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Changing the Channel on Climate Change

How Televisual Media Can be Used to Teach Children About Climate Change

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Abstract

Climate change is the foremost threat to humankind, with a failure to curb emissions leading to disasters like flooding, mass extinctions, and global food shortages. Yet public understanding of climate change is poor, especially among children. So from where does our understanding of climate change come? At over 10-hours of media content consumed by children each day—the majority from televisual media—it is clear much of our information comes from media. Is it possible, then, to use televisual media to teach children about climate change? To answer this question, I conducted research on topics such as the public perception and understanding of climate change, the state of science education, prosocial media, educational media, child behavioral and cognitive development, the shift from broadcast to digital televisual media, and models of environmental children's television. Additionally, I conducted semi-structured interviews with four science educators to better understand which science topics are taught in the classroom, how they are best taught, and the role of media in classroom education. And finally, I evaluated the environmental children's television show *Plum Landing* to assess which environmental topics are deemed developmentally appropriate, the integration of televisual media onto digital platforms, and the need for accompanying hands-on and interactive learning materials. My research suggests that for children to best learn about climate change through televisual media, the program should inspire children to explore in nature, promote positive environmental behaviors, contextualize the issue in ways that are relatable to children, and must include additional hands-on activities that reinforce the concepts.

Problem Statement

Children today are using and consuming more media than ever before. Researchers have documented that, on average, children spend over seven hours a day using media (Strasburger et al., 2010). When combining the simultaneous use of smart phones, computer, TV, and other electronic devices, nearly 11 hours of media content is crammed into those seven hours (Lewin, 2010; Rideout, 2013). As expected, some of the effects can be negative. Research over the past half-century has shown that the influence of media on children is a significant factor leading "to aggressive behavior, risky sexual behavior, substance use, and eating disorders" ("Media and Violence," 2013; Strasburger et al., 2010). Children's media habits are correlated with a 31% increase in risk of being overweight, and by virtue of spending "almost every waking minute" using some form of media (Lewin, 2010), they spend less time reading, sleeping, and doing hobbies (Strasburger et al., 2010).

Yet, media also holds enormous positive potential. Numerous studies document that through modeling prosocial behaviors, media increases empathy and acceptance of diversity in its viewers (Hogan & Strasburger, 2013; Greitemeyer, 2011). Moreover, in recent years, the educational media sector, particularly apps and digital textbooks, has flourished. Pearson, the world's largest educational and learning company, has invested $9.3 billion in "digital innovations" over the last 10 years (Barnes & Chozik, 2012). As of September 2014, educational apps are the second largest genre in Apple's App Store, comprising over 10% of all apps ("Most Popular," 2014). Between the iTunes store and Amazon.com, there are approximately 10,000 "educational apps" and games for children on digital platforms (Dobrow, 2015).

However, the largest media market, and consequently the medium with the largest educational potential, is television. In 2013, the television industry raked in $74 billion, with digital video accounting for an additional $3.5 billion, and draws in 283 million American viewers (Thielman, 2014). But there is clearly a shift in how television is being watched. Older children and teenagers increasingly diversify their screen watching by devoting several hours to computers, smart phones, and tablets, where they watch "old" content on these newer, digital platforms, and often consume different media at the same time (Rideout, Foehr, & Roberts, 2010; Dobrow, 2014). Regardless of how it is watched, networks like PBS have long provided educational programming with shows like *Sesame Street* and *Arthur*, and these shows offer children early exposure to topics like reading, math, and more recently, science (Sesame Workshop, 2014). With 75% of public television funding coming from federal sources, coupled with President Obama's "Innovate to Educate Campaign," which promotes science, technology, engineering, and mathematics (STEM) education, the vast majority of funded programming in the past four years has emphasized these topics (Lee, 2012; "PBS KIDS, 2011").

Science is featured prominently in the recent push for STEM education in educational media, but one topic desperately needs more coverage: the environment, particularly climate change. Climate change is, without a doubt, one of the biggest threats to all of humankind. In July of 2014, the United Nations issued its gravest climate change report, spelling out the severe and extensive consequences if governments do not commit to immediate and wide reaching efforts to reduce carbon and methane emissions:

> *Failure to reduce emissions, the group of scientists and other experts found, could threaten society with food shortages, refugee crises, the flooding of major cities and*

> *entire island nations, mass extinction of plants and animals, and a climate so drastically altered it might become dangerous for people to work or play outside during the hottest times of the year* (Gillis, 2014).

Despite the warning, recent studies indicate only "63-percent of Americans believe climate change is happening" (Leiserowitz et al., 2010). Most Americans do not rank global climate change among their highest concerns, and believe it affects "geographically and temporally distant people and places or nonhuman nature" (Leiserowitz, 2005). Even worse, according to a study conducted by Yale University, only 50-percent of Americans understand that human activity is the primary cause of climate change (Leiserowitz et al., 2010).

Children are also uninformed about the environment and climate change. One Canadian study found that only about one-third of 8 and 9 year-old children interviewed had heard of climate change, with no indication that they knew what it meant or how it worked (Pruneau et al., 2001). The importance of finding avenues to deliver environmental knowledge to children cannot be overstated. It is well documented that our attitudes toward the environment begin to develop in childhood (Kopnina, 2011; Lyons & Breakwell, 1994). The more positive exposure and knowledge people get as children, the more likely they will value the environment as an adult (Corbett, 2006). With today's children bound to be affected by environmental problems from our current actions, and saddled with the task of providing solutions, believing in the inherent value of the environment is vital (Lyons & Breakwell, 1994). But still, the question that remains is how to best educate children about the environment in engaging, entertaining, and scientifically accurate ways.

Traditionally, the first place to look for ideal pedagogical practices is the classroom. However, when it comes to the environment, and science as a whole, very little is taught to

children. According to various sources, “only 6-13% of total instructional time is spent on teaching science to grades 1-4” (“The Words on the Street.” 2012). Instead, the bulk of science curriculum target middle and high school aged students even though learning about science is developmentally appropriate at a much younger age (“The Words on the Street,” 2012). The absence of science at a young age has dangerous implications for environmental attitudes. “How much young people know about science and how willing they are to accept changes made by scientific developments play a significant role in engendering environmental attitudes” (Lyons & Breakwell, 1994). Through starting science education earlier, which includes learning about the environment, and giving children more science knowledge, they will be more likely to develop a lasting interest in learning about science, in turn adding to their knowledge and curiosity about the environment (“The Words on the Street,” 2012; Lyons & Breakwell, 1994).

Given the immense amount of time children spend with media, developing ways it can be used to teach them about the environment seems like a logical approach. Several studies have already shown that mass media are a primary source of environmental information for young people (Lyons & Breakwell, 1994; Zhao, 2009; Serf, 2010). Additionally, children who are already curious or concerned about the environment consistently cite science programming on TV as a significant influencer in leading them to be more informed (Lyons & Breakwell, 1994). Many forms of media can provide developmentally appropriate environmental information and in engaging formats, but with televisual media dominating the media market, it arguably holds the greatest potential for delivering information that is both exciting and not taught in conventional learning settings.

However, conventional wisdom tells us that to learn about anything regarding the environment, one must have direct contact with nature. As it stands, children have few opportunities to "play, explore, and observe in nature" ("The Words on the Street," 2012). Some researchers believe that to get children interested and concerned about the environment, the first step is to build an emotional connection and to "love and feel the natural world" (Chawla, 1988). To get children engaged in the health of the environment, outdoor time may simply be the ideal method to establish that relationship. But when children are spending decreasing little time outside, how effective can televisual media be in teaching them about the environment? Does a television show provide enough information and entertainment to get children curious and concerned about the environment, or must televisual media act as the catalyst for getting them in nature? Can televisual media promote positive behavioral changes in children that help the environment? What do those behaviors look like?

With climate change at stakes, finding ways to teach children about the environment is critical. My thesis will investigate these questions through various lenses, such as children's current views on the environment, the quality of science education in the classroom, the learning power of media, as well as interviews with educators, and case studies of current environmental children's television shows.

Literature Review

How much do children know about the environment?

In order for any type of educational televisual media to be an effective learning tool, the content must be developmentally appropriate. Therefore, it is important to determine

what knowledge children already possess about the environment and their familiarity with climate change.

Scant research has been conducted exploring children's knowledge of climate change (Lovell & O'Brien, 2009), but in what is published, the outlook is bleak. One study surveyed 24 third grade children from urban Montreal, Canada and nearby suburban Moncton to compare their perception and knowledge of climate change. Though a small sample size, the results were telling: Just 37.5-percent of Montreal children and 25-percent of Moncton children had heard of climate change, with no suggestion of knowing what it meant or how it worked (Pruneau et al., 2001). Despite their greater awareness, only about 10-percent of Montreal children could name tangible signs of climate change in their own environment, and half gave inconsequential responses like sports played in different seasons (Pruneau et al., 2010). Moncton children were slightly more knowledgeable; roughly 13-percent could name a clear sign of climate change, with responses splitting between 'more frequent freezing and thawing' and 'higher temperatures' (Pruneau et al., 2001). The study suggested that the type of developed environment of the child's hometown could possibly explain the differences in knowledge. For example, more Montreal children may have heard of climate change because of its cosmopolitanism and greater access to global topics (Pruneau et al., 2001). Similarly, it is possible that Moncton children were more adept at identifying signs of climate change because of the town's proximity to nature, the slower pace of life, or both (Pruneau et al., 2001). Still, about 90-percent of both groups of children said they do not think about climate change and none could estimate when climate change would be a serious problem (Pruneau et al., 2001).

The same study, which also surveyed teenagers and adults, identified a few key issues that blocked the adoption of pro-environmental behaviors. The definition of pro-environmental behaviors is ambiguous, but what is generally meant is "behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world (e.g. minimize resource and energy consumption, use of non-toxic substances, reduce waste production) (Kollmuss & Agyeman, 2002). The most significant were the idea that humans cannot change the climate, the effects of climate change will not impact one's own life, and a "lack of knowledge and understanding of the phenomenon" (Pruneau et al., 2001).

One of the most fundamental solutions to these issues, which all center on personal detachment, is to increase the amount of time children spend in nature. Countless studies indicate that the amount of direct contact and interaction children have with nature contributes significantly to how they value the environment, their environmental knowledge, and subsequently, their concern (Corbett, 2006; Lyons & Breakwell, 1994; Louv, 2008). However, children today do not have frequent experiences in nature ("The Words on the Street," 2012). In one survey asking 830 mothers from geographically representative cities, suburbs, small towns, and rural areas nationwide about their children's play habits, only 26-percent said their children played outside everyday, compared with the 71-percent they reported for themselves as children (Clements, 2004; Louv, 2008). While children's media consumption plays a role in the decline, the issue is broader. In recent years "countless communities have virtually outlawed unstructured outdoor nature play, often because of the threat of lawsuits…"(Louv, 2008). Instead, communities promote organized outdoor activities, such as youth soccer leagues, clearing

stretches of forest in the process (Louv, 2008). One explanation for reduced outdoor playtime could be a growing urban population, but in the study of 830 mothers, "the responses did not vary a great deal between…rural and urban areas" (Clement, 2004).

An encapsulation of the trend is evident in a study conducted at the University of Maryland. Researchers found that from 1997-2003, 50-percent fewer children ages 9-12 spent time outside "hiking, walking, fishing, [playing at the beach], and gardening" (Louv, 2008). And the trend is consistent for children from different demographics. Despite the greater percentage of open space in rural areas, the land is, by and large, allocated for agricultural practices, offering rural children no more unstructured outdoor opportunities than urban children (Louv, 2008).

The decline in children in nature has dangerous implications for future environmental efforts. A 2004 U.S. study of randomly selected adults found that nature activities as children predicted "pro-environmental attitudes and behaviors like recycling, "green" voting, and participation in programs like Earth Day (Chawla, 2006). High school students in Wisconsin also attributed their involvement in environmental clubs to experiences in nature around their home and school (Chawla, 2006).

And the ramifications can persist for generations. "With greater detachment from nature, there is less curiosity about the natural world, and fewer people with bodies of knowledge to define and describe the changes that occur" (Louv, 2008). The number of children who decide to become scientists has decreased, and with that, so has the ability to identify what species are invasive and what populations are changing (Louv, 2008). The types of knowledge that are required to identify threats to ecosystems and habitats are no longer being emphasized or taught (Louv, 2008).

When children lack the firsthand experiences in nature, other sources of information cloud their perception. Children's stories about witches and beasts living in the woods, for example, might scare them from enjoying an outdoor experience (Chawla, 1988). In a study that brought children to rural Vermont, "only when [the children] overcame anxiety could they allow themselves to appreciate nature" (Chawla, 1988). However, the lack of direct interaction with nature does more than make children anxious—it has fundamentally shifted the way we view the environment. "In the space of a century, the American experience of nature—culturally influential around the world—has gone from direct utilitarianism to romantic attachment to electronic attachment" (Louv, 2008). The electronic attachment means that instead of our experiences showing us that nature is beautiful, our connection is based on what we hear and read. Several researchers say this tends towards examples of ecological deterioration, and can have negative impacts.

