ABSTRACT

HARTLEY, JENNA MARIE. Change-Makers in Chuck Taylors: How Youth Can Impact the Environmental Attitudes of Their Local Officials via Intergenerational Learning. (Under the direction of Dr. Kathryn Stevenson).

Plastic pollution from marine debris is one of our most pressing environmental problems: it can damage marine and coastal ecosystems, threaten food security and safety, and even endanger human health. Without intervention, the flow of plastic into the ocean will reach 710 million metric tons by 2040, presenting a growing threat to marine ecosystems and people depending on them. Although scientists continue to address the crisis with technical solutions, community and government support are necessary to prevent and remediate plastic pollution. Unfortunately, progress on environmental issues is stymied by deep divides in two areas: political party and age. However, recent research has shown that young people have the capacity to bridge these gaps and bring adults towards environmental consensus in a process called intergenerational learning. This research explores whether K-12 marine debris education designed to maximize intergenerational learning may be a powerful strategy to accelerate interdisciplinary, community-level solutions to the marine debris crisis. An educational curriculum was implemented in elementary school classrooms across the state of North Carolina, USA, testing the potential of intergenerational learning to increase levels of marine debris concern among children, their parents, and even their adult-aged community members. The efficacy of this intervention was empirically tested through quantitative pre- and post-surveys of students and their parents; retrospective post- surveys of local officials tested the efficacy of the intervention beyond the immediate family dynamic and into the political sphere. Emerging results from this research suggest novel findings in the field of intergenerational learning, on the topic of marine debris, and in the sphere of youth political participation. Most importantly, this

work measures the potential of children as powerful family and community change-agents on environmental issues. The power of this cannot be overstated, nor can the need for change in a time of environmental urgency.

Change-Makers in Chuck Taylors: How Youth Can Impact the Environmental Attitudes of Their Local Officials via Intergenerational Learning

by
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DEDICATION

At its core, this work is about education, and the heart of education lies within the teachers working day-in and day-out to make the world a better place. Therefore, this work is dedicated to the participating teachers and students that made this project possible, all along believing and practicing one of the main tenets of the North Carolina State University Environmental Education Lab: education is empowerment.

BIOGRAPHY

Jenna was born-and-raised in North Carolina to a long line of dairy farmers. She grew up among the pines in southern Orange County on a plot of land surrounded by family. She has fond memories of being able to run barefoot between family members' houses, not realizing at the time how uncommon and special this close family proximity was. In the summers, she often visited her large extended family members either on the dairy farm in Charlotte or in the mountains of Montreat. Although she didn't necessarily consider herself a "nature kid" from a young age, she was certainly embroiled in some cousin-led nature shenanigans both on the farm and in the mountains like rock-hopping, looking for crawdads, running from cows, hiking, playing in old hay barns, or riding homemade go-karts on dirt trails around the farm.

She was inspired by her Orange High School AP Environmental Science teacher, Mrs. Lisa Seidensticker, to think more critically about the environment, but didn't feel particularly strong in the sciences, so went to college with an anticipated Spanish major. At Beloit College, Jenna played soccer and was lucky to be assigned Shannon Carmody as her freshman roommate. Shannon invited Jenna to come along on a trip that Shannon had written a *Beloit College Venture Grant* for, where Shannon planned to investigate invasive species along the banks of the Colorado and Utah rivers. That rafting trip through slot canyons opened Jenna's eyes to science in a hands-on way that hadn't happened before – Jenna came home declaring that she was going to be a geology major having never even taken a geology class. Three years later, Jenna graduated with a BS degree in Environmental Geology, as well as additional geology field experiences in Ecuador, Puerto Rico, Colorado, and Montana granted by Beloit College, the National Science Foundation-Research for Undergraduates, the Keck Geology Consortium, and the Yellowstone-Bighorn Research Association.

Channeling Mrs. Seidensticker, Jenna went on to teach high school Earth Science in New York City as part of the New York City Teaching Fellows Program post-graduation. She taught Earth Science high school courses during the day, coached the soccer and handball teams in the afternoons, and earned her Master's degree in Secondary Science education from CUNY-Lehman College in the Bronx during the evenings. Jenna stayed in New York City for four years, until the pull of the pines and family brought her back to her home state of North Carolina. In fact, she went back to her high school alma mater and taught Earth Science, Biology, and AP Environmental Science in the same classroom where Mrs. Seidensticker had taught her years before. Jenna taught and coached soccer at Orange High School for another 3 years, where she cemented her growing belief that young people are motivating leaders in environmental fields.

Inspired by a local Professor who spoke at a professional development workshop for environmental science teachers one summer, Jenna returned to graduate school at the University of North Carolina at Chapel Hill to work towards her MS in Environmental Sciences & Engineering while still coaching the Orange High School women's soccer team and serving as a Graduate Research Assistant for the UNC-Chapel Hill Varsity Women's Soccer program (and getting married!). While presenting her research at a conference, she sat at a table where she knew no one, and two of the attendees were ASPPH (Associations of Schools and Programs for Public Health) Fellows hosted by the U.S. Environmental Protection Agency. Jenna made note of how wonderful the program sounded and applied a year later to join the next cohort. By a stroke of luck, one of the U.S. EPA hosts that year was looking for someone with experience in education, and Jenna joined the EPA as an ASPPH Fellow after the birth of her first child.

