not as environmentally focused.

Within the temporal and economic constraints of this project, it was not possible to adequately develop the creative portion of this thesis. While I was able to imagine how I would go about organizing an app, I did not attempt to launch a physical, functional app due to my lack of expertise in the area. I was merely able to create a prototype. This is a major limitation of the project as the ideas behind the app were largely hypothetical and not carried out fully. It is my hope that this section of the thesis can provide a general framework for an environmental education app for researchers with more time and perhaps a better understanding of the field of app development.

This thesis proposes one potential solution to bringing environmental education into a space where parents may feel more comfortable, but it is certainly not the only solution. In order to ensure that children will feel a desire to protect and solve the issues of the natural world, we must investigate additional ways to bolster environmental education. Future researchers should continue to think critically about the research questions posed at the beginning of this thesis: 1) How are parental and societal concerns impacting the way children interact with nature and how can these concerns be eased? 2) Knowing what we know about how children learn and how environmental education can foster an interest in nature, what different methods are environmental educators using to teach children about the natural world? 3) How can effective environmental education methods be adapted to, or enhanced by, the development of a digital app or game?

In addition to these questions, researchers and app developers should continue to research parameters for educational apps. Researchers should continue to investigate the

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role that parents and joint media engagement plays in children's learning, as that area is currently under researched. For environmental education apps, in particular, summative research covering the effects of these apps on children's learning should be tested to understand if the information delivered in these apps is, in fact, nurturing a love and passion for the natural world among young users. Furthermore, the development of environmental education apps should be more adequately researched to ensure they fit alongside the environmental education each child is receiving in school. Researchers and educators should also continue to explore how to make a subject work for children on a variety of levels in order to reach children of different developmental needs and learning styles. This thesis provides a general understanding that until we allow environmental education to extend beyond the classroom, students will not completely understand the role the environment plays in our lives and will not fully develop a desire to preserve it. Future researchers should continue to explore how to make environmental education informative, accessible, and adaptable so as to ensure effective environmental education is not lost.

Conclusion:

At the beginning of this thesis, three questions were posed: 1) How are parental and societal concerns impacting the way children interact with nature and how can these concerns be eased? 2) Knowing what we know about how children learn and how environmental education can foster an interest in nature, what different methods are environmental educators using to teach children about the natural world? 3) How can effective environmental education methods be adapted to, or enhanced by, the

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development of a digital app or game? By exploring each of these questions, I was exposed to an expansive selection of literature that sought to answer these questions or certain aspects of these questions, as well.

A large cluster of research has examined why children's experiences in the natural world are dwindling due to parental and societal concerns and why it is important to ease these apprehensions in order to foster a love and passion for nature early on (Brussoni et al., 2012; Malone, 2007; Staempfli, 2009; Carver et al., 2008; Shirani et al., 2012; Brown & Kaye, 2017; Wihardjo, 2017; Copeland et al., 2012; Beyer et al., 2015; Fisher-maltese, 2016; Treagust et al., 2016; Beery & Jørgenson, 2016; Cheng & Monroe, 2012; Fleer, 2013; Ogelman, 2012; Otto & Pensini, 2017). An abundance of past research has also analyzed what methods work best when looking to implement an informative and effective environmental education curriculum (Brown & Kaye, 2017; Cheng & Monroe, 2012; Fisher-maltese, 2016; Wihardjo, 2017; Treagust et al., 2016; Ogelman, 2012; Otto & Pensini, 2017; Beyer et al., 2015; Beery & Jørgensen, 2016; Melhuus, 2012; Sobel, 2015; Staempfli, 2009; Moore et al., 2012; Tugurian & Carrier, 2017; Waite, 2017; Demirbas, 2017). Literature has also been shared that examines the potential benefits of educational media and how digital media can be used as an effective supplement to instructional learning (Zipke, 2017; Noorhidawati et al, 2015; Crawford et al, 2016; Anderson et al, 2015; Kim & Smith, 2017; Richert et al, 2011; Batholomew, 2017 Pierce & Cleary, 2016; Kermish-Allen, 2016; Castek & Beach, 2013; Hirsh-Pasek, 2015; Wartella, 2015; Sobel, 2015; Waite, 2017; Land & Zimmerman, 2015). However, very few, if any, sources have attempted to fuse all of these topics together to investigate how digital media can be used to enhance environmental education and assuage both the parental and societal concerns surrounding children's

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natural exploration. This thesis sought to tackle this gap in the literature and propose an environmental education app that would supplement children's environmental education in school but in the comfort of their own home, backyard, neighborhood, or wherever their parents feel most comfortable.

This thesis contains just one possible proposal to solving a much larger issue. Children's experience in the natural world is decreasing and unless we shift our attention to fostering positive natural experiences children will not be able to understand the consequences of the current state of our environment. It will be up to these children, and future generations, to grapple with the effects of our deteriorating environment. They will have to solve environmental disasters such as climate change and pollution, but we cannot expect them to understand the magnitude of these disasters or expect them to have the knowledge or desire to solve these issues unless we foster a love and passion for the natural world through effective environmental education.