> *If we fill our classrooms with examples of environmental abuse, we may be engendering a subtle form of dissociation. In our zest for making them aware and responsible for the world's problems, we cut our children off from their roots. Lacking direct experience with nature, children begin to associate it with fear and apocalypse, not joy and wonder* (Louv, 2008).

With children having less direct contact with nature, the question that arises is: From where does their knowledge about the environment, insufficient though it may be, come? Ignoring media for the moment, the classroom and parents rank as the top two sources. National surveys indicate that science instruction time is abysmal, but analyzing state science standards can offer a more detailed, insightful perspective into the strengths and shortcomings of environmental education.

In the conclusion of the Canadian study investigating children's knowledge of climate change, the researchers prescribed more "judicious educational approaches" to teach all sectors of the population about climate change (Pruneau et al., 2001). Some states in the U.S. are starting to address this vague recommendation through inclusion of environmental issues in state mandated science curricula. For example, the newest Massachusetts Science and Technology/Engineering Standards for Pre-Kindergarten to Grade 8, which are based on the Next Generation Science Standards, show promising signs of early environmental education. Beginning with preschoolers, the curriculum focuses largely on having the children observe their own environment, such as the plants and animals, moon and sun, and the weather ("Massachusetts Science," 2013). They learn to connect their senses and bodies to those of animals, exploring how different creatures use their own specialized body parts to survive (2013). Emphasizing personal connection, the state standards begin on an encouraging note.

The theme continues in Kindergarten. Children learn that all plants and animals, including themselves, require the same ingredients to sustain life: food and water ("Massachusetts Science," 2013). Teachers provide examples of how plants and animals interact, and how through these interactions, they can effect change in their environment (2013). The curriculum does not explicitly mention focusing on any negative environmental changes, but the metaphor of the human impact on the climate is undeniable. An outright discussion on human caused environmental degradation toes the line of developmental appropriateness, but the fact that the analogy can be drawn is, again, encouraging.

Unfortunately, as children grow older, the curriculum shifts away from learning about the environment for its own sake. The focus is on quantitative skills and their application to engineering problems ("Massachusetts Science," 2013). In third grade, there is some discussion on changes in the environment, and how they impact what can and cannot survive, as well as consideration of human influence of weather-related events (2013). But the conclusion is to solve any related problems—that is, human problems—with engineering. Through engineering and technology, the curriculum teaches that humans can enhance their interactions with their surroundings (2013). It is unclear to what extent the discussion about engineering considers the effects on plants and animals; these types of lessons may be left to the discretion of the teacher.

Graduating into fourth and fifth grade, science topics shift away from life science to more earth science and systems-based learning. Fourth graders are directed to spend the bulk of class time learning about geology, including topics of where fuels come from, what is renewable, and what is not ("Massachusetts Science," 2013). Yet, somehow there is no indication that the lessons address the human component to these fields: how our extraction and combustion of these fuels impact the environment. Fifth grade science adopts a more systems-based approach, exploring how ecosystems connect plants and animals (2013). Within this, children learn how agricultural and industrial processes affect ecosystems, and why using fewer resources is beneficial (2013). And again, there is no explicit mention to how humans influence these practices. The state standards dance around the human relevance to the topics, either by not addressing the root of the problem, or by removing humans from being affected by the consequences.

The ensuing dilemma, then, is what constitutes good environmental education. Incorporating nature topics into early education moves in a positive direction, but does avoiding the human relationship give children a skewed perception of how the environment works? There are certainly arguments over what is considered developmentally appropriate in elementary school, and discussing how humans can negatively affect the environment may make children feel responsible for its degradation in a damaging way. How the curriculum lays the foundation of the environment's interconnectivity is valuable itself, and in the eyes of the standards' architects, enough for children.

However, whether the curriculum inspires children to spend time outside is murky. It seems that the curriculum in pre-K and Kindergarten do more to inspire a sense of wonderment in the world around us, and encourages observation and curiosity. Researchers agree, "Preschool age is a developmentally pivotal time to provide children with a strong educational foundation that helps to foster a natural curiosity about the world around them and to establish the foundations for future scientific exploration ("The Words on the Street," 2012). Fostering a sense of curiosity about nature aligns neatly with the literature's emphasis that time spent in nature as a child builds and strengthens a lifelong connection to the environment. Yet, as children move through school, the emphasis on quantitative analysis overtakes observation of the environment. Science education focuses more heavily on engineering and how humans can design their way out of environmental problems, without addressing the human causes of some of these problems.

Based on research and the Massachusetts state science standards, it seems that for televisual media to be effective, its content must inspire children to explore nature to

combat their detachment from and diminished concern for the environment. The amount of time we spend in nature as children is a leading reason globally for why we care about the environment as an adult (Chawla, 2006). In a study comparing motives for environmental activism in Norwegians and Kentuckians, one of the biggest factors was "positive experiences in natural areas in childhood," with less than half citing education and witnessing environmental destruction firsthand as their main reason for activism (Chawla, 2006). To use televisual media to help accomplish this seems counterintuitive; by definition media are not consumed in nature and do not share the same spaces as nature. However, educational television shows, like *Sesame Street*, are empirically proven to teach children new concepts. Without explaining how televisual media can teach and engage children, which will be investigated in the next section, an approach that models a child who is engaged and exploring in nature could provide a solid foundation. Accurate information about the environment and introducing the idea of climate change could then be woven into the story.

Learning Theories and Applications in Media

Any discussion about how media can be used to teach children about the environment requires an understanding of how they learn and their cognitive development. And moreover, the end goal of having children learn about the environment is to eventually have a child adopt positive environmental behaviors. Therefore, investigating theories of behavioral development and how media influence behaviors are equally important.

To begin, children can learn in four basic ways: from direct experience, observational learning, symbolic learning, and cognitive learning (Scheibe, 2007). In direct

experience, the child actually performs the behavior. Then, through operant conditioning, the child is either rewarded for positive behavior and the learning is reinforced, or punished for negative behavior and discouraged from repeating that behavior (2007). The effectiveness of the reward or punishment varies by age and the person doing the conditioning; children tend to be more responsive to family members, but teens respond better to their peers (2007). Learning from a direct experience has obvious limitations with televisual media since it cannot directly reward the viewer (2007). However, a parent or peer can encourage or punish something a child does or says after learning it from the medium (2007).

For teaching about the environment, a direct learning experience like exploring in nature is obviously ideal. But a television show can only encourage a child to get outside—a positive environmental behavior—which leads to a direct experience. It ultimately depends on the child to follow the media's encouragement that makes it successful, and to feel rewarded by their experience. Additionally, whether these actions are promoted depends on the knowledge of the child's peers who deem it positive or negative.

Symbolic learning, which is learning through written or spoken language, is also at odds with televisual media. Generally, older children and adults acquire information symbolically when they are told to do or not do something (Scheibe, 2007). Whether they actually do it is based on the credibility of the source (2007). Children can learn symbolically from parents, siblings, and peers, but the quality of learning varies based on how much the source knows. Given the prevalence of misinformation, relying on a parent to learn about the environment symbolically is inadequate.

Televisual media can teach symbolically, but it more directly lends itself to facilitating observational learning. Observational learning is when a child watches someone else do a particular behavior and then imitates it (or decides not to based on observing the consequences) (Scheibe, 2007). In a real-life context, children learn better through observation when they identify with the person they are observing, traditionally the same-sex parents and older siblings (2007). In televisual media, children connect better with someone of the same race, and it is an especially effective model when the medium is recognized as a reliable source of information (2007). However, how much a child takes what they have observed from media and incorporates it into their behaviors varies greatly by age. Developmental differences influence how they interpret media messages and also their general understanding of media (2007).

To apply these principles to media's role in teaching about the environment, it is clear that who models a behavior and what age group the behavior is targeting carries a lot of weight. If the goal of an environmental children's show is to focus on inspiring an interest in the environment in urban Black and Latino children, featuring urban Black and Latino children who are curious about nature would be the most effective approach. Additionally, modeling behaviors that are appropriate for the desired age group is important. Based on Piaget's cognitive-developmental theory, a child's thinking is qualitatively different at different ages (Scheibe, 2007). As a child develops, they build cognitive schemes "by actively exploring, manipulating, and making sense of his or her environment" (Scheibe, 2007, Inhelder & Piaget, 1958). A child uses these schemes as the foundation for new information, whether it is "knowledge about the real world [or] inferences drawn about relationships and character motivations" (2007). Therefore, to use

televisual media to teach children about the environment, the audience needs prior exposure to the topic (or related topics), and the show needs age appropriate lessons and content. Without meeting these requirements, the children may lack the cognitive schemes needed to understand the information and adopt the behaviors. However, once a child has built enough schemes, they can rely on his or her own understanding and cognitive ability to further their learning (i.e. cognitive learning) (Scheibe, 2007).

Piaget's theories can also illuminate more specific ways children learn from media. In his four stages of development, one of the hallmarks of children in the preoperational stage (ages two to seven) is their tendency to believe that other people know or can see what they do (Inhelder & Piaget, 1958). Their subjective worldview indicates "that they can be easily confused by media storylines that emphasize different characters' understanding of something that happened" (Scheibe, 2007). As children move from the preoperational stage to concrete operational around age seven, they are able to think more objectively and consider multiple perspectives (Inhelder & Piaget, 1958). As a result, older children can follow main ideas and recall information about something they have been taught or experienced, which may make viewing televisual media a more enriching educational experience at that age (Scheibe, 2007). For environmental televisual media, it makes more sense then to target older children (ages seven and older) who are developmentally mature enough to understand the nuances of the content and identify with multiple perspectives.

Several theories offer alternative explanations for how and what we learn from televisual media. George Gerbner's Cultivation theory frames television as the central storyteller, depicting a coherent and patterned set of images, messages, behaviors and view of society that may or may not be accurate (Gerbner et al., 1986; Kaul, 2000). When viewed

frequently, the viewer is "likely to think in the ways that are reflected on television, regardless of their personal experiences, communities, or life situations" (Gerbner et al., 1986). When television is viewed frequently, as it is with children, the viewer "is likely to think in the way that are reflected on television, regardless of their personal experiences, communities, or life situations (Gerbner et al., 1986). Eventually, television helps shape how we view ourselves, "cultivating" a certain definition of a type of person, gender, sex, and race in society (1986).

If televisual media is as powerful as the Cultivation theory indicates, creating a show to teach children about the environment could have a major impact on their view of nature and understanding of phenomenon like climate change. The formulaic content on television offers opportunities to use the influential power of media to teach about the environment. By drawing upon the formal features of television—cuts, sound effects, music—and the archetypal story arc of an episode, such as how problems arise and are resolved, the ubiquity of television could begin cultivating environmental beliefs and behaviors in children. Using familiar character tropes—without further engendering damaging stereotypes of gender, sex, and race—can make the environmental topics more relatable. A single show that emphasizes learning about nature is not enough to counter the more prevalent incorrect messages that television presents, but in this way, an environmental show that provides children with accurate environmental information and demonstrates positive behaviors could begin to lead to more amiable and realistic views of nature.

At the same time that heavy television viewing cultivates a certain definition of ourselves based on the images we see, heavy viewing has direct implications for environmental knowledge and beliefs, as well. Building off of Gerbner's work, research

suggests that heavy viewers are less knowledgeable about the environment, and also that, due to the way science on television is "often associated with violence and strange alien futures," they are less trusting of "science and the science community" (Shanahan et al., 1997). The current patterned images and messages on television seem to have detrimental consequences for environmentalism, but it is unclear if better environmental and science programming is the most effective at reducing misconceptions and ignorance; the solution could simply be viewing less television. While less TV viewing sounds ideal since it could lead to more time in nature, television's prominence and staying power might only make it realistic to work towards changing the content to reflect positive environmental images, beliefs, and behaviors.

The Drench model and Constructivism offer two more theories for how children may learn from media. The Drench model asserts, "unusual character portrayals or certain prominent characters may influence viewers more than usual, mundane depictions" (Kaul, 2000). The Constructivist view states that children are more "responsive to information and images that help them make sense of their own world, lives, and experiences" (2000). Assuming the Drench model for teaching about the environment, an unusual main character may grab the attention of the children, but other research strongly suggests that personally identifying with the character creates a stronger attachment. The personal connection also ties into the Constructivist theory that children may be more responsive to media if it relates to their own lives. To learn about the environment, then, it is necessary that children have either previous firsthand experiences in nature to draw from or other exposure to nature topics.

In a similar vein as the Constructivist theory, Seymour Papert's theory of constructionism explains that learning—that is, "building knowledge structures"—is best accomplished when the learner is "consciously engaged in constructing a public entity, whether it's a sand castle on a beach or a theory of the universe" (Papert and Harel, 1991). In Papert's theory, the process of physically creating something to accomplish a task is more effective at building those knowledge structures because the learner is engaging more deeply and critically with a problem. Constructionism ties in directly with the notion of hands-on learning, and while it does not directly relate to televisual media consumption since a child cannot physically build knowledge from a technological device, it is important to include. Constructionism is regarded as an important theory of learning, and so finding ways to use televisual media to facilitate a physical engagement with new concepts may prove to be critical for learning about the environment and climate change.