At the U.S. EPA, Jenna joined the EnviroAtlas team, where she worked on preparing educational materials for the tool and communicating the science of EnviroAtlas extensively to students and teachers both locally and across the country. This environmental education (EE) work was incredibly rewarding for Jenna and she wanted to further her credentials in the EE field. She received her North Carolina EE certificate from the current U.S. EPA administrator, Michael Regan, and was awarded as the *North Carolina Environmental Educator of the Year* award as part of the Governor's Conservation Achievement Awards in 2018. Motivated by the EE field and feeling like she was finally "home," Jenna presented at the Environmental Educators of North Carolina conference where she (again!) sat down at a lunch table where she knew no one. She struck up a conversation with Danielle Lawson, a PhD student at the time and now EE Professor, who was part of the NC State University EE lab.

Danielle introduced Jenna to her advisor, Dr. Kathryn Stevenson, and Jenna immediately felt connected to Dr. Stevenson and the work that she and her students were doing as part of the EE Lab. Shortly thereafter, Jenna began her role as a PhD student researching the work that is shown throughout this dissertation. In an interesting turn of events, she also moved back to the same area where she grew up with her family, thus creating her own multi-generational living situation in which her son interacts with multiple generations of family on a nearly-daily basis, informing both Jenna's intergenerational learning research and personal life in myriad ways.

Still enjoying her work with the U.S. EPA, Jenna has maintained a part-time education and outreach role there while also pursuing her PhD full-time. She was lucky and honored to be selected as a NOAA Dr. Nancy Foster Scholar after her first year as a PhD student, and since beginning her PhD program, has expanded her family, as she welcomed twins Booker and Della in August 2021. Going forward, Jenna is open to many job and career options, and looks forward to additional opportunities to continue practicing and learning environmental education in ways that are meaningful for people of all ages, backgrounds, experiences, and walks of life.

ACKNOWLEDGMENTS

All of this work and research centers on young people, their educations, and their families. Therefore it perhaps should come as no surprise that my family has been the singularly most supportive force in my PhD experience. There are far too many friends and family members to thank here, but first and foremost, none of this would have been possible without my partner, Keith. Since starting my PhD program with a two year-old and then getting pregnant in my third-year of the program with twins (due anytime in the next two months!), there have been innumerable occasions during this PhD process when I have leaned full-freight on Keith to keep our family together. He has worked, cooked, cleaned, participated in daycare drop-offs and pickups, and in the first years when my course load was heavier, he played all weekend with our son Everett while I worked on squeezing everything in. It would have been impossible for me to pursue this dream without his support and encouragement. Thank you, Keith. I am hopeful that in the long run, it was the right choice for our family – you have always encouraged me to keep that long view in mind throughout, and I am grateful for it.

Similarly, I have been fortunate to live near extended family such that they could be supportive in a likewise fashion. Thank you to Chuck, Mary, Buddy, Ellen, Beth, Alex, Sam, and Kelli for the familial support, breaks from work, and perhaps most importantly, food. It seems like a small thing, but there were so many times where it made all the difference. Thank you.

Huge thank you to the educators and teachers who believed in this project and made it happen. Over 60 teachers and thousands of students participated. We're all so grateful. Also, an enormous amount of gratitude to Dr. Liz DeMattia, the fearless leader and educational wiz at the helm of the Duke University Marine Lab Community Science Initiative who wrote the marine debris curriculum that this research centers on. Liz, you have been such a delight to work with –

thank you for making all of this simultaneously fun and rigorous. Thanks also to technical consultants Renee Strnad and Dr. Jenna Jambeck for their expertise on environmental education curriculum development and the topic of marine debris, respectively. It was an honor to include such high-level experts on our team.

Thank you to the financial supporters that made an undertaking like this possible, and to Susanna Klingenberg for helping me apply to many (if not all!) of these opportunities! Specifically, thank you to North Carolina Sea Grant for funding this research idea and project, thank you to the NOAA Dr. Nancy Foster Scholarship program for taking a chance on me as the first education-focused scholar they have ever had (it has been an honor I've worked hard to try and live up to!), thank you to the Beth Wilson Scholarship and the Warren Wolfpack Scholarship both from NC State University, and thank you to the Phi Kappa Phi Honor Society. As a part-time working mom pursuing a PhD, the financial support offered by these institutions was the only reason that I was able to join, participate, and complete a PhD program, truly. In a similar vein, thank you to my mentors and colleagues at the U.S. EPA, who supported my shift from a full-time position to a part-time position with lots of flexibility to enable my participation in this PhD program while continuing to work on the EnviroAtlas project, which is so near and dear to my heart. Special thanks to my mentor Jessica Daniel, who epitomizes good mentorship – Jessica, you see me in a way that I may never be able to see myself, but I will always strive to be the person you think I am. Your confidence in me is something to behold. I don't know what I did to deserve you as a mentor, but I do know that I'm the better for it. Thank you.

Special thanks to the other students in the NC State Environmental Education lab. Dr. Stevenson has cultivated a lab that is simultaneously rigorous, hard-working, and relentlessly supportive and fun. These might seem like delicate traits to balance among a group of people, but

I commend Dr. Stevenson for making it happen. Danielle Lawson, Brent Jackson, Caitlin Reilly, and Lauren Gibson are some of the people I admire most in our field, and I can't wait to continue to be their friends and colleagues for years to come. Danielle, thank you for taking me under your wing from that first lunch at the EENC Conference and ever since. It was so affirming to watch how much you embraced collaboration and good teaching just in how you helped me – I am so happy for your new role as a Professor at Penn State and I know that your students are just as lucky to have you as I was.