At the very least, I hope that this thesis can contribute to the vast literature explaining why effective environmental education for young children is so important. I also hope this thesis can contribute to the literature explaining how digital media can actually enhance children's education when used as a supplement to instructional learning if implemented correctly. If executed correctly, digital media can offer a potential solution to the decline in children's natural exploration and mitigate parental and societal concerns by offering activities that can occur in the comfort of their own home or neighborhood. This survey of environmental education curriculums, parental and societal concerns, and the affordances of educational media mean to serve as a starting point for those interested in

enhancing environmental education programs and making them accessible outside of classrooms in order to strengthen children's environmental knowledge.

Chapter 5: App Development

Using the research gathered from this study, I have developed a proposal for a new environmental education app called TRACKZ. TRACKZ, I believe, exemplifies what an effective, truly educational app should be. In order to truly be an educational app, the app must promote cognitively active, engaged, meaningful, socially interactive, and goal directed learning. The app must also include components such as characters or multi-player aspects that allow children to learn how to collaborate and work with others. The app must be carefully researched in order to ensure that the lessons and activities will effectively reach the target demographic and enhance learning objectives. TRACKZ is an educational app designed to get children outside, exploring, and discovering the natural world around them in an entertaining, safe, and informative way.

Methodology:

An app prototype developing website, Marvelapp.com, was used to aid in the design of this project. The website permits app creators to use their premade designs, as well as upload their own, in order to create a visual representation of their ideas. Research gathered from both the interviews and the literature was used to inform the design and information included in TRACKZ (<https://marvelapp.com/817dd9a>)

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App Design:

The first page of the app asks for an adult to type in a password in order to ensure that the child user has informed a guardian that they are outside exploring (Figure A). This feature seeks to mediate the concern raised in the literature stating that parents and guardians do not always feel comfortable allowing their children to play outside unsupervised. The following page allows children, parents, and other users to sign in (Figure B). New users are asked to provide their age, name, and what type of activities they are in the mood for that day (Figure C). Users can select one or all of the following options: Experiment, Search, Create, and/or Play. This is designed in an effort to mediate the concern raised among many participating environmental educators that felt that in order to generate positive experiences with the natural world, we must permit students to interact with nature in a way that feels comfortable to them. Students vary greatly in their preferred learning styles, so in order to maximize their learning potential, this feature allows them to have some control over the way in which they receive information. The question is phrased as “What do you feel like doing today?” due to the fact that children’s preferred learning styles can change frequently and unpredictably. Existing users are prompted with the same question as well so that the app can customize activities and lessons depending on users changing moods (Figure D). The app takes this idea of

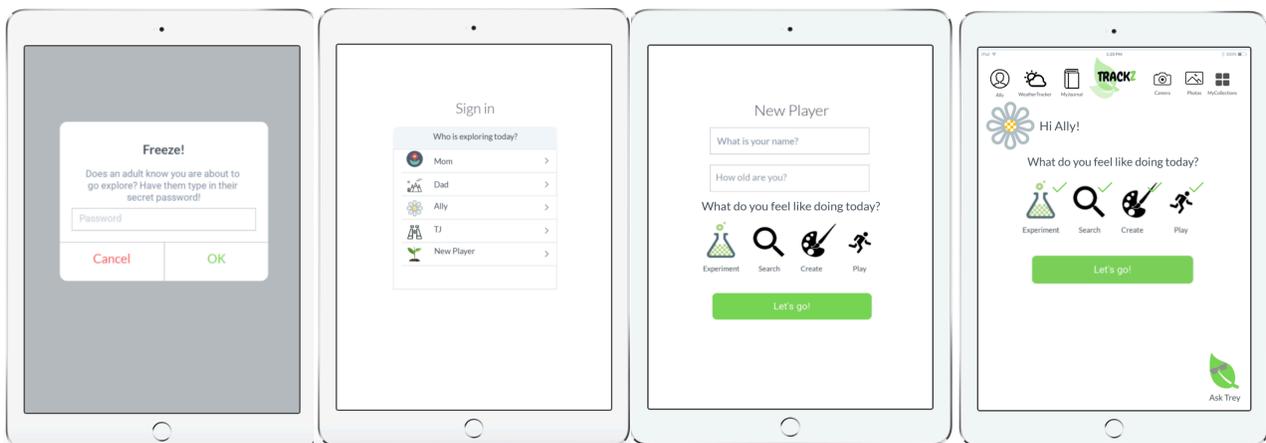


Figure A

Figure B

Figure C

Figure D

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customized activities one step further, by allowing multiple players to sign up together.

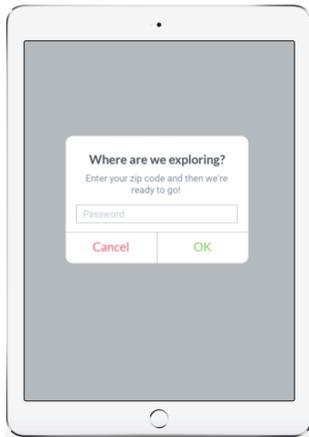


Figure A

This provides the app with a clear idea of the audience it is trying to reach. For example, if both Ally and Mom sign in, activities can be a bit more complex as the Ally will have an adult alongside her to help her navigate each event.