For learning behaviors from media, the Social Learning theory offers the most direct explanation. Working off the basic assumption that viewing modeled behaviors results in imitation of those behaviors (Yates, 1999), Albert Bandura applied observational learning to symbolic stimuli like televisual media (1999). In the most famous experiment (but not without its flaws) conducted by Bandura, a child watched a video of a man acting aggressively toward a Bobo doll, who in turn imitated the modeled behavior when left in a room with the doll (1999). Another study by Bandura and Menlove had children who were afraid of dogs watch videos of other children interacting positively with dogs. After one month, the children got to interact with dogs, and showed an improvement in "approach behavior" (1999).

While Bandura's research indicates that children can learn both positive and negative behaviors from media, only a fraction of the literature focuses on the positive behaviors from prosocial media compared to the hundreds of studies exploring the negative influence of violent media content (Greitemeyer, 2011). It is difficult, then, to extrapolate how children can learn positive environmental behaviors from media without first investigating what a positive behavior looks like.

First off, a major reason for the discrepancy is that "a simple, strictly agreed upon definition of 'prosocial' does not yet exist" (Hogan & Strasburger, 2013). Whereas determining if televisual media contains violent content is fairly easy, the ambiguities of 'prosocial' means researchers cannot follow a standardized rubric. However, the basic mechanisms behind the way children learn from televisual media are the same for both types. The first, to reiterate the Social Learning theory, is that media model behaviors that a child may observe and adopt because they think are appropriate (Yates, 1999; Hogan & Strasburger, 2013). The second is that the emotional responses from watching televisual media are similar to responses to real life events (Hogan & Strasburger, 2013). The main obstacle, then, is to operationalize what is meant by 'prosocial.'

What is 'Prosocial' Media?

Most researchers adopt their own criteria and metrics to measure what a prosocial behavior represented in media looks like. Gentile and Crick (2006) outlined a scale that includes criteria like: saying supportive things to peers, cheering someone up when sad, and being helpful and kind (Hogan & Strasburger, 2013). Mares and Woodard (2001) "define prosocial content and effects [as] friendly interaction, aggression reduction, altruism, and stereotype reduction" (Hogan & Strasburger, 2013). Another collaborative

study developed the SELECT (Social and Emotional Learning in Educational Children's Television) rating instrument, which indicates whether an educational television episode features any of six social and emotional learning (SEL) skills (Christensen & Myford, 2014). The six skills are divided into three categories: social awareness and interpersonal interaction skills, which includes cooperating and helping between multiple characters to reach a shared goal, naming an emotion that someone else is feeling (i.e. "You look sad."), and non-violent conflict resolution; decision-making skills, in which a "character brainstorms, considers options, or assesses potential consequences;" and self-awareness and self-management skills, such as naming one's own emotions or asking the audience how they feel, and "managing one's own emotions" (Christensen & Myford, 2014).

Other studies aim to explain what a specific prosocial medium tries to accomplish. In a study investigating the role video games play in cultivating positive behaviors, a prosocial videogame was defined as having a goal that benefits another character, and that playing them is strongly associated with "helping behavior, cooperation and sharing, and empathy" (Greitemeyer, 2011). The creators of *Sesame Street*—perhaps the most famous prosocial television show—said their goals were to build "social competence, tolerance of diversity, and nonaggressive ways to resolve conflict" (Hogan & Strasburger, 2013). *Mister Rogers' Neighborhood* wanted to foster positive behaviors like "nurturance and sympathy, task persistence, empathy, and imaginativeness" through his show (2013). The success of those two shows clearly suggests that people believe televisual media can teach positive behaviors. And additionally, several one-shot studies have shown that watching a "prosocial clip of a movie or television show made a child more likely to help in similar real-life situations afterwards" (Hogan & Strasburger, 2013).

Pro-environmental behavior does not necessarily imply prosocial behavior. Pro-environmental behavior more directly refers to "behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world" (Kollmuss & Agyeman, 2002). For children, examples can include recycling and celebrating Earth Day (Chawla, 2006), as well as simply exploring outside, or changing daily routines and habits that may use excessive resources (i.e. electricity, water). However, if positive environmental behaviors are embedded into the modeling of prosocial behaviors, which children respond to, it is possible that they could adopt both types of behaviors. For example, to model helping behavior, where an individual offers to assist another individual with a task or problem, the task could be about picking up trash, planting a garden, or building a solar panel for a tree house. In modeling empathy—identifying, acknowledging, and/or understanding another individual's feelings and acting in a way that is sensitive, respectful, and/or encouraging—the children might help a friend understand why they are scared to explore the nearby forest, or learn why one child loves to draw pictures of birds. The range of possibility in incorporating positive environmental behaviors into positive social and emotional learning is only limited by one's creativity.

Learning these pro-environmental and prosocial behaviors from media can ultimately help with a child's overall positive development, as well. The Positive Youth Development theory asserts that all children have "the potential for successful, healthy development and…the capacity for positive development" (Lerner et al., 2005). All a child needs are "the five C's:" a sense of personal "competence, confidence, connection, character, and caring/compassion" (Lerner et al., 2005). When a person has all five, he or she will want to contribute back to society (2005). Given the "plasticity" of human development,

many psychological, ecological, and historical factors influence a development and behaviors, in addition to genetics (Lerner et al., 2005).

Media is not explicitly mentioned as a factor that can influence a child's development, but it is easy to apply the viewing of prosocial content to building the five C's. By viewing a character that behaves altruistically, shares, and shows empathy for others, it can serve as a model for children. Focusing on the environment establishes a setting that naturally contextualizes the ideas of competence, confidence, connection, character, and compassion. And with the emphasis on getting children outside in nature, they can directly apply the lessons and behaviors they observed in the media in their own lives.

A key issue will always be ensuring that the prosocial content is developmentally appropriate. Additionally, the window of time in which a child best responds to prosocial content is limited. According to research conducted by Mares and Woodard (2001), "prosocial programming leads to a greater effect on prosocial behavior in children ages three through seven years; the effect peaks at seven years, and declines thereafter from seven through twelve years of age" (Hogan & Strasburger, 2013). Given that seven years old also corresponds to a child's transition into the concrete operational stage (which, as mentioned, indicates that a child is more cognitively developed and can begin to think objectively and follow nuanced narratives), that age (and up) is ideal for making televisual media an effective way for children to learn about the environment.

Debates Over the Meanings of "Educational Media"

As ill defined as 'prosocial' is, the phrase 'educational media' is even more poorly understood. The passage of the Children's Television Act of 1990 ignited much debate over the definition in an effort to "encourage broadcasters to air more programming that would

serve the needs of children" (Fisch, 2014). The agreed upon definition was nonspecific and broad, stating that educational meant "content that will 'further the positive development of the child in any respect, including the child's cognitive/intellectual or emotional/social needs'" (as cited in Fisch, 2014). Researchers who analyze whether educational programming accomplishes its goal often develop their own, more precise definition. In a content analysis of children's television, Condry, Scheibe, Bahrts, and Potts (1993) stated that a program is educational if:

> *A significant portion of the program is devoted to teaching information that the children in the audience are not likely to already know (e.g. the alphabet, vocabulary, historical or scientific information, applied information for everyday life) or demonstrating skills or crafts* (as cited in Fisch, 2014).

Different programs have different approaches to integrating educational content and criteria for what to include. However, just because a show is educational does not make it good or enjoyable to watch. "Television producers and programmers wrestle with the problem of how to create a program with prosocial messages that is interesting and entertaining enough to keep children's attention" (Yates, 1999). As with any educational topic, a show that teaches about the environment must balance information with entertainment, avoiding sounding overly didactic.

PBS's *Sesame Street* is commonly regarded as one of the most successful educational children's television shows, managing to create curriculum-based programming that is efficacious but also entertaining. *Sesame Street* is built on eight core features that distinguish it from other children's programming: "a detailed curriculum, appeal, explicitness, relevant child-centered content, repetition and reinforcement of material,

modeling and identification, viewer participation, [and] parent involvement and engagement" ("The Words on the Street," 2012). The audio and visual components of televisual media "provide extra support for learning, [helping] *Sesame Street* teach their lessons" (2012). The learning goals include building "social competence, tolerance of diversity, and nonaggressive ways to resolve conflict," and other prosocial messages (Hogan & Strasburger, 2013).

By most metrics, *Sesame Street* has accomplished its goals. A 1974 study showed that viewers of the show were more cooperative than non-viewers, could label cooperation when they saw it, and understood that cooperation was the best way resolve a conflict when a problem arose (Hogan and Strasburger, 2013; Yates, 1999). Additionally, research has continually shown that *Sesame Street's* technique of "reinforcing concepts and understanding by using explicit and concrete examples with sufficient repetition" aligns with how children learn and is an effective approach (Scheibe, 2007). And by engaging children with entertaining and creative content, they are better able to absorb the information ("The Words on the Street," 2012). The positive effects of viewing an educational program like *Sesame Street* extend well beyond childhood. "Preschool children who view educational TV programs are often better prepared for school, and are often even better students when they attend high school" ("The Words on the Street," 2012).

Part of *Sesame Street's* success, as evidenced by their core feature 'parent involvement and engagement,' is that the show encourages co-viewing between an adult and the child (Reiser, Tessmer, and Phelps, 1984). Co-viewing gives adults the opportunity to comment or label prosocial and educational messages as they happen, which helps the child understand concepts the program presents (Hogan & Strasburger, 2013; Reiser,

Tessmer, and Phelps, 1984). The feature is supported by the concepts of scaffolding and Vygotsky's 'zone of proximal development,' where a child can learn more with the help of a more experienced child or adult (Scheibe, 2007). Research has helped demonstrate the effectiveness of co-viewing. In a study investigating whether children learn topics from *Sesame Street* better when an adult views with the child, the answer was conclusively 'yes' (Reiser, Tessmer, and Phelps, 1984). By commenting, asking questions, repeating ideas, and drawing the child's attention towards the concepts in the show, children in the experimental group (those with adults participating) showed improvement in their posttest performance (1984).

Applying *Sesame Street*'s inventive and highly successful strategy of blending education with entertainment is essential to teach children about the environment. Although *Sesame Street* plays toward a younger audience than what an environmental show would target, no child will ever choose to watch a television show about nature unless it engages him or her in a fun, creative way. Additionally, integrating similar core features as *Sesame Street*—a detailed curriculum, viewer participation, appeal, relevant child-centered content, and promoting co-viewing ("The Words on the Street," 2012)—which are supported by extensive research, can ensure that the environmental program accomplishes its goals.

Models of Environmental Children's Television

Captain Planet and the Planeteers

No conversation about environmental children's television would be complete without discussing *Captain Planet and the Planeteers*, arguably the first successful show to emphasize environmental themes (Muir, 1993). Premiering in September 1990, *Captain*

Planet told the story of Gaia, the spirit of the earth, who creates and bestows five magic rings of power upon five geographically and ethnically diverse teenagers, known as "the Planeteers" (1993). Each episode presents a new threat to the environment via some sort of "eco-villain", with Gaia mobilizing the children "to different areas of the planet to fight pollution, global warming, species extinction, the destruction of the rainforest, ozone depletion and many other pressing problems" (King, 1994**;** Muir, 1993). A thirty second "Planeteer Alert" with tips for viewers about how they can help the environment, as well as facts about habitats, ecosystems, and destructive practices embedded into the narratives, round out the educational component of the show (Muir, 1993; King, 1994).

Captain Planet thrived on formulaic episodes with good versus evil tropes and a hefty dose of exaggeration. Environmental crises would arise in the form of destructive industrial forces depicted as "demonized and nightmarish" villains (Muir, 1993). The Planeteers would respond to the threat, and the conflict would resolve with the villains enlightened and everyone reflecting on the seriousness of the environmental problem (1993). And *Captain Planet*'s simplistic narrative definitely succeeded. In 1993, it was the top-rated animated children's program in the United States, reaching seven million viewers in 80 countries (1993). Several celebrities voiced main characters, which added legitimacy and credibility to the messages (1993). TBS President Ted Turner lauded the series saying, "Captain Planet reminds us that everyone plays a vital role in solving our environmental problems and that together, we have the power to solve these problems" (1993).

However, the commercial success did not match the educational value in several ways. First, by virtue of creating engaging television, episodes often excluded certain perspectives and dramatized the conflict for visual appeal (Muir, 1993). One episode

showed sea levels rising above the Statue of Liberty, and another explained that burning trash burned a hole through the ozone layer, both of which are inaccurate and overly simplistic (1993). The boiled down, dichotomized environmental conflict with quick resolutions discouraged critical thinking and skewed viewers' sense of how long it takes to effect positive environmental change (1993).

In an interview, a producer of *Captain Planet* extolled the educational power of the show and its role in raising awareness about crucial environmental issues.

> *If we'd had a program like "Captain Planet" thirty years ago we wouldn't be in the mess we're in now…children are going to be, are the leaders of tomorrow. And, because the issues are very complex…they don't understand the issues. I mean you can't find one adult in a hundred thousand that can tell you what creates the ozone hole, or what causes global warming… [After watching Captain Planet] they'll (the children) know what the ozone hole is, they'll know what rainforest is, they'll know what acid rain is, they'll know what strip mining is, they'll know what driftnet fishing is…*(King, 1994).