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I have felt so fortunate to have a PhD department and committee that oozes support from every angle. I can't describe how much I have learned and grown from them, in ways both edifying and powerful. Thank you to the PRTM Faculty and Staff – I have always felt so welcomed and loved in the department. Dr. Sarah Carrier, thank you for believing in me far more than I believed in myself, and for encouraging me to start to see some of that with my own eyes. That may be the best gift a teacher can give someone, and you write the book on doing it well. Dr. K.C. Busch, you are the teacher I aspire to be! I remember taking your evaluation class with two notebooks always open – one to take notes on the material, and one to take notes on your pedagogical strategies in the hopes that someday I might be able to implement them in my own classroom. Thanks for opening your heart to all of your students – so many great teachers and impacted students will continue to come out of your daily work. Dr. Nils Peterson, you are a hilarious genius. I loved meetings with you to talk about papers and statistics, because I always

left feeling smarter and lighter having laughed through most of it (and that says a lot, considering my initial phobia of statistics). Thank you for sharing your wisdom and humor with me, all while setting a perfect example of how to separate life and work, and enjoy the more important things at every opportunity. And finally, Dr. Stevenson: Kathryn, words won't ever suffice. Goethe said, "What chance gathers she easily scatters. A great person attracts great people and knows how to hold them together," and I think this suits you perfectly. You cultivate both light-hearted camaraderie and a hard work ethic (no easy task!), and it has been such an honor to learn and grow under your leadership and feel supported by you and those in your lab through all aspects of life. The fact that you were on speed-dial when I went to the Emergency Room is a testament of how much you care deeply about the health, well-being, and success of your students. My gratitude for you knows no bounds, and I am excited to finally graduate and officially call you my friend whether you like it or not. ☺

Finally, a huge thank you to my son Everett. Everett, you might not know it, but you have had a huge impact on my PhD. You were two when we started this, and you'll be almost six and a big brother to twin babies Della and Booker when all is said-and-done. Through these past few years, you constantly helped me to stay grounded and focus on the here-and-now. Thank you for giving me so much grace, for loving me so fully and without expectation, and for always knowing exactly the right time to shut the computer screen and say, "*Bye-bye, work! Time to play*!" I love you now and always.

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CHAPTER 1: Introduction

Background on Environmental Education

Environmental education (EE) is poised to offer multiple opportunities for solutions in the current environmental movement (Blumstein & Saylan, 2007). One of the emerging trends in EE is a move away from information-delivery instructional methods and more towards curricula that allow students to make real-world, data-driven decisions that result in local actions. As such, EE curricula have recently been increasingly embedded into national educational learning environments both internationally and in the United States. Globally, multiple countries including India, Brazil, Kenya, Philippines, China, Japan, Tanzania, Colombia, and Finland now mandate EE for all formal schooling (Earth Day, n.d). In the United States, EE programming is eligible for funding under Title IV, Part A of the "Every Student Succeeds Act" (ESSA, 2015). This recent financial and political support for EE across US classrooms resulted in the 2018-2019 school year having the highest budget allotment for EE in history. While this increase in attention, concern, and financial backing for EE is promising, questions remain as to the efficacy and ability of EE programs to promote change.

There has been no time in history when environmental problems have been so ubiquitous or threatening to humanity (Almeida, 2015; Cuff & Goudie, 2009; Diamond, 2005; Earth Summit, 2012; Krapivin & Varotsos, 2007; Nielsen, 2005; Pretty et al., 2007). Recent assessments from the U.N. paint a disheartening picture of the globe's environmental future, with executive director of U.N. Environment stating that if people fail to make fundamental changes in their consumption patterns, we will be continuing towards a "bleak future" (Parker, 2019). The environmental status of the planet seems to be standing at an important crossroads – scientists claim that the Earth can recover and pivot towards a more sustainable future, but only if paradigmatic shifts are made to alter how and what humans consume, how we produce energy, dispose of waste, and decrease our negative impacts on the planet's air, water, and land (Parker, 2019). EE is an important mechanism for positive change, and youth empowered by EE have made significant local and household changes in environmental behaviors (Duvall & Zint, 2007), but some argue that, "by most objective measures, the money granted [for EE] has been wasted" because people have failed to make the personal connection between the state of the environment and their personal actions (Blumstein & Saylan, 2007, p. 974). EE is not alone in its struggle to link pro-environmental attitudes to behaviors and even environmental policy; indeed, the disconnect between effectively shifting environmental attitudes into environmental behaviors is one that has puzzled conservationists, scientists, and environmentalists for decades (Heberlein, 2012). However, the EE field has made great strides to close that gap by establishing environmental literacy guidelines, a framework which merges awareness, knowledge, attitudes, skills, and behaviors (Hollweg et al., 2011). Thus, EE researchers and practitioners have taken to combining these elements in EE programming and instruction to maximize environmental literacy and, consequently, potential environmental behaviors.

Linking Generations: How Do Children Hold Promise?