Once the user has signed in, they will be prompted to type in their zip-code (Figure E). This feature allows the app to further customize each activity. Using the zip-code, the app will be able to

generate activities that are feasible within the parameters of the region such as the time, weather, climate, and type of neighborhood. For example, if the app is being used in a seaside town, it is reasonable to suggest that children collect objects such as seashells. That



Figure F

same activity, however, becomes impossible in other regions. For this prototype, the zip-code being used is 02118, which represents the South End area of Boston. So, the app must consider what natural experiences are accessible to users in such an urban area.

After the zip-code has been entered, the user is finally presented with the list of suggested activities and lessons

customized to their region, age, and preferred styles of learning.

The sample list generated on this prototype was generated for an eight-year-old girl in the South End of Boston who was interested in all activity types (Figure F). This sample list includes the following activities:

SAMPLE LISTS:

South End at 3:00 PM on April 30th:

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- Can you find a bug or insect near you? Draw what it looks like here!
- Describe your surroundings!
- Color Hunt
- Story Explo
- Add today's weather to your WeatherTracker
- Using the zoom lens on your camera, take a close-up of a leaf. Sketch or describe what you



Figure G

see in your journal.

- Earlier today, you observed the shadow an object made near the window. Go check in and observe that object now. Describe how it changed in your journal.
- Look around you. How many homes do you see? What animals live in those homes?
- Design and build a fairy home here!
- Let's do an experiment!



Figure H

Pages were not built for each activity, as some are intuitive, such as asking users to describe their surroundings. Pages were built for the following activities as they require more explanation: Color Hunt (Figure G), Story Explo (Figure H), Add today's weather to your WeatherTracker (Figure I), and Sketch or describe what you see



Figure I

in your journal (Figure J). A participating environmental educator who explained that students

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have responded well to color scavenger hunts in the classroom suggested the Color Hunt activity. In order to adapt these classroom scavenger hunts, which instructed students to find various colors in nature, to this digital platform I designed an activity in which the children would be shown various colors and asked to take pictures of items containing those colors in nature. The Story Explo activity

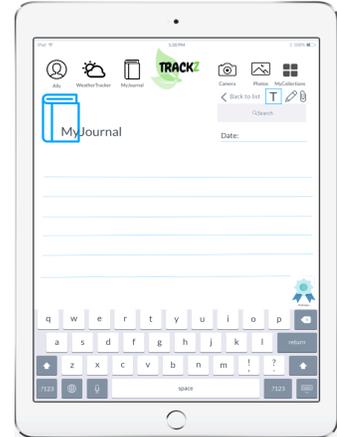


Figure J

uses an assortment of children's books relating to nature to motivate children's outdoor exploration. Each user can unlock the next page or section of the book by either walking a certain amount of steps, taking a photo of their surroundings, making an observation about their surroundings, or adding objects to their collection.

The WeatherTracker seeks to address the concerns raised among the participating climate change advocates who warned that children couldn't possibly understand the magnitude of climate change unless they are encouraged to notice it early on. The weather tracker allows users to add their own data, compare their data and the data of others, search through all data, and share their data with the larger database. When inputting their own data, (Figure K), users are encouraged to guess the temperature, select images of what they observe outside, and select from a word bank of adjectives or write their own that they feel describes the weather. They can then compare their observations with the actual weather report. Finally, the Journal allows users to write, draw, or photograph any of their observations. On the home page, there are buttons allowing users to view their profile, WeatherTracker, Journal, Camera, Photos,

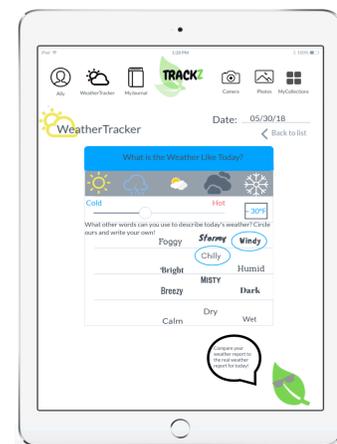


Figure K

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Collections, Badges, and previous Explorations at any time without being prompted by the list. In this way, children will be able to access and contribute to their saved work at any point.

Users also have access to their badges through the MyBadges link on the home page. On the MyBadges page (Figure L), users can collect a wide variety of badges, which reflect different skills and topics. In this prototype, only a few examples

are shown, but there are many opportunities for children to collect badges. For example, in order to gain an Expert badge (Figure M), users must engage in a series of activities, which highlight their knowledge of certain cautions to take when

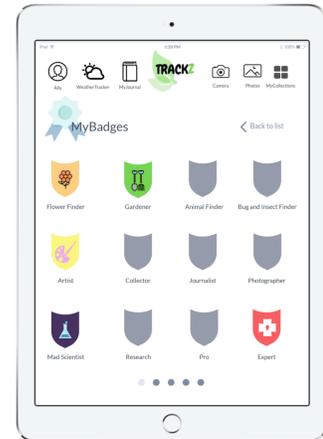


Figure L

exploring nature. The activity shown on this prototype is a matching activity where users are asked to identify images of poison ivy. This specific activity is just one step towards achieving the Expert badge. Other activities will provide users with knowledge of UV protection, insect protection, and other poisonous plants. Participating environmental educators warned against framing these potential dangers in a frightening way. For this reason, the wording of each Expert Badge activity is empowering rather than discouraging.