Exposure to these topics in an entertaining context can no doubt leave a lasting impression on the young viewers, but as with any environmental show, the question arises about what children should do with this information (King, 1994). The producer believed the thirty-second "Planeteer Alerts," which offered solutions like carpooling, recycling, and turning off the lights as ways for children to help the environment, gave the audience tangible ways to contribute (1994).

However, simple, individualistic solutions do not address the larger, systemic reasons for these environmental threats, nor do they constitute a researched educational curriculum (King, 1994). Children are given a falsely empowering solution and

misinformation about the true nature of many environmental problems to make the content age appropriate. It is difficult to strike a balance between giving children something constructive to do and not anesthetizing the realities of environmental destruction. Unfortunately, *Captain Planet* did not really accomplish either. The show's entertainment value is significant, and is a vital component to any educational television. But the education is meaningless if the information is not true.

Additionally, the issues championed by *Captain Planet* completely contradicted the rest of TBS's programming. Ads persuading children to buy the newest consumable goods were sandwiched between episodes that emphasized resource conservation and condemned the excesses of industrialism (Muir, 1993; King, 1994). The series itself launched a line of *Captain Planet* themed products and apparel aimed at children (King, 1994). So at the same time *Captain Planet* "helped make environmental efforts 'cool' for children" (Muir, 1993), the desire to maximize revenue defeated the core tenants of the show in a way that should make any critical thinker question the show's credibility.

And of course, television as a medium for spreading environmental messages warrants criticism. The idea to use television to spread a message "is a logical choice, since it reaches so many people, and is such a central part of our culture, but it also manifestly defeats some of the messages of the pro-environment value system" (Muir, 1993). Many critics argue that first-hand experiences in nature are vital to caring about the environment, and that watching *Captain Planet* is a vicarious experience (1993). Television viewing isolates the viewer from the natural world, so "while children gain a better sense of environmental issues, they lose a sense of the environment" (1993). Though it would still be a vicarious learning experience, perhaps the flexibility of today's digital platforms, which

give a child more opportunity to interact with the content via touchscreens and supplementary activities, would make the viewing experience less isolating and can allow the entertainment of the show to lead to greater learning.

Still, as *Captain Planet* was, with its lack of educational value, it is hard to argue that no exposure to environmental topics is better than some exposure. The action packed episodes hold a child's attention so they are still engaged by the time the 'Planeteer Alert' plays. And for children who do not have easy access to natural spaces, the vicarious experience of watching the show may be necessary for them to build a relationship with the environment.

Sesame Street

Although *Sesame Street* is not an environmental children's television show, as the premier educational television show on television, the loveable Muppets have tackled a wide range of educational topics. With the growing discourse surrounding climate change and emphasis in schools to teach a STEM-heavy curriculum, *Sesame* saw the need to develop science and environmental content for their preschool audience. In a paper presented before the International Communication Association detailing their environmental curriculum, researchers explained, "Introducing young children to the natural world is the first step toward developing interest in science and a strong foundation for scientific inquiry" ("The Words on the Street," 2012).

With an audience as young as *Sesame's*, it is difficult to craft a curriculum that is age appropriate and educationally substantive. Inspired by Richard Louv's book *Last Child in the Woods: Saving our Children from Nature-Deficit Disorder, Sesame* developed a curriculum designed to "foster the development of a sense of awe, wonder, and curiosity

about nature that young children possess" ("The Words on the Street," 2012). Children naturally "engage in science thinking by experiencing the world around them, developing theories about what works and why, and testing them in different settings and situations, like the backyard or in the home" (2012). Building a curriculum around something a young child is already familiar with, essentially a form of scaffolding, gives him or her a sense of connection to the material. And with *Sesame Street*'s cast of furry friends, their tactic of using "fun, visual, tangible, and familiar ways" to get children exited and engaged in science culminated in *Sesame Street* devoting the entire 40th and 41st seasons to topics about science and nature (2012).

True to form, when developing the curriculum for Season 40, researchers at *Sesame* conducted an extensive study to evaluate children's nature knowledge. From a group of 379 preschoolers, half of the children were asked to watch seven pilot episodes focusing on seven key environmental concepts: bees and pollination, camping and the outdoors, different habitats, metamorphosis and transformations, gardens, amphibians, and nature ("The Words on the Street," 2012). The children watched each episode two or three times a week over four weeks, while the control group watched an equal number of health and nutrition episodes. When tested again, the test group's knowledge had improved on metamorphosis, pollination, hibernation, and habitats (2012). Interestingly, all of the topics children improved on directly relate to animals, but no connection is drawn in the paper itself.

To complement Season 40, Season 41 explored environmental education through science and scientific investigation. By taking an environmental perspective, *Sesame* saw opportunities to teach science in way that allows children to "interact with different

habitats, animals, and plants," making science engaging and tangible ("The Words on the Street," 2012). Following a similar approach as Season 40, the episodes focused on seven key terms that would engage children without being too complex. The terms were: scientific process, gravity, soil composition, wind, camouflage, arachnids, and experiments (2012).

However, since science vocabulary and concepts can be more abstract, researchers needed a new testing method to contextualize the topics for children. Based on the processes by which children acquire basic words, researchers determined that storytelling and "rich contexts" best engaged children in the "content and maximized retention of concepts" ("The Words on the Street," 2012). In addition to conducting a pretest with vocabulary objectives, researchers read a story to the children spotlighting Big Bird's friend Snuffy, who suffered a mysterious allergic reaction when near Big Bird (2012). Then throughout the episode, the select vocabulary was repeated within the framework of the story. Reinforced with visual and aural stimuli, pre-school aged children were eventually able to master and apply the concepts (2012).

Sesame Street's effectiveness at teaching preschool children scientific concepts—topics that seem too advanced for many elementary schoolers—offers a strong argument for teaching science earlier in education. Current pedagogical thought tends to support the idea that teaching science to young children is excessive and too demanding for preschoolers. In the presentation *Sesame Street* researchers gave before the International Communications Association, they acknowledged that terms like "science" and "scientific process" intimidate educators and parents from introducing these topics ("The Words on the Street," 2012). However, beyond intimidation, reasons for waiting to introduce science-

based topics fall short. Several studies suggest that children as young as two and three years old show the cognitive ability to process complex scientific concepts, exemplified by their innate curiosity and explorative play (2012). The truer argument should focus on teaching approach rather than the content itself. And not only has *Sesame Street* demonstrated that young children can learn science by simply "observing, questioning, investigating, collaborating, and reporting their findings (2012)," but proven that televisual media is an engaging, effective approach for fostering "a sense of connectedness, interest, and care for the community and environment (2012)."

Interviews

Sesame Street created and refined an engaging and successful way to facilitate learning for young children through televisual media. The seasons *Sesame* devoted to teaching about the environment suggest that science education is gaining traction, and their methodical testing indicates that media can be an effective tool. However, referenced earlier in the Next Generation Science Standards and Massachusetts Department of Education curriculum, the amount of instructional time devoted to teaching children about science is abysmal; a national survey concluded that only 6-13% of class time in grades 1-4 is spent on science ("The Words on the Street," 2012). From this, it is realistic to assume only a fraction is, in turn, spent on environmental education.

In a formal learning environment like school, the challenge in teaching science—or any subject—is two-fold. Teachers must cover a diverse range of content, but, of equal importance, teach the material in ways that engage the students. Traditionally, textbooks, lectures, and experiential assignments such as science labs are the main ways of teaching, and each approach varies in effectiveness depending on the material and the learner.

However, hands-on learning tends to be viewed as the gold standard for student engagement and quality of learning. This concept draws upon the Papert's theory of constructionism, which as previously explained, asserts that physically creating and constructing facilitates deeper learning and engagement with new concepts (Papert and Harel, 1991). When those knowledge structures begin to form, more learning scaffolds on top and the process repeats.

With the growing popularity and diversity of media, new avenues have opened to use media—from televisual to interactive—to teach science engagingly in science in a classroom setting. In a recent national web-based survey of 503 pre-K-12 teachers conducted by PBS Learning, 43% of teachers were using "online video, images, and articles" in the classroom, and "sixty-five percent of teachers reported that technology allowed them to demonstrate something they [could not] show in any other way" (Mills and Gandy, 2013). Additionally, three-quarters of respondents believed that educational technology helped motivate students to learn (Mills and Gandy, 2013). Despite its potential, media are far less integrated into schools (Conley, 2010). Teachers face financial and institutional obstacles that create unequal access to technology in schools, as well as attitudinal obstacles from teachers and school boards that slow down media's incorporation (2010).

To gain a better understanding of what science and environmental topics are taught in the classroom, as well as what methods teachers use to best facilitate learning, I conducted four semi-structured interviews with teachers and professors. I interviewed: David Joseph, the former science coordinator for the Hanscom Middle School—a school in the Lincoln Public School district and serving military dependents at the Hanscom Air Force Base; Becca Fasciano, a former outdoor education teacher and the current science

coordinator for the Hanscom Middle School; Terry Green, the science specialist at The Lincoln School; and Tufts University Mechanical Engineering professor Chris Rogers. Unfortunately, only two of the interviewees could speak specifically about the 7-9 year old age group I am focusing on, which is undeniably a shortcoming of these interviews. However, their experiences working with children still offer valuable insight into how science is taught in primary education, what topics are addressed, and the roles of media within these contexts.

In the interviews, I asked three series of questions. The first set asked the school teachers to expand upon what science topics they cover, what types of teaching are most effective in getting the students to learn the material, what criteria are followed, and what environmental topics are discussed within the general science curriculum. The next group of questions focused on the environment, namely climate change. I asked them to comment on the level of current environmental knowledge their students had and any insight they had on their students' feelings about climate change, as well as where the best places to find accurate environmental information may be, and what methods of teaching would be best to have children learn about the environment. The last series of questions focused on the role of media in learning and teaching in the classroom. I asked whether they believed media was an engaging teaching tool or served more as a distraction, if they used media in their own classroom (and how), and what topics they would like to see covered in televisual media.

The first series of questions regarding what science topics are taught revealed, unsurprisingly, that the teachers adhered to the curriculum outlined by the Next Generation Science Standards and Massachusetts Department of Education (Joseph,

personal communication, April 12, 2014). In this curriculum, middle school teachers focus primarily on physical science, such as forces in motion and the solar system (Fasciano, personal communication, December 2, 2014). When I asked about the extent that environmental science and climate change were addressed, both Joseph and Fasciano said they were nearly absent. According to Joseph, the frameworks do not explicitly allow the time for these topics, but can be integrated into other units at the teacher's discretion (personal communication, April 12, 2014). The unit on plate tectonics, for example, includes some discussion on global warming, and another teacher incorporates Antarctica's melting ice into another lesson (Joseph, personal communication, April 12, 2014). According to Fasciano, climate change is "loosely discussed" in the context of a fifth grade unit on weather, such as using rainfall and storms as metrics for measuring climate change (personal communication, December 2, 2014). Joseph explains that in most cases, animals are taught to the exclusion of everything else because of their salience in children's lives (personal communication, April 12, 2014). When students finally learn life science in seventh and eighth grade, the curriculum focuses on biomes and ecosystems, but never directly addresses climate change or negative human impacts on the planet (Joseph, personal communication, April 12, 2014).

Becca Fasciano reassured me that the lack of environmental topics in her classroom was not a personal choice. To create balance, she incorporates the environment and climate change into an extension course she teaches about worldwide STEM developments (Fasciano, personal communication, December 2, 2014). In the class, which focuses on the world food supply, helping the students connect their lives to the world at large takes priority. "We're looking at where are the crises, what factors come into play, and trying to

bring that understanding of our global environments into their lives" (Fasciano, personal communication, December 2, 2014). By focusing on food, Fasciano is able to connect global events to subjects that are important to her students (personal communication, December 2, 2014).

Green, who is the science specialist for grades 1-4 at The Lincoln School in Lincoln, Massachusetts, embeds topics about nature and the environment into her 9-week life science unit. Focusing primarily on habitats, Green emphasizes the diversity of habitats and the various requirements a habitat must meet to sustain life (personal communication, December 11, 2014). When it comes to climate change, the discussion is less direct.

> *Certainly the kids in the community I teach…read a lot, visit a lot of museums, they've heard a lot [about climate change], and many of the parents are very educated in investigating a lot of the science topics that are in the news. So kids bring up those topics. I don't do a specific unit on global warming, but I do environmental units that pertain to the outdoors around us, and then bring in these ideas as they're brought up in class (Green, personal communication, December 11, 2014)*

Even still, Green believes that climate change requires that her students have a lot of previous knowledge about how the environment works.

> *But for a topic [like] global warming, kids need to have the basic understanding of 'How does the environment work, and how do all these other factors influence it?' and then 'What do I do that is influencing it?' before I can get into in depth discussion on global warming…[It's] probably not something I would do. It seems like a middle school topic that kids could really sink their teeth into once they really know how the environment works (Green, personal communication, December 11, 2014).*

Green's words encapsulate the recurring theme of how environmental topics are taught in schools. The state curriculum affords class time for teaching about life sciences, mainly in the form of animals and their habitats, but climate change is taught only if the teacher believes it is germane enough to wedge it into other topics, or if they devote additional time to an extracurricular class. Personally, I believe that weaving discussion about the environment and climate change into existing units is, in many ways, the right way to teach these issues. The way Green contextualizes the students' questions into parts of her environmental unit makes a lot of sense both for the age group and for the time restrictions. Even still, the other 27 weeks of Green's program focus on other science domains—earth, physical, and engineering sciences—that have no explicit connection to environmental science unless she ties it together (personal communication, December 11, 2014). I do not want climate science to be taught to the exclusion of other topics, but the rigidity of the Science Standards for the State of Massachusetts is disheartening. The onus falls on the teacher's personal commitment and belief that climate change is worthwhile and age appropriate.