Considering that the family unit is one of the strongest communication systems (McLeod & O'Keefe, 1972), one method for examining, predicting, and possibly influencing individual environmental behaviors is within the family context. The family is a dynamic social group in which both parents and children learn from and teach each other in a multigenerational social system (Yerby, Buerkel-Rothfuss, & Bochner, 1990). Transmission of information within families can impact familial attitudes on multiple environmental topics ranging from consumer behavior (Ekström, 1995; Moore, Wilkie, & Lutz, 2002) to environmental issues (Easterling, 1995; Ballantyne, Fine, & Packer, 2001; Grønhøj, 2007) and climate change (Lawson, et al., 2019). This bi-directional transfer of knowledge from child to adult and/or vice-versa is referred to as intergenerational learning, or IGL (Bottery, 2016; Duvall & Zint, 2007). Although evidence is strong for IGL influence running in the direction from the parent-to-child direction on various topics including choosing to eat organic foods, purchasing environmentally friendly products, curtailing electricity use, and handling waste responsibly (Gotschi, Vogel, & Lindenthal, 2010; Grønhøj, 2007; Grønhøj & Thøgersen, 2012), experimentally-designed quantitative evidence for IGL in the child-to-parent direction has only been emerging in recent years (Lawson et al., 2019). IGL programs that are designed to be hands-on, focus on local issues, include field-based experiences, and encourage parental participation have been shown to accelerate this type of environmental literacy and IGL in both students and their parents (Duvall & Zint, 2007; Lawson et al., 2019). Therefore, we recommend IGL programming as a mechanism by which to teach EE, encourage engaging family conversations at home, and link attitudes and behaviors for both students and parents, and potentially even wider adult audiences, thereby providing solutions for some our deepest environmental problems.

Although most IGL research to-date has focused on the internal family dynamic, a recent surge in youth environmental activism suggests that the influence of young people may extend beyond their immediate families. For example, youth have been leading environmental movements in multiple environmental contexts ranging from local issues such as “Little Miss Flint," Amariyanna Copeny, tackling lead in her Michigan, USA community during their water crisis at age 8 (and subsequently being invited to the White House to meet the President of the United States) and Greta Thunberg leading international school strikes to spur climate change action at age 15 (and subsequently speaking in front of international leadership; Marris, 2019).

Additionally, international youth-led activist groups such as Student Strike for Climate Action and Extinction Rebellion have ushered in youth political support for the issues of environmental degradation in attempts to make up for the ways they perceive their governments have fallen short (Payne & Hart, 2020). Around the world in recent years, these protests have taken to the streets to urge policymakers and politicians to act quickly on environmental issues (Payne & Hart, 2020). Thunberg's initial sit-in at the Swedish Parliament led to worldwide protests and media attention about climate change and earned her a spot at the UN Climate Conference, where she held world leaders accountable for their role in climate change, asking them "*how dare you*?" (Payne & Hart, 2020). But Thunberg is not alone: in addition to participating in classic models of political participation – for example, young people are running for and winning public office at astonishing rates (Eichen, 2018). Today's youth are challenging the familiar model of institutional political participation that once belonged to past generations and making it into their own form of "engaged citizenship" through non-institutionalized means such as school strikes (García-Albacete, 2014); social media campaigns (Scherman et al., 2015); and taking on leadership roles within organizations and communities (Zeldin et al., 2013).

Despite a new, politically active generation of young people increasingly on the rise (e.g., in a U.S. national poll, 83% of youth surveyed said that they believed they had the power to change the country and reported practicing subsequent actions related to those attitudes; CIRCLE, 2020) as well as emerging, novel methods for youth political participation (Shea & Harris, 2006), youth political activism is not new. Indeed, social movement scholars have long agreed that young people have been historically and still are presently key actors in the rise and success of many social movements, claiming that "… it is hard to imagine the landscape of activism in the United States without the efforts of young people" (Earl et al., 2017, p. 2).

However, little is known empirically about exactly how youth-led movements impact adults, particularly among those who have the political power necessary to impact policy and legislation. Although one recent report notes that adults hold positive perceptions of youth in political spheres (Thew, 2018) and while there are cases of youth playing a role in politicizing or influencing their parents (Bloemraad & Trost, 2008; Lawson et al., 2019), no report quantitatively cites the impacts of youth on adults' (other than their parents') levels of concern or levels of support for marine debris policy and/or ordinances, specifically adults that are elected political officials.

Marine Debris: A Pressing Environmental Topic for Youth Environmental Activists

Of the myriad environmental issues facing humanity today, one that has tangible and real-time policy implications for change is that of waste disposal, and specifically, plastic. The issue is multi-faceted: plastic serves many critical functions for humans, while also polluting the air we breathe, water we drink, and even rainfall (Brahney et al., 2020). These impacts are most acute for vulnerable human populations (Bullard, 2008), but can extend across many sectors, such as damaging marine and coastal ecosystems (Elias, 2018). Over a third of plastic produced is used to make packaging items, most of which are quickly discarded (Thompson et al., 2009). These durable "single-use plastics," in particular, may persist in the environment for centuries to millennia (Elias, 2018), and without comprehensive and aggressive intervention, the flow of plastic into the aquatic environment is projected to reach up to an annual 20 – 53 million metric tons by 2030 and a cumulative 710 million metric tons by 2040 (Borrelle et al., 2020; Lau et al., 2020). Current trends in total plastic production worldwide suggest that, given a business-as-usual scenario, "the total amount of plastic waste available to enter the marine environment from land could increase by an order of magnitude even over the next decade (2015-2025)" (Worm et al., 2017, p. 6).