The final feature of this prototype is the Ask Trey function. Trey is a character that is meant to encourage and support users natural experiences. Not only does Trey interact with users, but also provides them with additional resources. The prototype reveals how the Ask Trey page would appear if accessed through

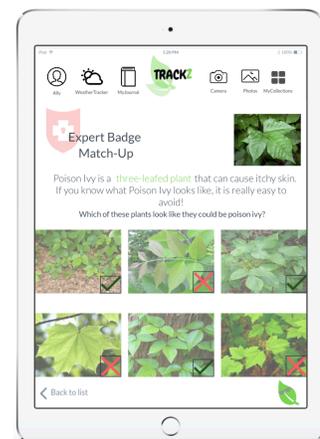


Figure M

the 7th activity, "Earlier today, you observed the shadow an object made near the window. Go

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check in and observe that object now. Describe how it changed in your journal (Figure N).” The subject of this activity is shadows, so when a user clicks Trey’s icon on this particular activity, the Ask Trey page (Figure O) automatically generates more shadow activities, books, and additional shadow facts in order to allow the user to explore this specific interest further. This feature is designed to take advantage of

some children’s short attention spans. Participating environmental educators warned that young students interests can be fleeting, so it is important to capitalize on their interests immediately as they may dissipate quickly. On the Ask Tray page, students can also ask questions, browse frequently asked questions, share their own ideas or stories, and submit pictures of objects that they want to identify



Figure N

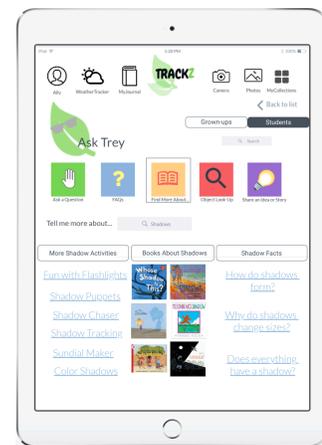


Figure O

through Object Look-Up. There is a separate Ask Trey page for adults, either parents or educators, who need further assistance with the app or environmental education in general.

Limitations and Directions for Future Research:

This prototype seeks to address each of the concerns raised in the thesis to a certain degree, but this is only one possible solution to bolstering environmental education and this design is not without fault. One of the hardest obstacles when developing this design was modifying environmental education techniques that are effective in a classroom setting to a digital platform. Many aspects of environmental education require flexibility, leniency, and alteration from environmental educators. This ability to adjust lesson plans and activities based

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on the children's ever-changing interests and desires is crucial for a successful environmental education. However, a digital app does not lend itself to this adaptation so easily. Since each aspect is programmed so meticulously, it was difficult to develop ways to foster this child-directed learning that participating environmental educators explained was crucial for an effective environmental education.

Another major obstacle was the website used to design the prototype. I do not have an engineering background or any prior knowledge of coding, and I was therefore required to use a website that would permit me to design an app using only preexisting images and templates. This not only limited the options for the app's interface and color scheme but also prevented me from developing many activities and lessons. For example, participating environmental educators expressed that students enjoy creating homes for fairies, animals, and other woodland critters. One activity asked students to make such a home either physically or digitally depending on what materials they had access to. However, due to the limitations of this website, it was not possible to design such an innovative idea as there were no preexisting images.

The prototype for TRACKZ was supposed to include sample lists for various regions, in order to illustrate the wide variety of activities and lessons generated based on different zip-codes. However, given the scope of the project as well as the restrictions of the website, it was not possible to generate such an elaborate design. The time constraints for the project also posed a challenge to conducting the formative and summative research necessary to measure the efficacy of this app on young users. It is my hope that this prototype can be developed even further in the future to include the research and redesign necessary to maximize educational efficacy. The premise of the app involves understanding environmental features of every region of the country, which is a huge undertaking even without the time constraints of this project.

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Future research could involve launching prototypes for specific areas, and enlisting inhabitants of additional areas to describe the environmental features of their specific region to minimize the responsibility of the app developer.

At the very least, I hope this prototype illustrates the potential for educational media to bolster environmental education initiatives. However, I do hope the research found in the study and synthesized in the development of TRACKZ can serve as a jumping off point for other researchers and educators interested in expanding environmental education into homes and using educational media as an instructional tool. While the development of this prototype required much research, the research conducted barely scratches the surface of what must be done to ensure that the app serves as an effective environmental education tool. TRACKZ provides the foundation for an environmental education app for children, but it is just one small step towards answering the questions posed at the beginning of this thesis: 1) How are parental and societal concerns impacting the way children interact with nature and how can these concerns be eased? 2) Knowing what we know about how children learn and how environmental education can foster an interest in nature, what different methods are environmental educators using to teach children about the natural world? 3) How can effective environmental education methods be adapted to, or enhanced by, the development of a digital app or game? Future research must continue to pose these questions, and use the findings of this thesis and the TRACKZ prototype as a foundation for developing potential solutions.