Even with Fasciano and Green finding ways of incorporating environmental science into their classrooms, there is an underlying sense of apprehension. Green explained that she doesn't believe in-depth discussion on global warming is right for her students because of its complexity (personal communication, December 11, 2014). In Joseph and Fasciano's experiences at Hanscom Middle School on the Hanscom Air Force Base, where the students are the children of military officers, the hesitancy is more complex. Many of the students come from Texas, Arkansas, and Kentucky where the teaching of religion and creationism often trumps science and climate change (Joseph and Fasciano, personal interviews, April

12 and December 2, 2014). Finding tactful ways to include environmental topics is even more difficult when the population of students is fundamentally skeptical about science (Joseph, personal interview, April 12, 2014). In a liberal state like Massachusetts, we sometimes forget the presence of anti-science beliefs and how that complicates its teaching. There are many unique challenges to acknowledging that worldview while not watering down environmental and climate topics. Nevertheless, I believe that the urgency of climate change begs that we find ways to teach it to children that resonate personally and are age appropriate.

To get a better sense of how this might be accomplished in the classroom, I explored the different ways teachers get their students thinking critically and engaged in other science topics. In my interviews, some common themes emerged when I asked about preferred teaching methods. First and foremost, all three educators agreed that hands-on learning ranks the highest in terms of student engagement. From Dave Joseph and Becca Fasciano's experiences, they attest that children love experiments (Joseph, personal communication, April, 12, 2014), but that a balance must be struck between the experiential and the text. In Fasciano's classroom, she strives for a "75-percent experiential, 25-percent text" split, subscribing first to the "constructivist model that kids need to make meaning of the world through doing, and then learn [and] add to what their understanding through reading" (personal communication, December 2, 2014). From Dave Joseph's experience, he has found that even though this combination engages students, the teacher needs to push the students to "dig deeper to get the content" from experiments and crystallize the learning (personal communication, April 12, 2014). The textbook helps in

these circumstances by providing background knowledge, which then enables the experiments to "put the fun into science" (personal communication, April 12, 2014).

While hands-on learning creates a physical connection the material, the end goal is to build a personal connection. Terry Green accomplishes this through a couple of approaches. For one, Green is adamant about taking her class outside. In her unit on invasive species, for example, she takes her students outside to the nearby wetlands where they remove garlic mustard (personal communication, December 11, 2014). For the third grade unit on water, Green has the children look at how much water they use in their own homes by estimating and collecting data (personal communication, December 11, 2014). These components gets them thinking about their own water consumption, such as how many gallons of water are used in a bath (Green, personal interview, December, 11, 2014).

Activities and experiments are engaging, but from Professor Chris Rogers' work with LEGO, he believes that they do not necessarily get the student thinking critically. In his philosophy, the goal of the teacher is to try to "take a story or an idea that you have in your head, and…put it in the head of the kid" (personal communication, December 3, 2014). There is no one right way to accomplish this task, but rather a balance of three methods. First, a teacher can tell their story via lectures and demos (Rogers, personal communication, December 3, 2014); the child, then, builds knowledge from watching or listening. Secondly, a teacher can show the student their story by bringing in other speakers to talk, viewing TED talks, or through a guided lab experiment (a lab is, after all, a teacher's recipe with a predicted outcome and takeaway lesson) (Rogers, personal communication, December 3, 2014). And thirdly, a teacher can enable students to have their own story (Rogers, personal communication, December 3, 2014). Rogers believes that

through enabling a child to have their own story, the child thinks critically about what he or she is actually learning (personal communication, December 3, 2014). Enabling, unlike a procedural lab assignment, is a dynamic process; a teacher can have one story, the student another, and they can argue their points until their stories align (Rogers, personal communication, December 3, 2014). Through questioning, explaining, and revising, the child reaches a greater depth of learning.

Hands-on learning can lead to critical thinking, but it is not synonymous with enablement. Professor Rogers explains the relationship in the context of building a LEGO Taj Mahal:

> *In hands-on learning, there are many different ways I can do it. I can do hands on learning just with showing and telling; I can make you follow directions. You can get pretty far, you can understand new ways of putting pieces together…But ultimately you haven't really engaged deeply with how they designed the Taj Mahal…The instant you start enabling, you've gone from one Taj Mahal to many, many right answers…Then this also rapidly changes your classroom. In the first two, the showing and the telling, if I told you how to make the Taj Mahal, it's easy for me to grade…On the other one, when you're developing your own mausoleum, it's a little bit tougher to give a grade (Rogers, December 3, 2014).*

The enabling, Rogers explains, means that each child's design will be different, causing students to incorporate the successful pieces of others' work into their own (personal communication, December 3, 2014). "What I've done is gone from a classroom where there is one teacher and many students, to one where there are many teachers" (Rogers, personal

communication, December 3, 2014). That transformation is emblematic of critical thinking and demonstrates the power of enabling.

It is clear from the interviews that hands-on learning is more effective at engaging the students than a textbook, but it is less clear if the hands-on activities achieve the enabling component. To explain, I will take an example from Becca Fasciano's class, where to teach forces of motion she brings her students to a nearby skateboard park. There, they run and roll balls up and down the ramps (personal communication, December 3, 2014). We did not discuss exactly how this lesson was taught, but it is easy to imagine the difference in learning that the lesson could have if taught with a showing approach versus an enabling approach. In the former, the teacher tells the students that a ball higher up the ramp has greater potential energy than one closer to the ground and the class goes to the park to confirm this hypothesis. In an enabling approach, students are asked to design an experiment that demonstrates differences in potential energy using the balls and the ramps. The enabling approach not only engages the class, but also gets them thinking deeply about the concepts.

Ideally, then, teachers should incorporate activities that enable into lessons about science and the environment. However, the limited instructional time and breadth of material teachers must cover may not lend itself to the classroom restructuring that Rogers describes. And ultimately, the baseline goal is to engage students. From the teachers' experiences, hands-on learning is successful.

Given what I heard about hands-on learning and enabling as the ideal pathway to deeper learning, it seems counterintuitive to look towards media as an equally good option to teach science. Media, particularly my focus on televisual media, is, as Professor Rogers

says, “decidedly one way,” with very little of the “enabling packaging” in the video or show (personal communication, December 3, 2014). Nevertheless, I asked each teacher to comment on how media are used in their classrooms and whether they can be effective teaching tools.

Across the board, teachers agreed that the use of media—which ranged from tablets to YouTube videos—engages the students and bolsters learning in new ways. At the Hanscom Middle School, where every student has an iPad, Becca Fasciano described how technology helps her students visualize and make connections to the world beyond the classroom. In one instance, a student found a video about how melting polar ice caps are threatening polar bear populations, and shared it with the class. “Being able to share that [video] and have that conversation…was really meaningful and powerful to those kids” (Fasciano, personal communication, December 2, 2014).

Terry Green integrates short video clips into her lessons to introduce concepts and to extend the learning in ways that cannot be done in the classroom (personal communication, December 11, 2014). For her upcoming unit on simple machines, Green says she is looking for a video that will help introduce what simple machines do, what they look like, and where children may find them in daily life (personal communication, December 11, 2014). She says that her students love the video clips, but explained that how useful the video is rests on her ability to find something that engages the children, communicates the main ideas, uses age appropriate vocabulary, and, above all, is scientifically correct (Green, personal communication, December 11, 2014). To bring the concepts back to the classroom environment, the video segues into a half-hour activity “that [takes] the topic and [has] [the students] make meaning from it, from what they

learned from the video clip and what we've learned in class" (Green, personal communication, December 11, 2014).

The pairing of video media and hands-on activity echoes what Professor Rogers believes with regard to how video media can be made useful in promoting quality learning. To paraphrase his words, video alone will never lead to enablement because it is inherently passive; it requires additional activities or programs that get children thinking critically. For instance, shows like PBS's *Design Squad*—an engineering and design show for children—acknowledge and mitigate these shortcomings by challenging them to design and share their projects on the Design Squad website (Design, 2014). Other shows provide additional materials that children can do at home to build upon what they watched.

Despite televisual media's "passivity," it is anything but useless. Joseph, Fasciano, and Green all described how actively their students engaged with different media. As Fasciano said, "I think there are really great uses for technology to help kids experience things that they otherwise wouldn't be able to have any understanding of…I think we're a visual world, so being able to watch a video helps these kids a lot" (personal communication, December 2, 2014). The way it can broaden learning and facilitate connections between the students' own lives and the rest of the world is obvious. In the case of Becca Fasciano's student sharing the polar bear video, the student was able to expand upon what she knew about polar bears and the state of the Arctic. But expecting media to offer the best kind of learning to every child is unrealistic; a combination of approaches is always ideal, and the exact combination also varies with the topics themselves. With my goal of educating children about the environment and climate change,

media plays an invaluable role. But to ultimately make a child care, they also need direct contact—they need to spend time in nature.

Fasciano is a firm believer in the value of a personal relationship with nature. "With nature, you have to get your hands dirty, see that stream, see what the flood of the banks does to the river bank in order to appreciate it and to develop that relationship…I think having that familiarity and having that relationship with the natural world instills…a sense of ownership" (Fasciano, personal communication, December 2, 2014). Fasciano worked as an outdoor education teacher with programs from rural western Massachusetts, Attleboro (a small city with easy access to nature), and Boston (personal communication, December 2, 2014). From these diverse experiences, she witnessed how vital being outside was to her students' interest and connection to the material. She also noticed that when her students didn't have much previous exposure to nature, their level of comfort waned.

> *At the Berkshire Outdoor Ed center (in Western Mass), there was a lot more familiarity with the outdoor world. At Horizons for Youth we worked with a lot of kids from Boston. It was a targeted outreach to Boston area schools, so those kids were more nervous about spending the day in the woods; a lot of unfamiliarity, nervous about bugs, nervous about getting dirty. [It wasn't] everybody, but there were more of those reactions. At Audubon Society, we were right in the center of Attleboro [which is] a little city, so it was a bit of mix of some people who had familiarity and some people who were not quite as familiar. Some kids were more nervous when they didn't have the previous exposure (*Fasciano, personal communication, December 2, 2014*).*

One particular class in Attleboro for children ages 3-4 and their parents epitomized her belief in the importance of outdoor experiences. For the class, the group would gather

every week in the town green and follow animal tracks. On one walk, the group came upon raccoon prints, and decided to follow them. The tracks happened to lead right to the tree where the raccoon was sitting. And the raccoon had clearly been nursing. Instead of the typical contempt towards raccoons, "the kids were mesmerized…and the parents, too" (Fasciano, personal communication, December 2, 2014). Witnessing the mother raccoon caring for her young resonated with the parents. "Instead of people saying that they needed to get rid of raccoons, the parents were realizing not just that nature lives right in the center of the city, but that there is a stewardship responsibility to protect nature" (Fasciano, personal communication, December 2, 2014).

Perhaps, then, media is most valuable when it either facilitates a hands-on learning activity or builds upon one. If the parents and children had watched this type of encounter on a screen, chances are, the way they viewed nature in their hometown would be unchanged. The firsthand experience creates an indelible memory. The group was able to form their own opinions and reach their own conclusions. To use Professor Rogers' description of enablement, the parents and children were not told or shown that nature is important: They saw the raccoon and developed their own conclusions about what she and her habitat meant in their lives. After this experience, a connection was formed. And now, one could argue that watching a video or show about raccoons in nature would be more impactful.

Media, hands-on learning (including exploring outside), and enablement are all valuable methods to get a child to think critically about science and the environment. How and when each approach is used will always vary with the subject, but the end goal remains the same: Get the students to find a connection to the material. Enablement forces a child to

reach their own conclusions, hands-on learning tries to build a connection through doing and creating, and media can connect a child to the outside world in ways hands-on learning cannot. All three methods offer different advantages, especially in the classroom. So even if schools do not teach enough environmental topics, if the students were engaged enough by going outside, by viewing media, by doing hands-on activities, and by thinking, the connection will continue to grow.

Plum Landing: A Case Study

From *Sesame Street* to *Arthur*, the Public Broadcasting Service (PBS) has always been positioned on the forefront of children's educational media. Their endeavors into children's environmental media are no different. In the spring of 2014, Boston PBS affiliate and children's programming powerhouse, WGBH, debuted one of the first—if not the first—curriculum-based environmental shows for children. Titled *Plum Landing*, the show features Plum, a videogame-designing alien from the faraway, barren planet Blorb, who ventures to Earth to learn more about its fascinating biodiversity and to inspire her work (Plum, 2015). With the help of five young Earthlings, Plum learns about some of Earth's puzzling phenomenon, such as how lakes appear in the desert, and why only young fish live in mangrove swamps (2015). To offer a diverse range of topics, episodes are divided into four ecosystems—desert, mangrove, mountain, and jungle (2015).