Building students' ocean literacy—an understanding of how the ocean and humans are interconnected—is critical to address marine debris as it ensures a future citizenry has the knowledge, skills, and motivations to support healthy marine ecosystems (Hartley et al., 2015; NOAA, 2013). Furthermore, K-12 schools serve as community centers, with that role being strongest in underserved communities (Bingler et al., 2003). Within these school settings, curricula rooted in citizen science (wherein youth contribute to the collection of scientific information [Bhattacharjee, 2005]) are positioned to extend youth-led engagement from family units to the communities, as citizen science is an inherently public process (Turrini et al., 2018). Children are well-positioned to inspire awareness and action on marine debris among their parents, as has been shown in environmental contexts like flood resilience and climate change (Lawson et al., 2019; Williams et al., 2017). Furthermore, marine debris is a compelling environmental cause for young people to champion (Hartley et al., 2015) because the problem is highly visible, persistent, and concrete solutions like trash reduction are readily apparent (Torres et al., 2019). A recent study found that environmental advocacy videos on the topic of marine debris were able to reduce attitude and behavioral gaps between partisan groups (Jennings et al., 2020). Engaging with younger audiences on marine debris therefore provides a promising approach to address a pressing environmental issue and an opportunity to empirically evaluate the community impacts of political activism led by young children (Ballantyne et al., 1998; Duvall & Zint, 2007; Lawson et al., 2019).

Dissertation Focus

This dissertation proposes that EE, young people, and IGL may be one way to bridge the divide between marine debris attitudes and behaviors in order to catalyze change across generations at a critical point in environmental history. This Ph.D. dissertation will explore the use of IGL within the field of marine debris-based environmental education through an article-style dissertation. Specifically, all research studies herein will occur within the state of North Carolina, ranging from schools in counties from the mountains to the sea. The overall research questions driving the study are: Which factors predict the marine debris behaviors of young people, and are familial factors related to IGL significant predictors? Also, does marine debris education increase concern for marine debris and/or support for marine debris policy among community adults and local officials through intergenerational learning?

Guided by these research questions, this article-style Ph.D. dissertation is designed to (1) *situate* the overall study in theory, (2) *experimentally test* whether the key intergenerational learning elements exist in both the marine debris and younger child context, and then (3) *build* on what we know about intergenerational learning to take it beyond just the dynamics of the immediate family and explore how far it might be able to extend. Accordingly, each of the three main chapters will be written as a peer-reviewed manuscript covering the following topics: (1) presenting a a framework for incorporating IGL-focused marine debris curricula into formal educational setting, drawing on promising practices from environmental education, civic education, and IGL literature; (2) identifying predictors of youth marine debris behaviors within a family context; and (3) presenting evidence of youth influence on marine debris concern and policy support among adults and local officials in their communities, including overcoming political divides. Through this work, we hope to propel multiple different areas of research, including environmental education, intergenerational learning, and solutions for the marine debris environmental crisis. In conclusion, this dissertation purports that intergenerational learning work of this nature can potentially help to close some of the largest divides on environmental issues – the widening partisan gap and the large generational gap – with young people bridging barriers and truly, meaningfully, being at the heart of community-wide change.

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CHAPTER 2: Intergenerational learning: A recommendation for engaging youth to address marine debris challenges

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Abstract

Youth can impact environmental attitudes and behaviors among adults. Indeed, research on intergenerational learning has demonstrated the influence of young people on adults in their lives for myriad environmental topics. Intergenerational learning (IGL) refers to the bidirectional transfer of knowledge, attitudes, or behaviors from children to their parents or other adults and vice versa. We suggest an educational framework wherein K-12 marine debris education designed to maximize IGL may be a strategy to accelerate interdisciplinary, community-level solutions to marine debris. Although technical strategies continue to be developed to address the marine debris crisis, even the most strictly technical of these benefit from social support. Here, we present 10 Best Practices grounded in educational, IGL, and youth civic engagement literature to promote marine debris solutions. We describe how integrating IGL and civic engagement into K-12-based marine debris curricula may start a virtuous circle benefiting teachers, students, families, communities, and the ocean.

Introduction

Plastic marine debris damages marine, freshwater, and coastal ecosystems (Elias, 2018) threatening food security, food safety, and human health (Barboza et al., 2018; Rhodes, 2018). Although the "Age of Plastics" (Avio et al., 2017) has provided modern conveniences including disposable packaging, sterile medical products, and transportation components that reduce fuel usage, over a third of the global plastic produced is made into single-use items and used in packaging products (Thompson et al., 2009). Without comprehensive and aggressive intervention, the flow of plastic into the aquatic environment will reach up to an annual 20 – 53 million metric tons by 2030 and a cumulative 710 million metric tons by 2040 (Borrelle et al., 2020; Lau et al., 2020), presenting a growing threat to marine ecosystems and people depending on them (Gall & Thompson, 2015; Lau et al., 2020; Rochman et al., 2015; Wilcox et al., 2015; Worm et al., 2017).

Diverse technical strategies exist for reducing existing marine debris and preventing additional waste generation (Lau et al., 2020), and the most promising of these involve a public engagement component. Scientific advances designed for reduction and prevention include developing plastic alternatives (Löhr et al., 2017); toothpastes and face soaps free of microplastics; and filters for washing machines to capture microfibers (McIlwraith et al., 2019). These technological advances are critical to reducing plastic pollution, and their development and implementation may benefit from public and social support (Hartley, et al., 2018; Pahl et al., 2017; Vince & Stoett, 2018). Encouragingly, several technical strategies are specifically designed to engage the public. Notable examples include the popular Baltimore "Mr. Trash Wheel," a hydro- and solar-powered trash interceptor with almost 30,000 followers on Twitter (Lindquist, 2016). Similarly, Ocean Conservancy's "Skip the Straw" campaign has engaged companies (e.g., Starbucks), local communities, and schools in collaborative efforts to reduce or eliminate single-use plastics (Mahdawi, 2018). This ongoing campaign has resulted in over 19,500 pledges to choose straw alternatives (Ocean Conservancy, n.d.), in addition to sparking a national conversation on why and how to reduce marine plastic (Mahdawi, 2018). Technical solutions to environmental challenges work best when paired with socially supported institutions (Ostrom, 1990). Public engagement on marine debris has promoted corporate social responsibility (Lyon & Maxwell, 2008) and encouraged support for a future circular economy (ten Brink et al., 2008), both of which hold hope for impacts that reduce waste generation at its source. While this coupling of technical solutions with public involvement is encouraging, the plastic pollution problem continues to grow, highlighting a need to engage wider audiences.