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Conclusion

This thesis sought to identify certain obstacles to environmental education as well as educational media, and through an effective study develop a prototype of an environmental education app for children that mediated both areas of concern. Educational media, if developed thoughtfully, can enhance children's instructional learning. In order to foster an effective environmental education through media specifically, it is imperative that we develop thoughtful educational tools such as this app that focus on alleviating societal apprehensions surrounding outdoor exploration, encourage hands-on, active learning opportunities that reach different types of students, and generate positive bonds with the natural world.

References

- Anderson, C. L., Miller, B. G., Eitel, K. B., Veletsianos, G., Eitel, J. U. H., & Hougham, R. J. (2015). Exploring Techniques for Integrating Mobile Technology into Field-Based Environmental Education. *Electronic Journal of Science Education, 19*(6). Retrieved from <http://ejse.southwestern.edu/article/view/14752>
- Audley, S., & Stein, N. (2017). Creating an environmental resiliency framework: Changing children's personal and cultural narratives to build environmental resiliency. *Journal of Environmental Studies and Sciences, 7*(2), 205-215.
- Baker, E. (2014). Developing an App-Titude for Learning in the Outdoors. *Primary Science, 135*, 19-21.
- Bartholomew, S. R. (2017). Using Pokéman GO to Teach Integrative STEM. *Technology and Engineering Teacher, 76*(5), 24-27.
- Beery, T., & Jørgensen, K. A. (2016). Children in nature: sensory engagement and the experience of biodiversity. *Environmental Education Research, 0*(0), 1–13.
<https://doi.org/10.1080/13504622.2016.1250149>
- Berk, L. E. (2013). *Child Development* (9th ed.). Boston: Pearson.
- Bers, M., Candland, Douglas K., & Ferguson, Christopher J. (2010). Let the Games Begin: Civic Playing on High-Tech Consoles. *Review of General Psychology, 14*(2), 147-153.
- Beyer, K. M. M., Heller, E. F., Bizub, J. M., Kistner, A. J., Szabo, A., Shawgo, E. E., & Zetts, C. J. (2015). More than a Pretty Place: Assessing the Impact of Environmental Education on Children's Knowledge and Attitudes about Outdoor Play in Nature. *International Journal of Environmental Research and Public Health, 12*(2), 2054–2070.
<https://doi.org/10.3390/ijerph120202054>

ENVIRONMENTAL EDUCATION THROUGH MEDIA

- Bond, B. J. (2018). Parasocial Relationships with Media Personae: Why They Matter and How They Differ Among Heterosexual, Lesbian, Gay, and Bisexual Adolescents. *Media Psychology, 0*(0), 1–29. <https://doi.org/10.1080/15213269.2017.1416295>
- Brown, J. M., & Kaye, C. (2017). Where do the children play?: An investigation of the intersection of nature, early childhood education and play. *Early Child Development and Care, 187*(5-6), 1028–1041. <https://doi.org/10.1080/03004430.2016.1227325>
- Brussoni, M., Olsen, L. L., Pike, I., & Sleet, D. A. (2012). Risky Play and Children's Safety: Balancing Priorities for Optimal Child Development. *International Journal of Environmental Research and Public Health, 9*(9), 3134–3148. <https://doi.org/10.3390/ijerph9093134>
- Carson, Rachel, Darling, Lois, & Darling, Louis. (1962). *Silent spring*. Boston : Cambridge, Mass.: Houghton Mifflin ; Riverside Press.
- Carver, A., Timperio, A., & Crawford, D. (2008). Playing it safe: The influence of neighbourhood safety on children's physical activity—A review. *Health & Place, 14*(2), 217–227. <https://doi.org/10.1016/j.healthplace.2007.06.004>
- Castek, J., & Beach, R. (2013). Using Apps to Support Disciplinary Literacy and Science Learning. *Journal of Adolescent & Adult Literacy, 56*(7), 554–564. <https://doi.org/10.1002/JAAL.180>
- Chen, Tutwiler, Metcalf, Kamarainen, Grotzer, & Dede. (2016). A multi-user virtual environment to support students' self-efficacy and interest in science: A latent growth model analysis. *Learning and Instruction, 41*, 11-22.
- Cheng, J. C.-H., & Monroe, M. C. (2012). Connection to Nature: Children's Affective Attitude Toward Nature. *Environment and Behavior, 44*(1), 31–49. <https://doi.org/10.1177/0013916510385082>