Unlike a commercial show like *Captain Planet and the Planeteers, Plum* is created to teach specifically researched topics to six to nine-year olds, with an emphasis placed on prey-predator relationships, ecosystems, and the human influence on the environment (Plum, 2015). Further establishing themselves as innovative programmers, WGBH created the show exclusively for digital platforms (LaMonica, 2014). The rise of iPads, computers,

and smartphones and decline in the amount of time people watch television on a TV set pushed WGBH to break from broadcast (2014). And the flexibility with the Internet allows accompanying games, activities, animations, short live-action videos, and interactive apps to be nestled next to the webisodes, offering children opportunities to actively engage with the content and round out the learning experience (Plum, 2015; LaMonica, 2014).

As alluded to, the webisodes' content and learning objectives were methodically researched and refined. However, the development processes for an environmental show presented unique research challenges. Little research currently exists on the "extent to which young children comprehend issues related to the environment and sustainability" (Paulsen & Carroll, 2010a). Therefore, creating a developmentally and educationally appropriate show for children required assessing the needs of the audience in a way that had not yet been attempted by larger academic and institutional bodies.

To begin conducting the 'Needs Assessment,' "WGBH hired independent evaluator Concord Evaluation Group, LLC (CEG)…to gather data on children's knowledge and attitudes about the environment and sustainability" (Paulsen & Carroll, 2010a). The questions aimed to answer the following:

- "The extent to which kids understand that they are part of their environment and that people are part of ecosystems
- "The extent to which kids comprehend that some things are renewable and others are not
- "The extent to which kids know that all species have to share resources and that some resources are finite

- "The extent to which kids comprehend that there are factors that can influence the environment, even if they cannot be seen
- "The extent to which kids care about their environment
- "The extent to which kids practice "green" habits
- "The extent to which kids spend time in nature"

To explore these topics, researchers used several methods. Most of the data was generated from direct questioning, with the facilitator asking questions such as, "What do you do with something that you don't need anymore?" and "Can you think of something far away that we need to survive, even though we can't see it?" (Paulsen & Carroll, 2010a). At various points, children were also asked to draw pictures of their own interpretations of how people and nature may interact. For example, they were asked to draw their concept of "environment" without any prompting or defining, as well as where water comes from before it reaches their house, and where it goes afterwards (2010a).

The responses illuminated many trends in children's understanding of the environment, though most of them highlighted misconceptions. After reviewing the pictures of a child's interpretation of 'environment,' over half of the children drew plants or trees (60%) and the sky (60%), and a natural terrain, such as grass or mountains (56%) (Paulsen & Carroll, 2010a). Less commonly, though still notable, the children tended to include animals (29%), people (21%), and man-made objects (19%) in their pictures (2010a). All trends on a micro-level, the Needs Assessment points out more broadly that nearly all participants drew the environment as it related to a familiar place, and did not view it as existing far away (2010a).

> Recycling also recurred as a synonym for environment. The assessment states: *Almost 17% of the kids included a recycling theme in their drawings, even though we had no even discussed the topic of recycling. During the group discussions, kids explained that they had been learning about the environment in the context of discussions about recycling. These kids had learned about recycling through television shows, in school and at home* (Paulsen & Carroll, 2010a).

When the children were asked to consider if they were a part of the environment, recycling again came up since recycling implies that humans can affect or change the environment (Paulsen & Carroll, 2010a). Though a promising sign of deeper understanding, most responses were that humans are mammals (15%), humans also live on Earth (18%), and, most commonly, the children just guessed (48%) (2010a).

The uncertainty surrounding whether humans are part of the environment in the same way as plants and animals did not affect whether children said they cared about the environment; a full 73% claimed that they cared "a lot" (Paulsen & Carroll, 2010a). Moreover, almost every child said they liked to play outside, possibly a demonstration of how much they care (2010a). However, very few of their favorite activities involved directly interacting with nature. The vast majority were activities played outside, such as sports, biking and scootering, and playing on playgrounds (2010a). Getting 16% of the responses, only "climbing trees" and "swimming in pools or lakes" were favorite activities that involved interacting with nature (2010a).

An interesting trend emerged when the children were asked for reasons the environment should be protected. The Needs Assessment did not calculate the statistical breakdown, but the children's responses were more or less split between the need to help

the Earth in a general, almost anthropomorphized sense (an example being, "The planet will start to die") versus protecting the environment for the benefit of the animals, plants, and people that inhabit it. These two types of responses indicate that children (and probably adults, too) may tend to distance themselves from environmental issues. Instead of environmental degradation harming them, it generally and nonspecifically hurts the Earth as a whole. Obviously, teaching a child that their parent's car harms the environment and, ultimately, them, is a somber topic and probably not appropriate for their age. Understandably, WGBH did not want to address this issue in the context of *Plum Landing*. Still, it is important to note that such a distinction exists and it is worth considering when developing educational programming about the environment.

Another prominent research question that the Needs Assessment investigated was how children conceptualized which resources are finite. Focusing on water and trees, researchers concluded that, "most kids demonstrated a partial understanding of the water cycle, but very few seemed to comprehend that water eventually gets re-used" (Paulsen & Carroll, 2010a). Only 12% of the children, almost all 9 year olds, fully understood the water cycle (2010a). Similarly, older children could grasp that the same water is used and re-used by people, animals, bugs, and plants alike (2010a). However, other topics were easier to understand across all ages. For example, "most kids understood how water becomes polluted," listing pollutants and sometimes explaining that they harm aquatic life (2010a). Most children also understood that trees were a renewable resource, but at the same time, did not understand that water and birds were not (2010a).

Additionally, researchers explored whether children could recognize how the different aspects of the global environment are interrelated. In certain contexts, namely

with animals, they saw how species were interdependent (Paulsen & Carroll, 2010a). However, when animals were taken out of the equation and the concept of interrelation was made more abstract, most children could not understand how a factor "far away" could impact their own environment (2010a). For example, when asked to name "something far away that might hurt us/impact our environments, even though it could not easily be seen," most named "concrete, tangible things like animals and the threat to humans from animals and insects" (2010a). Even though they had mentioned pollution when discussing water, that threat was less serious or real than wild animals (2010a).

As the assessment summarizes, seven points emerged as potential topics an environmental children's show could explore. A show could touch upon sustainability and the reasons for it, framing the environment in ways besides recycling, inspiring children to get outside and be in nature, explain how some resources are renewable and others are not, and more information about the factors affecting the environment (Paulsen & Carroll, 2010a).

The thorough research WGBH conducts (or contracts out) for the show curriculum is complemented by similar research for the educational activities that enrich the learning experience for its viewers. For *Plum Landing,* WGBH developed a combination of hands-on activities that explored various environmental topics and live-action video segments showing children doing those activities. These activities are, in many ways, just as important as the webisodes since they reinforce the learning and engage the viewers in ways that encourage deeper thinking and get them outside in nature. And since *Plum* is created for digital platforms, parents and children viewing the webisodes have easy access

to other content on the show's website. The quality of the supplementary materials needs to be as engaging.

To develop and test activities for *Plum*, the team at WGBH visited 16 different summer camps and programs in urban, suburban, and rural towns in Massachusetts to see how children responded. Affirming other research conducted on ideal teaching methods, "all of the programs reported that most kids prefer hands-on activities, games, and being physically active;" the activities that they enjoyed the least were "school-like activities," such as worksheets and lectures (Paulsen, 2013). Additionally, educators and children alike enjoyed using technology as a means to develop activities and as a topic to build an activity around, whether it was through Internet resources or leading photography activities (2013).

A key part to the success of these activities is their relatability. By designing activities that get children outside in their own communities, it allows them the opportunity to view environmental topics and issues in the context of their own lives. In a video about watersheds, the children watch another child first make a watershed diorama using everyday objects and model how pollutants travel from water source to water source (Paulsen, 2013). Then, the child in the video explores the watershed close to her home (2013), applying the learning from the indoor model to a relatable, real world experience. This crossover ties in nicely with the Needs Assessment's discovery that a child's conception of the environment is a place close to them; the environment doesn't immediately conjure up images of rainforests and deserts (Paulsen & Carroll, 2010a). Those types of environments may be exciting and visually alluring, but are not essential for driving home the important concepts and themes.

The last part of the program research consisted of testing the pilot episode of the series, along with a complementary live-action segment, to see if the children who viewed the episode demonstrated "significantly better knowledge about specific science concepts" than the children who did not view the episode (Paulsen & Carroll, 2010b). Using a classic experimental setup, 80 children were selected from a national sample, with 40 assigned to watch the "pilot animatic" and 40 assigned to regular programming (2010b). The episode featured the characters in a desert learning about water and the types of life that climate sustains (2010b). After viewing the animatic, the children who watched the pilot were significantly more likely to understand the concepts being tested in every category (2010b). Even better, the episode was "universally appealing across both genders, all races and ethnicities, all age groups, all socioeconomic backgrounds, geographic regions, and settings," with 91% reporting that they liked watching the show (2010b).

Since the episode featured an unfamiliar climate like the desert, the accompanying live-action segment connected the theme of water scarcity and conservation to a place more familiar to the children: a garden in the summertime (Paulsen & Carroll, 2010b). In the clip *Jacinda's Garden*, they see Jacinda using rain barrels to collect and save water to help her plants grow (2010b). Almost 90% of the particpants enjoyed the segment, and 90% also "understood that the rain barrels collected or stored water" (2010b). However, only 52% could think of a way they could save water themselves (2010b).

Plum Landing went through many iterations and seven years of development before ultimately landing on the final version. Applying the research from the Needs Assessment, the four "worlds" that the characters explore—mountain, jungle, mangrove, desert—make learning about the environment fun and exciting, and the live-action segments and

activities ground the topics in a familiar context. Though not explicitly mentioned in the research, the five child characters—Brad, Clementine, Oliver, Gabi, and Cooper—appeal to the various demographics WGBH reaches. Particularly with regard to race, numerous studies suggest that children relate better to characters that share their ethnic or racial background (Martins & Harrison, 2012). Evidenced by the racial makeup of the children that participated in the referenced studies, many of WGBH's viewers are white. Therefore, Brad and Clementine are two white characters, possessing stereotypically gendered characteristics; Brad is bold and adventurous, and Clem takes a more soft-spoken, transcendentalist perspective. Oliver and Gabi are brother and sister, and are the two characters of Color in the show. Similarly gendered, Gabi is more cautious and Oliver is fearless. Cooper acts as the typical "scaredy-cat," afraid of anything that moves in nature, but also at times struck by its beauty. For viewers who may not have many experiences being in nature, Cooper is funny and relatable.

Lastly, the character of Plum, who is a small purple alien, may seem like a strange eponymous character for a show about the Earth's environment. However, what is clever about her character is that she is naïve to how Earth's climates work. Through the vague missions she assigns to the characters, she allows everyone—the five children, the viewer, and herself—to learn about the various ecosystems at the same time. She shifts the authority of knowledge to the characters and empowers them to take charge of their learning.

This technique has valuable developmental benefits, tying into Piaget's theory of cognitive development and Vygotsky's 'zone of proximal development.' For the target group of ages 6-9, Piaget states that children are between the later part of the

preoperational stage and sitting comfortably in the concrete operational stage (Scheibe, 2007). The improving ability to consider multiple perspectives and the capacity to assimilate and accommodate new knowledge means that the way Plum facilitates learning is developmentally stimulating. Additionally, since Plum is the one coming up with missions but can only give clues, she is allowing the characters to scaffold knowledge on top of her own.

The group dynamic of *Plum Landing* also promotes prosocial behaviors. Many missions require that the children work in small groups, dividing work and cooperating to accomplish the task at hand. In the episode "A Peek at the Peak," the children are divided into teams to observe and record the different elevation zones of the mysterious 'Mount X,' which Plum wants to feature in a new game (Plum, 2015). Brad and Gabi are one team, placed in the subalpine zone, where they work together to record the different plants and animals of the zone (2015). When Brad does not initially see any signs of animals, Gabi suggests looking up, where Brad spots a Clark's Nutcracker (2015). Excited, they then observe and learn about the symbiotic relationship between the bird and the Whitebark Pine, a direct result of their teamwork (2015). In Cooper and Oliver's team in the montane zone, the viewers see Cooper's fear of snakes, and understand why he may feel scared (2015). Oliver helps Cooper work through his fear, describing how the snake is not poisonous and probably only climbed on him because it thought he was a tree (2015).

What sets *Plum Landing* apart from other environmental children's shows is how, in addition to the cultivating of prosocial behaviors towards other people, it emphasizes building a social and emotional connection to nature. In the episode 'Mangrove Mystery,' the children set out to investigate the rumor of a 'sea cow' (Plum, 2015). While exploring

the depths of the swamp via hydrophobic bubble, they realize that all of the fish are babies (2015). But no sooner do they make that observation than a shark arrives, and begins hunting them (2015). The crew narrowly avoids being eaten by hiding in the protective hollow created by the mangrove roots, where they see that all of the baby fish have also sought refuge in their spot (2015). By enduring a harrowing experience—one that baby fish endure frequently—the characters empathize with the fish, and also recognize the indispensible role that mangrove swamps play in protecting the biodiversity of the swamp ecosystem.