Youth have played an increasingly important role in civic engagement throughout history, and social movement scholars agree that they continue to be "critical to the rise of many social movements" (Earl et al., 2017, p.2; Shiller, 2013). Recently, youth leadership has shaped social movements including March for Our Lives, the DREAMers, and Black Lives Matter, among others (Earl et al., 2017). This leadership includes action in environmental contexts, such as the Flint, Michigan water crisis, the fight at Standing Rock to stop the North American Dakota Access Pipeline (Hogan, 2019), and the Fridays for Future school-strike movement (Alter et al., 2019; Corner et al., 2015). In this paper, we propose that simultaneous outreach to local officials and voters via youth is a promising strategy to build community support for addressing marine debris. We offer a framework of best educational practices and examples of actionable strategies that build ocean literacy among students, contributes to marine debris research through citizen science, and empowers students to engage their parents and broader communities (see *A Suggested Framework* section below).

Building students' ocean literacy—an understanding of how the ocean and humans are interconnected—is critical to address marine debris as it ensures a future citizenry has the knowledge, skills, and motivations to support healthy marine ecosystems (Hartley et al., 2015). Furthermore, K-12 schools serve as community centers, with that role being strongest in underserved communities (Bingler et al., 2003). Within these school settings, curricula rooted in citizen science (wherein youth contribute to the collection of scientific information [Bhattacharjee, 2005]) are positioned to extend youth-led engagement from family units to the communities, as citizen science is an inherently public process (Turrini et al., 2018). Children are well-positioned to inspire awareness and action on marine debris among their parents, as has been shown to work in environmental contexts like flood resilience and climate change (Lawson et al., 2019; Williams et al., 2017). This process of transferring knowledge, attitudes, or behavior from children to adults and vice versa is known as intergenerational learning (IGL) (Bottery, 2016), and emerging research suggests that IGL from the child-adult direction might extend beyond the immediate family from children to local officials and voters. We suggest that designing education for youth-led marine debris solutions may contribute to mitigation of the marine debris global crisis by accelerating community-level awareness.

Why is intergenerational learning so promising for addressing marine debris?

Integrating IGL into K-12-based marine debris curricula may help address marine debris by starting a "virtuous circle" (Norris, 2000) benefiting teachers, students, families, communities, and the ocean. We propose that a purposefully-designed curriculum can support a virtuous circle benefiting stakeholders and the ocean (Figure 2.1). In a purposefully-designed curriculum with the links of this circle in mind, teachers engage students in learning about marine debris causes and solutions through classroom-, field-, and citizen science-based activities. Students then share what they learn with their parents and community members, creating multiple links in a circle to unite communities in response to marine debris. In such a virtuous circle, as benefits to each link (teachers, students, parents, and communities) become apparent, community support for K-12 marine debris curricula progressively grows, feeding back into the beginning of the process and encouraging future adoption. Perpetuation of this cycle can create benefits at each step and help reduce marine debris while also improving K-12 education. Links in the circle could be strengthened by young people who hold a unique power to influence their peers, parents, and potentially adult community members (Ballantyne et al., 1998). We propose that such a curriculum can support a virtuous circle, benefitting youth, teachers, parents, and community members while also providing broad benefits to the ocean.