ENVIRONMENTAL EDUCATION THROUGH MEDIA

- Chung, S., & Cho, H. (2017). Fostering Parasocial Relationships with Celebrities on Social Media: Implications for Celebrity Endorsement. *Psychology & Marketing*, 34(4), 481–495.
<https://doi.org/10.1002/mar.21001>
- Clements, R. (2004). An Investigation of the Status of Outdoor Play. *Contemporary Issues in Early Childhood*, 5(1), 68–80. <https://doi.org/10.2304/ciec.2004.5.1.10>
- Collado, S., Staats, H., & Corraliza, J. A. (2013). Experiencing nature in children’s summer camps: Affective, cognitive and behavioural consequences. *Journal of Environmental Psychology*, 33(Supplement C), 37–44. <https://doi.org/10.1016/j.jenvp.2012.08.002>
- Copeland, K. A., Sherman, S. N., Kendeigh, C. A., Kalkwarf, H. J., & Saelens, B. E. (2012). Societal Values and Policies May Curtail Preschool Children’s Physical Activity in Child Care Centers. *Pediatrics*, 129(2), 265–274. <https://doi.org/10.1542/peds.2011-2102>
- Crawford, M. R., Holder, M. D., & O’Connor, B. P. (2016). Using Mobile Technology to Engage Children With Nature. *Environment and Behavior*, 0013916516673870.
<https://doi.org/10.1177/0013916516673870>
- Creasey, S. (2013). Classroom Practice - Ah, the great outdoors: There's an app for that. *The Times Educational Supplement Scotland*, (2344), 32.
- Demirbas, C. O. (2017). The Effect of Out-of School Activities on Conceptual Change in Environmental Education. *Journal of Education and Training Studies*, 5(2), 232–242.
- Designing for Online Collaborations and Local Environmental Action In Citizen Science: A Multiple Case Study - ProQuest. (n.d.). Retrieved October 31, 2017, from <https://search-proquest-com.ezproxy.library.tufts.edu/docview/1865331111>
- Developmental Implications of Children’s Virtual Worlds - ProQuest. (n.d.). Retrieved November 26, 2017, from <https://search-proquest->

ENVIRONMENTAL EDUCATION THROUGH MEDIA

com.ezproxy.library.tufts.edu/docview/236433173?accountid=14434&rfr_id=info%3Axri%2Fsid%3Aprimo

Fisher-Maltese, C. (2016). “We Won’t Hurt You Butterfly!” Second-Graders Become Environmental Stewards from Experiences in a School Garden. *International Journal of Early Childhood Environmental Education*, 4(1), 54–69.

Fleer, M. (2013). Affective Imagination in Science Education: Determining the Emotional Nature of Scientific and Technological Learning of Young Children. *Research in Science Education*, 43(5), 2085–2106. <https://doi.org/10.1007/s11165-012-9344-8>

Gleason, T. R., Theran, S. A., & Newberg, E. M. (2017). Parasocial Interactions and Relationships in Early Adolescence. *Frontiers in Psychology*, 8. <https://doi.org/10.3389/fpsyg.2017.00255>

Griffiths, J. (2013). *Kith: The riddle of the childscape*. London: Penguin.

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting Education in “Educational” Apps: Lessons From the Science of Learning. *Psychological Science in the Public Interest*, 16(1), 3–34. <https://doi.org/10.1177/1529100615569721>

How to Help Families Feel Comfortable in the Outdoors. Educators. PLUM LANDING. (n.d). Retrieved January 06, 2018, from <http://pbskids.org/plumlanding/educators/educatortips/#player>

How to Use Digital Tools to Enhance Outdoor Explorations. Educators . PLUM LANDING. (n.d). Retrieved January 06, 2018, from <http://pbskids.org/plumlanding/educators/educatortips/#player>

Huynh, M. Q., & Ghimire, P. (2017). Browser App Approach: Can It Be an Answer to the Challenges in Cross-Platform App Development? *Journal of Information Technology Education : Innovations in Practice*, 16, 047–068.

ENVIRONMENTAL EDUCATION THROUGH MEDIA

Jennings, N., & Alper, M. (2016). Young Children's Positive and Negative Parasocial Relationships with Media Characters. *Communication Research Reports*, 33(2), 96–102.

<https://doi.org/10.1080/08824096.2016.1154833>

Judge, S., Floyd, K., & Jeffs, T. (2015). Using mobile media devices and apps to promote young children's learning. In *Young Children and Families in the Information Age* (pp. 117- 131). Springer Netherlands.

Kellert, S. (2015). Build nature into education. *Nature*, 523(7560), 288-289.

Kermish-Allen, R., Karlan, James, Kayira, Jean, Mueller, Michael, & Sobel, David. (2016).

Designing for Online Collaborations and Local Environmental Action In Citizen Science: A Multiple Case Study, ProQuest Dissertations and Theses.

Kim, Y., & Smith, D. (2017). Pedagogical and technological augmentation of mobile learning for young children interactive learning environments. *Interactive Learning Environments*, 25(1), 4–16. <https://doi.org/10.1080/10494820.2015.1087411>

Land, S. M., & Zimmerman, H. T. (2015). Socio-technical dimensions of an outdoor mobile learning environment: a three-phase design-based research investigation. *Educational Technology Research and Development*, 63(2), 229–255. <https://doi.org/10.1007/s11423-015-9369-6>

Malone, K. (2007). The bubble-wrap generation: children growing up in walled gardens.

Environmental Education Research, 13(4), 513–527.