On top of the positive behaviors *Plum Landing* demonstrates, part of what makes the show so appealing to children—and subsequently, an effective tool for environmental education—is how the show incorporates technology. For every mission, Plum gives the characters a 'Plink' (short for 'Plum Link') that serves as a camera, cellphone, search engine, measurer, time speeder, and everything in between. The Plink helps them record their observations, and identify all of the species of plants and animals they encounter (Plum, 2015). Its knowledge is impressive, but does not take away from the children's learning or from the experience of being in nature; webisodes always emphasize the sense of wonderment that comes from being in nature over the novelty of a gadget. Additionally, the children must still do the physical work of observation, leaving the Plink more as a tool to make the process of scientific discovery more fun. And given the current obsession children currently have with technology, incorporating an awesome educational device acts as a valuable bridge to inspire children to get outside.

From the exhaustive research, testing, and content development, *Plum Landing* captures the educational strength that defines all of PBS's child programming and couples

it with the entertainment value of the action-packed *Captain Planet and the Planeteers*. The show promotes positive social and emotional development and integrates environmental science into engaging plots, all while inspiring an appreciation for nature. In many ways, the decision to air the show digitally through four-minute webisodes helps children learn the material; the episodes are easy to view over and over and are not constrained to specific airtimes. The current trend towards digital binge watching validates the decision, but there is also an undeniable status and legitimacy that comes from a show picked up for broadcast television. *Plum Landing* undoubtedly hits all the benchmarks for quality environmental children's programming, but the gaps in children's knowledge of the environment merits the reach and attention a full-fledged television show would bring.

But what is not accounted for in broadcast that gives an undeniable edge to the potential educational power of digital for *Plum* is the ability to facilitate interaction. From the touchscreen of an iPad, to the accessibility of accompanying websites filled with activities, games, and supplementary information, the flexibility of digital offers children tons of avenues to expand their learning in ways that engage them and encourage them to interact with the material. In the same way Dave Joseph, Terry Green, Becca Fasciano, and Chris Rogers emphasized the value of experiential, hands-on activities, critical thinking, and enablement, the *Plum Landing* website includes games, activities, and a photography app that keep children thinking about and engaging with what they have watched. Whereas before on a television screen, a child had to make the physical effort to go to a computer or device to look up an activity or topic from the show, with digital platforms there is no barrier between what the children have watched and what else they can learn from activities and information found on the Internet. The switch to digital may just be

beginning, but there is reason to believe that it could revolutionize educational media in ways producers never dreamed with broadcast television.

Discussion

In the past year, even in the time since I have started writing this thesis, significant weather events have occurred and continue to occur that suggest the effects of climate change are already felt, and require immediate intervention. This year, Boston experienced the snowiest winter in its history, recording a mountainous 108.6 inches (Atkin, 2015). According to climate scientists, this type of winter will become the new norm as "sea surface temperatures get warmer and the atmosphere is able to hold more moisture," both of which are "driven by human-made greenhouse gas emissions" (2015).

On the other side of the country, California entered its fourth year of drought. According to a recent op-ed penned by NASA scientist Jay Famiglietti, the reservoirs and Sacramento and San Joaquin river basins have enough water left for about one more year (2015). Groundwater—the backup plan—is also rapidly depleting, and the drought shows no signs of relenting.

In Alaska, the Iditarod Dog Race was moved 300 miles north because the traditional starting point, Anchorage, received such little snow (Thiessen, 2015). In order to preserve the starting ceremony in Anchorage, 350 truckloads of snow were shipped in to form a trail (2015).

And despite overwhelming factual and anecdotal evidence, climate change denial remains strong. A recent investigation found that Florida state governor, Republican Rick Scott, had "barred" officials in Florida's Department of Environmental Protection from using the phrases "climate change" and "global warming" in all "official communications,

emails, and reports" (Terkel, 2015). This was done in spite of the fact that "last year, the National Climate Assessment named Miami as one of the cities in the United States most vulnerable to damage from rising sea levels" (2015).

Political intransigence is frustrating, but social change can, and does, happen more swiftly. The accessibility and omnipresence of media and technology make it an appealing vehicle to effect change, and ample evidence suggests that they possess this power. A recent story from WBUR, Boston's NPR news station, reported on a trio of 11-year old girls who were inspired to form their own environmental club after watching films in a series called "Young Voice for the Planet" (Shea, 2015). One film, which followed an 11-year old German boy's quest to plant one million trees to combat climate change, motivated the girls to testify at the local Board of Selectman meeting to change restrictions on solar panels on buildings (2015). The article passed, but more importantly, the film inspired young people to become civically engaged (2015)—a huge step towards working actively towards social change.

Additionally, the data from WGBH's focus groups for *Plum Landing* demonstrated that children retain information that they learn from media when it is presented in an engaging way. After viewing the pilot episode about the desert ecosystem, the children who watched were more than twice as likely as their peers to "report that there was water in the desert," nearly five times as likely to report that "water can be found underground," and demonstrated knowledge about oases (Paulsen & Carroll, 2010b). So knowing that media is an effective teaching tool, and seeing the desperate need for climate education, the question that remains is about the best practices for how to link the two.

From my research and interviews, several key points stand out. First, children like to be outside, but need to be shown that nature is fun and exciting. The Needs Assessment conducted for *Plum Landing* reported that many of children's favorite activities are outside, like sports and biking, but very few take place in natural spaces (Paulsen & Carroll, 2010a). Richard Louv provided an explanation for this phenomenon when he wrote that children have fewer opportunities to play in nature since communities often level natural, un-built environments to create more playgrounds and soccer fields, preferring order and structured play over unsupervised exploration (2008). And to be certain, an increasing number of children also prefer spending time inside on devices because "that's where all the electrical outlets are" (2008).

Any show that tries to teach children about the environment must first prove, then, that nature is worth caring about. Indisputably, the best way to accomplish this is through direct experiences. Research shows that childhood experiences in nature engender positive views of the environment and pro-environmental behaviors, and that these experiences stay with people their entire lives (Louv, 2008; Chawla, 2006). Becca Fasciano touched upon the importance of firsthand experiences in nature in her story about encountering a mother raccoon and her babies while teaching in Attleboro. When the group of parents and their young children she was leading saw the animals, their opinion shifted from seeing them as a nuisance to believing that the natural spaces in their town were worth protecting and preserving (personal communication, 2014). If the group had simply seen a family of raccoons on television, the event would not have been nearly as impressionable.

As it relates to the concept of cognitive schemes, children incorporate new information on pre-existing knowledge (Scheibe, 2007). When a child spends time out in

nature, his or her observations of and interactions with their surroundings shape their understanding of that environment. If he or she watched a television show that drew upon knowledge that comes from direct experiences in nature—habitats, different species of animals, predator-prey relationships—they would have an experience to draw from and relate to what they are seeing. This ties in with the theory of Constructivism, which states that children are "more responsive to information and images that help them make sense of their own world, lives, and experiences (Kaul, 2000). If a child has been in nature before, an educational show that takes place in nature would help the child better understand their own experiences, and hopefully, inspire them to have more. Therefore, above all else, an environmental children's show must demonstrate the beauty and wonder of nature; it must act as a motivator to get children exploring in nature.

Similar to direct experiences in nature, hands-on learning is the ideal method for getting children to engage with their learning and retain information. In each of the interviews I conducted, the educators emphasized how they incorporate activities and experiments into their lesson plans, as well as how much their students enjoyed doing them. This sentiment was echoed in the formative research for *Plum Landing* when the educators unanimously reported, "most kids prefer hands-on activities, games, and being physically active" (Paulsen & Carroll, 2010b). Professor Chris Rogers took it a step further in explaining that learning must enable children to formulate their own opinions and conclusions (personal communication, 2014). Often times, enablement stems from hands-on learning, but the activities must be designed to allow the student to create their own story through critical thinking (Rogers, personal communication, 2014).

In developing innovative ways to teach science, the three schoolteachers—Fasciano, Joseph, and Green—all discussed the usefulness of digital and visual media in their classrooms. Fasciano and Joseph, who both drew experience from the same school, said the one-to-one student-to-iPad ratio gives their students the ability to connect the classroom material to videos and images. Though the student may not be interacting with their learning in an experiential way, a digital, interactive medium like the iPad holds undeniable power in relating distant, large scale issues to the student's own life. Fasciano's story of her student finding a video of a polar bear on melting sea ice in the Arctic is a perfect example; seemingly removed from climate change, the student could find a compelling video to contextualize the issue, spawning a class-wide discussion that simply would not have occurred without the aid of the iPad (Fasciano, personal communication, December 2, 2014). There are certainly financial and ideological barriers to incorporating digital media in the classroom, but as the technology becomes cheaper and more familiar, we will begin to see more digital content being produced, and ultimately, media's potential realized.

Because it is a one-way process, televisual media does not lend itself to enablement or hands-on learning. It may be exciting, but hands-on activities are imperative to driving home the core concepts of an environmental show. Especially for a show about climate change, which is a far-reaching and amorphous topic, producers must work to create engaging activities that make the topics tangible and personal. Activities that tie into the concepts touched upon in the episodes can help to children to understand how climate change affects them. If the activities extend a step further to promote an environmentally positive behavior, the fact that children are physically interacting with the concept could inspire them to incorporate the pro-environmental behaviors into their own lives.

Plum Landing linked their visually appealing show with engaging activities and games by hosting the entire series on interactive, digital platforms (LaMonica, 2014). By doing so, children are, for example, able to watch episodes of Plum and the characters exploring and observing a mountain ecosystem, and then check out activities that help the viewer visualize watersheds, different animal habitats, and even watch a video of "viewers like you" go hiking at a nearby mountain (Plum, 2015). What was at first simply a four-minute animated episode has blossomed into a whole range of ways for children to relate the environmental topic to their own lives. While it is too soon to tell if digital content like *Plum* can rival the success of broadcast media, the integration of the two undoubtedly opens up exciting new potential for engaging children with all types of educational media.

Another way to make climate change relatable, and what would be the best way to frame an environmental children's show, is to focus on a familiar environment. According to the *Plum Landing* Needs Assessment, when children were asked to draw a picture of the environment, nearly everyone depicted it as a familiar place, like a park or backyard (Paulsen & Carroll, 2010a). Exotic locations and animals are undeniably exciting, and can act as a way to engage a child in a show about the environment, but to understand how an issue like climate change affects one's own life, it must be grounded and relatable.

There is no better example of this than the story on Columbia, South Carolina weather forecaster, Jim Gandy. In collaboration with Ed Maibach, founder of Center for Climate Change at George Mason University, and Joe Witte, a climate communicator for NASA, Gandy incorporated segments about climate change into his daily weather reports to "see if adding climate science to the weather forecast improves knowledge of the subject" (Fitts, 2014). Called *Climate Matters*, these segments used visuals and interviews to

illustrate the big picture of how weather, rainfall, and temperature have changed over the past four decades in Columbia (2014). However, the true key to success was two-fold. Weathermen are highly trusted public figures, with one survey reporting that 66% of respondents place weathermen as "the most trusted source of information on global warming, a larger percentage than named Al Gore" (Fitts, 2014). Even in a "'dark red' state with a lot of 'resistance' to the idea of climate change," viewers of Gandy's reports did not turn away from learning about climate change (Fitts, 2014; Ludden, 2013). Additionally, Gandy "made the issue personal for viewers, reporting on how climate change will make pollen and poison ivy grow faster and more potent," leading people to stop him on the street asking to hear more (Ludden, 2013). The combination of trustworthiness and relevance made for noticeable improvement in public understanding of climate change.

To continue on the theme of making climate change relatable, it is clear that children need more physical, visible representatives to stand-in for climate change—a lens through which they can understand the issue. Based on my research and interviews, animals and recycling seem to be the easiest to connect with and comprehend. For example, both Dave Joseph and Becca Fasciano stated that animals are often taught to the exclusion of other natural science subjects in school because of their popularity (personal communication, 2014). Additionally, evidenced by Fasciano's story of the raccoons, animals have an unparalleled emotional pull that makes them perfect ambassadors for promoting environmental protection (personal communication, 2014). Dr. Julia Corbett of the University of Utah explained it concisely in her book *Communicating Nature:*

> *It makes sense that we tend to identify most closely with the living, breathing components of the natural world. Visually, animals are concrete, picturable, and*

> *evoking of emotion. It's easier to reduce a complex environmental issue—such as climate change in the Arctic—to a story about the polar bears living there* (Corbett, 2006).

I imagine that, for these reasons, *Plum Landing* featured many animals to help children see the beauty in nature, from cute bilbies in the Australian desert, to Golden Eagles and its young in the mountains, to manatees in the mangrove swamps (Plum, 2015). To relate animals to climate change, creating storylines that center the ways in which a changing environment affects animals' habitats, migration, range, and general existence would be particularly effective. For example, an episode could highlight how a warming climate disrupts the Monarch butterfly migration since they depend on cold spring temperatures to tell them when to return back north. A beautiful and often-studied insect like the Monarch would demonstrate the reality of the issue, while also being sensitive to the fact that young children may be scared to learn how climate change directly affects them.