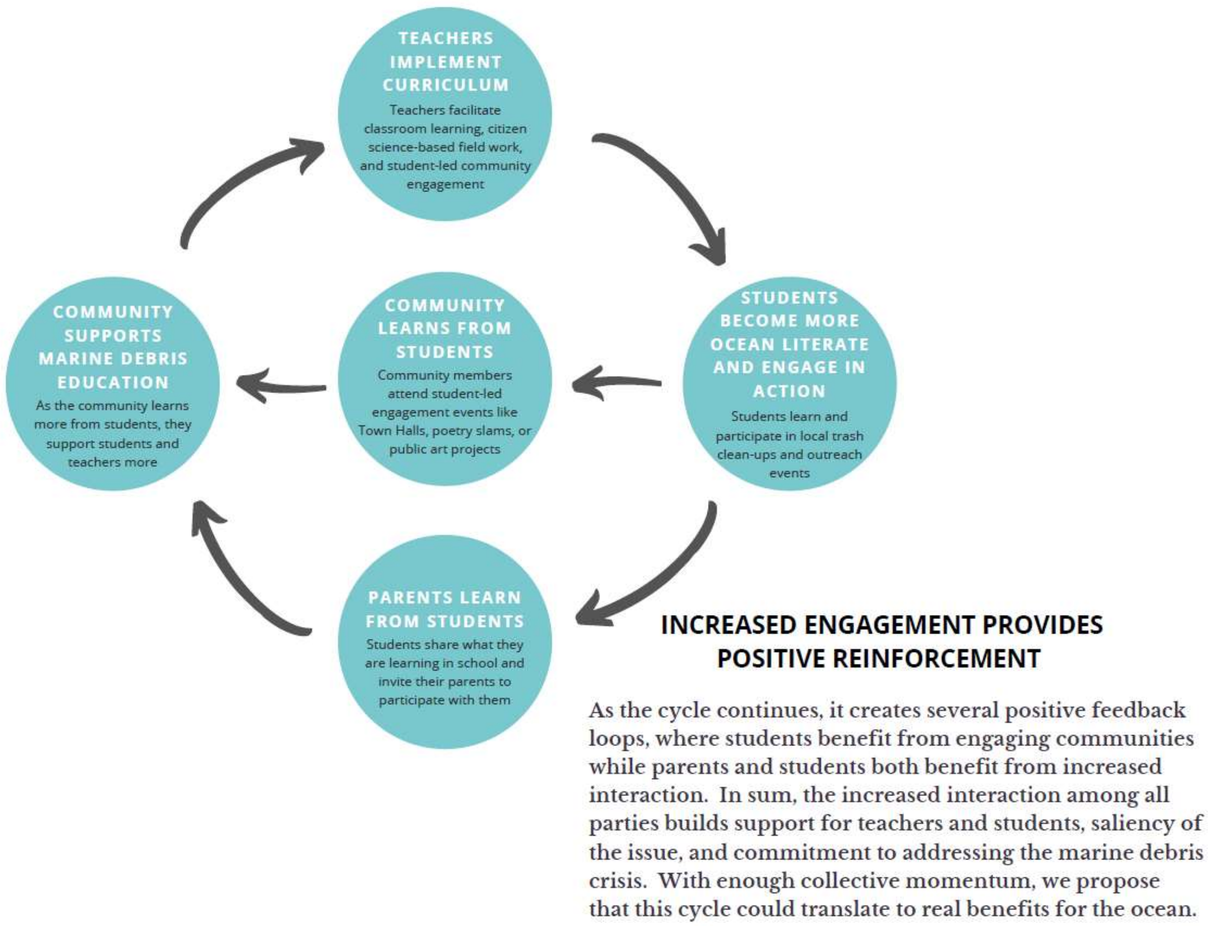

Figure 2.1. Proposed virtuous circle connecting K-12 education, students, parents, and community members**.**

Considering the first link in the virtuous circle, education for youth-led marine debris solutions has the potential to benefit teachers and students by promoting academic achievement. However, for teachers and students to benefit, the academic achievement must be linked to educational standards that often control instructional time (Johnson, 2006). Fortunately, marine debris aligns well with national science standards in many developed nations such as the Next Generation Science Standards in the United States (e.g., NGSS Lead States, 2013; Table S1), regional standards (e.g., Table S2), and localized standards such as the University of Toronto's Trash Team in Ontario, Canada (Rochman Lab, 2020; Table S3). Marine debris curricula also lend themselves to best practices grounded in learning theory. Situated learning theory suggests that direct connections between concepts covered in the classroom and daily life renders learning more effective (Brown et al., 1989; National Academies of Sciences, Engineering, and Medicine, 2018). These connections are easily made for marine debris because the debris and its sources are highly visible (Tudor & Williams, 2003) where most K-12 students live. Though the widespread nature of the problem makes it urgent, it also means students can directly address the problem with visible and tangible results (Hartley et al., 2015), such as citizen science-based waterway clean-ups or class competitions to reduce plastic use (DeMattia et al., 2020).

In addition to opportunities for standards-based, situated learning approaches, marine debris management offers opportunities for social, emotional, and cultural engagement, which improve learning outcomes for students (Brossard et al., 2005; Myers et al., 2004; National Academies of Sciences, Engineering, and Medicine, 2018; Spence, 2003; Tuss, 1996; Young et al., 2018). For instance, marine debris negatively impacts charismatic megafauna including sea turtles and whales (Ellis, 2003), triggering social and emotional connections between young people and the subject. Indeed, physical and online responses to whales and sea turtles struggling with marine debris have become paradigmatic of wildlife conservation in general. For example, a 2015 video of a young scientist pulling a straw out of a sea turtle's nose had over 41 million views at the time of writing (Figgener, 2015) and sparked international conversations surrounding single-use plastic use (Rosenbaum, 2018). Such empathetic connection to wildlife can inspire awe and wonder which supports strong cognitive connections with the animal world and sparks empathy for wildlife (Young et al., 2018).

Marine debris education in K-12 contexts can engage broad and diverse groups of parents and community members, the next links in the virtuous circle. Children have been shown to boost adult knowledge, attitudes, and behaviors related to environmental topics including air pollution, water pollution, and litter (Ballantyne et al., 2001), including increased support for watershed management (Sutherland & Ham, 1992), building flood resilience (Williams et al., 2017), and addressing climate change (Lawson et al., 2019). Notably, child-to-parent IGL has historically been effective in domains similar to marine debris (i.e., littering and recycling) (Istead & Shapiro, 2014). Child-driven IGL can be fostered through simple conversations between children and parents (Lawson et al., 2019). Child-to-parent IGL based on K-12 marine debris curricula have the potential to reach far more adults than any other marine debris program to date because 20% to 90% of all households globally include children, varying upon the country (United Nations, 2017). Additionally, child-driven public engagement events (e.g., creating public art displays from marine debris, hosting slam poetry nights, speaking at Town Hall meetings, etc.) have the potential to extend IGL beyond classrooms and dinner tables into the broader community.