<https://doi.org/10.1080/13504620701581612>

Massachusetts. Department of Elementary and Secondary Education. (2016). *2016 Massachusetts Science and Technology/engineering Curriculum Framework*. Massachusetts Department of Elementary and Secondary Education.

Mayer, R. E. (2014). Cognitive theory of multimedia learning. *The Cambridge handbook of*

ENVIRONMENTAL EDUCATION THROUGH MEDIA

multimedia learning, 43-71.

- Mayer, R. E. (2011). Chapter Three - Applying the Science of Learning to Multimedia Instruction. In J. P. Mestre & B. H. Ross (Eds.), *Psychology of Learning and Motivation* (Vol. 55, pp. 77–108). Academic Press. Retrieved from <http://www.sciencedirect.com/science/article/pii/B978012387691100003X>
- Melhuus, E. C. (2012). Outdoor day-care centres – a culturalization of nature: how do children relate to nature as educational practice? *European Early Childhood Education Research Journal*, 20(3), 455–467. <https://doi.org/10.1080/1350293X.2012.704766>
- Moore, S. A., Apicella, M., Marston, S. A., & Thompson, M. (2012). Designing Nature for Learning: School Gardens for Youth and Child Education. *Children, Youth and Environments*, 22(1), 250–259. <https://doi.org/10.7721/chilyoutenvi.22.1.0250>
- Moss, S. (2012). Natural Childhood. *National Trust*.
- Mostowfi, S., Mamaghani, N. K., & Khorramar, M. (2016). Designing Playful Learning by Using Educational Board Game for Children in the Age Range of 7-12: (A Case Study: Recycling and Waste Separation Education Board Game). *International Journal of Environmental and Science Education*, 11(12), 5453–5476.
- Noorhidawati, A., Ghalebandi, S. G., & Siti Hajar, R. (2015). How do young children engage with mobile apps? Cognitive, psychomotor, and affective perspective. *Computers & Education*, 87(Supplement C), 385–395. <https://doi.org/10.1016/j.compedu.2015.07.005>
- Ogelman, H. G. (2012). Teaching Preschool Children About Nature: A Project to Provide Soil Education for Children in Turkey. *Early Childhood Education Journal*, 40(3), 177–185. <https://doi.org/10.1007/s10643-012-0510-4>

ENVIRONMENTAL EDUCATION THROUGH MEDIA

- Otto, S., & Pensini, P. (2017). Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behaviour. *Global Environmental Change*, 47(Supplement C), 88–94.
<https://doi.org/10.1016/j.gloenvcha.2017.09.009>
- Peffer, T. E., Bodzin, A. M., & Smith, J. D. (2013). The Use of Technology by Nonformal Environmental Educators. *Journal of Environmental Education*, 44(1), 16–37.
<https://doi.org/10.1080/00958964.2012.688775>
- Piaget, J. (1971). *Biology and knowledge; an essay on the relations between organic regulations and cognitive processes*. Chicago: University of Chicago Press.
- Pierce, G. L., & Cleary, P. F. (2016). The K-12 educational technology value chain: Apps for kids, tools for teachers and levers for reform. *Education and Information Technologies*, 21(4), 863–880. <https://doi.org/10.1007/s10639-014-9357-1>
- Radesky, J., Schumacher, J., & Zuckerman, B. (2015). Mobile and interactive media use by young children: The good, the bad, and the unknown. *Pediatrics*, 135(1), 1-3.
- Richert, R. A., Robb, M. B., & Smith, E. I. (2011). Media as Social Partners: The Social Nature of Young Children’s Learning From Screen Media. *Child Development*, 82(1), 82–95.
<https://doi.org/10.1111/j.1467-8624.2010.01542.x>
- Rideout, V. (2017). *The Common Sense census: Media use by kids age zero to eight*. San Francisco, CA: Common Sense Media.
- Shirani, F., Henwood, K., & Coltart, C. (2012). Meeting the Challenges of Intensive Parenting Culture: Gender, Risk Management and the Moral Parent. *Sociology*, 46(1), 25–40.
<https://doi.org/10.1177/0038038511416169>

ENVIRONMENTAL EDUCATION THROUGH MEDIA

- Simmons, D. A. (1994). Urban Children's Preferences for Nature: Lessons for Environmental Education. *Children's Environments*, 11(3), 194–203.
- Smith, F., & Barker, J. (2001). Commodifying the countryside: the impact of out-of-school care on rural landscapes of children's play. *Area*, 33(2), 169–176. <https://doi.org/10.1111/1475-4762.00020>
- Sobel, D. (2014). Learning to Walk between the Raindrops: The Value of Nature Preschools and Forest Kindergartens. *Children, Youth and Environments*, 24(2), 228–238. <https://doi.org/10.7721/chilyoutenvi.24.2.0228>
- Sobel, D. M., & Letourneau, S. M. (2015). Children's developing understanding of what and how they learn. *Journal of Experimental Child Psychology*, 132, 221–229. <https://doi.org/10.1016/j.jecp.2015.01.004>
- Staempfli, M. B. (2009). Reintroducing Adventure Into Children's Outdoor Play Environments. *Environment and Behavior*, 41(2), 268–280. <https://doi.org/10.1177/0013916508315000>
- Treagust, D. F., Amarant, A., Chandrasegaran, A. L., & Won, M. (2016). A Case for Enhancing Environmental Education Programs in Schools: Reflecting on Primary School Students' Knowledge and Attitudes. *International Journal of Environmental and Science Education*, 11(12), 5591–5612.
- Tugurian, L. P., & Carrier, S. J. (2017). Children's environmental identity and the elementary science classroom. *The Journal of Environmental Education*, 48(3), 143–153. <https://doi.org/10.1080/00958964.2016.1191415>
- Vaala, S., Ly, A., & Levine, M.H. (2015) *Getting a read on the app stores: A market scan and analysis of children's literacy apps*. New York, NY: The Joan Ganz Cooney Center at Sesame Workshop.