Though my research never specifically highlighted recycling as a salient topic with regard to climate change, the *Plum Landing* 'Needs Assessment' demonstrated that when children think of the environment, the idea of recycling often comes to mind (Paulsen & Carroll, 2010a). Incidentally, *Plum* ended up emphasizing ecosystems and habitats over sustainability, but talking about recycling in a show about climate change can be useful. Recycling is a positive environmental behavior that is simple, has a direct and visible influence on the environment, and is easily performed by children. However, recycling does not directly influence or mitigate climate change; if a child recycles a can, the planet does not cool. There is certainly a cause and effect relationship, but one that would require an

explanation that may be too complicated for children age six to nine. So it becomes a question of priorities. Is it more beneficial to give children any type of way they can become stewards of the environment, or does recycling oversimplify the danger of climate change and skew a child's understanding of the issue?

Personally, I would opt for a show that promotes any pro-environmental behavior over presenting the issue without offering any way for the children to engage. Recycling is by no means the answer to climate change, but it lays the foundation for children to gain a greater awareness of the ways resources are used, and how humans are involved in those extraction and consumption processes. There are, however, better pro-environmental behaviors a show could feature. Biking instead of driving, eating less meat, peaceful protest, and educational campaigns are all behaviors that directly work to combat climate change. Whether children would find each of those options as appealing as recycling is uncertain, but they do help children make a substantive impact.

Despite the significant number of children that referenced recycling, many of them did not yet understand why they recycled. Thirty-eight percent, the largest group of respondents, could not provide a reason for recycling (Paulsen & Carroll, 2010a). Additionally, researchers found that younger children had a more difficult time explaining the reasoning than older children (2010a). What this leads me to conclude is that the younger viewers cannot yet fully understand multiple aspects of an issue as complex as the environment, a conclusion that is affirmed by cognitive development theory. Climate change is decidedly more complicated than recycling, so it serves to reason that children would have a difficult time understanding how an action contributed to climate change. And since humans are the driving force behind climate change, it seems, on one hand,

beneficial to try and break down the ways in which someone's actions directly influence the environment. However, as children, they are not the main contributors to climate change, nor do they have control over many of their damaging actions. So without offering substantive, achievable solutions, implicating children in climate change has the potential to both scare them and make them feel unnecessarily guilty. With the goal to get children excited about nature, fear is completely counterproductive. Rather, leaving the education component as how climate change affects their local environment via animals is more valuable and empowering.

Even if it is possible to frame climate change in a way that children will understand, there are many impediments to producing such a show. The greatest challenge—and one that ironically supports the fact that such a show should be made—is the public and political denial surrounding climate change. Many Americans do not believe that climate change is real or man-made, citing that the science is inconclusive. Moreover, it is hard to persuade someone of the validity of climate change when they do not even trust science as a whole. Dave Joseph and Becca Fasciano discussed the struggles of teaching science to science-skeptics at the Hanscom Military Base when they said that many of their students come from the southern United States, and share a background that places more faith in religion than science. It does not matter that an overwhelming amount of data proves that global climate change is human-driven when people fundamentally do not believe in the value of scientific reasoning. Now, with the sensationalized, contrarian discourse surrounding climate change, someone's stance on the issue becomes a political endorsement. Since networks try and appeal to as many viewers as possible, it makes

perfect sense that they would choose to shy away from the topic—there is a valid fear of alienating a part of their fan base.

The best places to pitch such a show, then, would most likely be an educational television network like PBS. The tenet of well-researched programming and the shift towards STEM-based content aligns with the principles of a show about climate change. However, the majority of funding for programming comes from large foundations and the public, so the shows, apps, games, and other projects that get developed all need to reflect the interests of these contributors. If, for example, the National Science Foundation, which funded a large portion of *Plum Landing* (Paulsen & Carroll, 2010a), decided funding a show about climate change was not in their best interest, PBS would have few alternatives for supporting the project. At best, climate change would have to be tempered with other educational objectives. Like *Plum,* the show could focus on getting children outside, and thinking like scientists. At worst, it would not get produced at all.

Aside from the "controversy" of climate change, there are genuine concerns about the type of show I have described. The greatest concern is that the issue of climate change and the science behind it is too advanced for children age six to nine. Explaining the processes of carbon emission, radiation entrapment, ocean warming, air current stagnation, rainfall patterns, and the slew of other causes and effects of climate change is undeniably complicated. Even though young children have shown the ability to grasp some complex scientific concepts, understanding these topics requires a significant amount of previous knowledge and experience. Terry Green voiced this same concern, saying that "for a topic [like] global warming, kids need to have the basic understanding of 'How does the environment work, and how do all these other factors influence it?' and then 'What do I do

that is influencing it?' (Green, personal communication, December 11, 2014). However, as with any scientific concept, the way the topic is contextualized and the level of detail is catered to the audience. Applying the best practices that I explained above make climate change approachable and teachable to a young audience.

Ideological differences aside, some of the best practices I have outlined—particularly drawing upon a familiar environment like a backyard and the use of animals—are only practical for an audience who has access to familiar natural spaces and appreciation of animals. WGBH chose to focus on these findings because, statistically, for their predominately white demographic, most of their viewers either live in close proximity to nature or have the ability to travel to natural spaces. However, these solutions exclude children living in urban areas, particularly poor urban areas, from relating to issues of the environment. It is not only important, then, but critical to develop more inclusive practices to teach children about the climate. Conducting additional interviews and surveys that address the needs of children from low-income urban neighborhoods could provide valuable insight into how the environment can be best contextualized given that many of those children will not have had personal experiences with the natural environment. Purely speculating, possible solutions could include studying weather and temperature, investigating places in the city that are cooler because of shade versus warmer areas out in the open, and other areas of knowledge that come directly from the experiences of living in a city. All children will be affected by climate change, and children living in cities need just as much knowledge about the changing planet as children living in rural and suburban areas.

From a production perspective, increasing the age range to eight to twelve would make the show easier to write since the children would have more tools for understanding the science. Twelve year olds are cognitively more mature, have more life experience, and have learned more about the environment in school, which gives them more knowledge to bring to the discussion of climate change. Writing an episode where the audience can understand more nuanced concepts means the quality of the information is better. But what keeps me from making the age shift is the behavioral component. Several studies of social and emotional learning suggested that children become less receptive to prosocial programming after age seven (Mares & Woodard, 2001). Just as the goal of prosocial programming is to impart prosocial behaviors, the goals of a children's environmental show include promoting pro-environmental behaviors. Although the two are not the same, prosocial behaviors provide a natural anchor for environmental action given the shared emphasis on empathy, cooperation, and non-violent decision-making skills (Christensen & Myford, 2014). If, over time, children become less willing to adopt the prosocial behaviors they see in prosocial programming, there is reason to believe that they will become less willing to adopt positive environmental behaviors, too.

The pros and cons of teaching the environment at different age levels open up the possibility for a differentiated curriculum. While it is appealing to imagine the silver bullet of children's environmental television—a single show that is the perfect assemblage of the best practices for the ideal age group—it is also a difficult order to fill. So rather than create a single show targeting the earliest age group ready to learn everything about climate change, a better option would be to develop several shows that each focus on a particular aspect of positive environmental education. Taking cues from how the Massachusetts

Science and Technology/Engineering standards began, a show for Kindergarten aged children could focus predominately on observation, weather, the sun and moon, and animals. Graduating into older grades, the show could emphasize the interrelation of all life; how the Earth is made up of systems that affect one another. Eventually, when a child has enough preexisting knowledge, a show could build on those concepts with more specific information for how climate changes works. The common threads of first-hand experiences in nature and pro-environment behaviors can be woven throughout. This type of televisual media-based curriculum takes advantage of the fact that children at almost all ages not only can benefit from learning something about the environment, but the cognitive capacity, as well.

Just as the content can be varied, incorporating different technological platforms can help make learning about the environment and climate change a richer experience. For an interactive platform like an iPad, which offers the ability to physically engage with the medium, environmental apps, games, and activities are ideal. If part of the televisual media learning experience included a stunning nature documentary akin to *Planet Earth*, a television screen would better captivate an audience than a computer screen. And if a show included many short video segments, such as webisodes like in *Plum Landing* or short live action vignettes, the mobility and flexibility of a laptop fits that media experience. With such a diversity of technology, as well as the uneven accessibility to some newer platforms, continuing to develop a range of televisual media for children's environmental education is the optimal solution.

The obstacles of creating an environmental children's television show about climate change are diverse, but not insurmountable. Focusing on key aspects of the environment,

such as animals and a child's backyard, can make the issue tangible and relatable for some children. And connecting these topics to an exotic ecosystem adds excitement to nature. Focusing on positive behaviors—on solutions—helps children engage with their learning and feel like they can make an impact. And above all else, inspiring children to see the value of the environment and the beauty of nature by getting outside and exploring will make learning and combatting climate change not just worthwhile, but a necessity.

To have the greatest impact, the newfound knowledge of the best ways to frame climate change must be coupled with efficacious ways of actually delivering the information to children. The lack of environmental education in schools and the complete disregard of climate change in government do not make it realistic to rely on the traditional avenues of change. The push for greater STEM content in state-mandated curriculum holds potential to include environmental topics in the classroom, but as evidenced by schools like the Hanscom Middle School, climate education will fundamentally conflict with people's ideologies. The ubiquity of televisual media, whether it is television or the rise in digital platforms, has the power to reach a large and diverse population, present the climate information in engaging ways, facilitate interactive, experiential learning, and inspire a sense of wonderment in nature. It requires smart, researched, and well-funded programming, but climate and environmental education for children through televisual media can and should be done.

Conclusion

Although my own research explores the scope and limitations of children's understanding of climate change, the effectiveness of televisual media to educate and to impart prosocial and environmental behaviors, the rise of digital platforms that facilitate

interactive learning, as well as suggests best practices for science education and ways to make climate change relatable, there is great need for additional research to further the study of all of these topics.

First and foremost, the literature on climate change communication would be hugely improved by a long-term, large-scale study on children's view on climate change. Though there were smaller studies, such as the Canadian study comparing the climate knowledge of children from Montreal and a nearby suburb, and the independent research conducted by WGBH for *Plum Landing*, there is no comprehensive analysis of children's views and understanding of climate change. Such a study should ideally span a geographically, socioeconomically, and racially/ethnically diverse sample to ensure all opinions, beliefs, and knowledge levels are acknowledged. This would by no means be easy to develop nor execute, but the results would provide helpful clues for what needs to be improved in environmental education, as well as what factors influence a child's understanding of climate change.

In a similar vein, more research should be conducted that investigates ways to get children who do not have easy access to nature, such as children from urban areas, more engaged and interested in the environment. My research demonstrated that firsthand experiences in nature are the strongest factor in promoting pro-environment behaviors and establishing a connection to the environment. Without these experiences, people are less compelled to fight to protect the environment. How, then, should we teach topics on the environment to children who are the furthest removed from it? What would be the best way to frame climate change for these children when they do not have a backyard to which

they can relate it? And when they are so far removed from nature, would they even see value in learning about it?

For children who do have the luxury of having a backyard or other nearby natural spaces, more research should be conducted that addresses whether children can understand the causes and effects of climate change in the context of their own life. What makes climate change so complex and difficult to teach is the indirect way our own daily actions impact the environment. Turning off lights when not in use is a positive environmental behavior, but one that does not clearly relate to the climate. At what age can children begin to make the connections between these behaviors and how it impacts the environment? And vice versa: At what age can children make connections between something happening in their backyard as a result of climate change and their own actions? Are these important connections to draw, or does the reality of a child's role in degrading the environment instill more fear than it does encourage action? The results of this study would be particularly useful for developing a variety of environmental educational curricula for classrooms and media.

Since not every environmental behavior is clearly related to preserving the environment and fighting climate change, more research should be conducted on the types of behaviors that children respond to the best. Additionally, given that research suggests that after age seven children show less willingness to adopt prosocial behaviors, is there a similar decline in willingness to adopt pro-environmental behaviors? Does the increasing amount of knowledge and awareness about the environment as children get older work with or against the adoption of behaviors? And would more children adopt a specific environmentally positive behavior if it was featured in an episode of an environmental

children's television show and modeled by characters in the show? More importantly, do these types of behavioral changes persist, or do they only last while the episode is fresh in the child's mind?

There is also a huge need for research on the developmental benefits and risks of educational media hosted on digital platforms. It seems that devices like iPads facilitate greater interaction between the child and the educational material due to the touchscreen, the ability to link activities, games, and apps, and perhaps even its size. But how does the learning from televisual media on an iPad compare to a traditional television screen? Does the association of television with important information and entertainment have anything to do with how much a child pays attention and retains the information being presented? More importantly, does the more personal, binge-watching experience of televisual media on a computer or iPad affect a child's retention of the material? Broadcast television is more conducive towards parent-child co-viewing, but does the ability to repeatedly watch a show free from programming schedules, as well as rewind it and share it create more opportunities for learning? How often are parents actually watching televisual media on a digital device with their child?

These are only a sampling of the questions that future research should address. Between the transition from broadcast television to digital platforms, the lack of knowledge and education of climate change, and the conflicting research on whether viewers can learn prosocial behaviors from televisual media, the need for continued research is immense. An issue as multifaceted, complex, and grave as climate change requires immediate and informed action from all angles and from all people. Perhaps overlooked, televisual media holds untapped potential to teach about climate change, and

for an audience that will undeniably bear the consequences of our environmental inaction—children.

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