ENVIRONMENTAL EDUCATION THROUGH MEDIA

- Valentine, G., & McKendrick, J. (1997). Children's outdoor play: Exploring parental concerns about children's safety and the changing nature of childhood. *Geoforum*, 28(2), 219-235.
- Vygotsky, L. S., & Wollock, J. (1997). *The Collected Works of LS Vygotsky: Problems of the theory and history of psychology* (Vol. 3). Springer Science & Business Media.
- Vygotsky, L. (1978). Interaction between learning and development. *Readings on the development of children*, 23(3), 34-41.
- Waite, S. (2017). Learning with nature: a how-to guide to inspiring children through outdoor games and activities. *Education 3-13*, 45(4), 516–517. <https://doi.org/10.1080/03004279.2016.1201521>
- Wartella, E. (2015). Educational Apps: What We Do and Do Not Know. *Psychological Science in the Public Interest*, 16(1), 1–2. <https://doi.org/10.1177/1529100615578662>
- Westlund, J. K., & Breazeal, C. (2015, March). The interplay of robot language level with children's language learning during storytelling. In *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts* (pp. 65-66). ACM.
- White, E. J. (2015). Seeing is Believing? Insights from Young Children in Nature. *International Journal of Early Childhood*, 47(1), 171–188. <https://doi.org/10.1007/s13158-014-0118-5>
- Wihardjo, S. D., Hartati, S., Nurani, Y., & Sujarwanta, A. (2017). The Effects of Green Schooling Knowledge Level and Intensity of Parental Guidance on the Environmental Awareness of the Early Age Student. *Educational Research and Reviews*, 12(5), 251–257.
- Zipke, M. (2017). Preschoolers explore interactive storybook apps: The effect on word recognition and story comprehension. *Education and Information Technologies*, 22(4), 1695–1712. <https://doi.org/10.1007/s10639-016-9513-x>

Appendices

Appendix A.

Participants:

Kris Scopinich, Director of Education Mass Audubon
Brian Gravel, Director of Elementary Education, Tufts University
Mollie Elkin, Digital Production Coordinator, WGBH
Paula Phipps, Associate Director, Biodiversity for a Livable Climate
Harriet Shugarman, Founder & Executive Director, ClimateMama
Rebecca Fasciano, Science and Applied Technology Teacher, Hanscom Middle School
Heather DiGiovanni, Preschool Director, Mass Audubon – Habitat
Chelsea Gutierrez, Camp Director, Boston Nature Center Summer Camp – Mass Audubon
Molly Zegans, Teacher/Naturalist, Boston Nature Center Summer Camp – Mass Audubon
Chris Rogers, Professor & Chair, Department of Mechanical Engineering, Tufts University
Claire Harris, Lead Preschool Teacher, Mass Audubon
Kim Baker, Camp Director, Boston Nature Summer Camp – Mass Audubon

Appendix B.

Questions:

Questions for Environmental Educators

- 1) What aspects of natural curriculum do you focus on in your classroom? Why did you choose these specific topics?
- 2) Are there any other topics you have tried to introduce that have not been successful? Why?
- 3) How do you introduce each topic?
- 4) How do you go about teaching each topic? What type of homework/ activities do you assign?
- 5) What activities have you found the most successful? Least successful? What do you think is the reason for this?
- 6) Do you assign activities for children to do on their own or at home? Or, do you focus on activities purely for a school setting? Have you found a difference in their level of interest with school activities vs. home activities?
- 7) Do parents seem responsive to these lessons or to the materials you send home with their children?
- 8) Are there any other aspects of these nature lessons that your students seem to respond well to?
- 9) How do you engage children of different learning styles and different developmental levels?
- 10) Are there any topics that you think are particularly important to introduce to children?

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Questions for App Developers

- 1) Can you tell me a bit more about the app development process? What type of research do you conduct and how do you go about it?
- 2) What are some best and worst practices for developing apps? Are there any aspects that you feel are typically overlooked?
- 3) Is it difficult to get parents and/ or children on board with new technologies?
- 4) What are some best and worst practices for using technology with children?
- 5) How do you introduce each topic to children?
- 6) Have there been any particular programs that children have responded well to?
- 7) What is important to keep in mind when using technology with children?