In addition to building ocean literacy among individuals, efforts to link students, parents, and community members may strengthen community ties that can complete and reinforce the virtuous circle, translating to real benefits for the ocean. Supporting child-led initiatives requires adult engagement, which benefits students, parents, teachers, and communities (Henderson & Mapp, 2002). For instance, parent engagement in schoolwork leads to increased engagement and academic achievement (Román et al., 2008), improved social skills and behavior, and higher self-esteem among students (Cotton & Wikelund, 1989). Parents benefit from increased involvement by developing more sensitivity to their children's needs, increased confidence in parenting abilities, and more positive relationships with children, teachers, and schools (Henderson & Berla, 1994). Community-engaged school initiatives may lead to greater support for schools, as well as greater community cohesion, as school-based events can bring together community members who would normally not interact (Epstein et al., 2018). These mechanisms and partnerships can create positive feedback loops which add to the sustainability of these initiatives, ensuring benefits continue (Epstein et al., 2018). When linked to marine debris, this intergenerational and community-wide learning has the potential to transform how communities may approach marine debris, which is arguably needed to address the global crisis. Seeking marine debris solutions tends to be less partisan than other environmental issues such as climate change (Eilperin & Dennis, 2019), and a recent study detected that environmental advocacy videos on the topic of marine debris were able to reduce attitude and behavioral gaps between partisan groups (Jennings et al., 2020). The potential for bipartisan plastic prevention and/or reduction may help ease the way for children to develop broad community coalitions.

Although this community-level IGL has not yet been examined for the topic of marine debris, qualitative research suggests children have led communities to act more sustainably in Australia (Stuhmcke, 2012), to participate in forest renewal through planting trees in Thailand (Gallagher et al., 2000), and to participate in a beach clean-up and natural area rehabilitation efforts in Mexico (Schneller, 2008). These qualitative studies are encouraging, but empirical research is needed to test and understand the magnitude of children's influence on community-level knowledge and behavior across contexts that include marine debris. If children can inspire adults both within and outside of their families to learn about and address marine debris challenges, then K-12 marine debris curricula in the youth-led marine debris solutions model may be a catalyst for the community-level change needed to address the global crisis. The benefits to communities could be multiplicative, resulting in stronger partnerships, cleaner watersheds, waterways, and oceans. The successful creation and implementation of such an ambitious curriculum (which is not the norm in classrooms) requires the development of guiding principles supported by theory and literature**.**

Intergenerational learning: A suggested framework for helping children lead marine debris solutions

We offer ten practices for developing education for youth-led marine debris solutions that support IGL by: *1) helping students learn* (Table 1; practices 1–4), *2) helping students engage their parents* (Table 1; practices 5 and 6), *3) empowering students to engage their communities* (Table 1; practices 7 and 8), and *4) providing structural and logistical support for students who are engaging with their communities* (Table 1; practices 9 and 10). The framework proposed here is modeled after existing IGL literature reviews and frameworks (Duvall & Zint, 2007; Lawson et al., 2018) and the practices are drawn from environmental education literature (Schusler et al., 2009; Schusler & Krasny, 2010; Volk & Cheak, 2003), IGL literature (Ballantyne et al., 2001; Duvall & Zint, 2007; Lawson et al., 2018; Lawson et al., 2019), and civic engagement and youth development literature (Christens & Dolan, 2011; Derr et al., 2018; Jensen & Schnack, 2006; Kirshner, 2015; Zeldin et al., 2013) respectively.

Child-driven intergenerational learning research related to environmental behavior is a nascent field, and no one to our knowledge has investigated the potential for children to affect change in communities at the scale which we are proposing. There has been research on how children can influence their immediate families (Lawson et al., 2019), and there has been research on how best to engage children in civic action (Kirshner, 2015). Our framework (Table 1) combines these two lines of research to propose a K-12 based intergenerational learning approach for promoting civic action to address marine debris. Best practices in the framework (Table 1) are representative of the ideas we present and we offer them as illustrative examples of the points we are trying to make, but do not provide a compendium of the literature. The table

(Table 1) is structured in chronological order of actions practitioners would take, and associated references reflect paradigmatic examples for each principle. We define practitioners broadly, noting that specific actors may vary across context. We invite others to test, refine, and build upon our proposed framework.

Helping Students Learn

First, we recognize that committed and interested teachers have better success generating student enthusiasm. We suspect that this will be especially true on the topic of marine debris as teachers can visibly model marine debris prevention activities including avoiding plastic straws and not using single-use water bottles in the classroom. Teacher-related factors predict student achievement in many domains (Hattie, 2009; Mahler et al., 2018), and we expect no different in marine debris contexts. Accordingly, we suggest that *offering professional development opportunities aimed at nurturing teacher motivation* (Mahler et al., 2018) (Table 1, practice 1) and engaging motivated teachers in education for youth-led marine debris solutions may simultaneously offer benefits to teachers (e.g., increased job satisfaction: Klusmann et al., 2008; Moè et al., 2010) and to their students in the form of improved learning outcomes, ultimately supporting an ocean literate citizenry.

Second, we recommend *long-term and in-depth lessons about marine debris* (Table 1, practice 2). Ideally, these long-term lessons would incorporate the science of marine debris, its impacts, and its solutions over an entire school year or an entire unit of study. The interdisciplinary nature of marine debris instruction can facilitate a longer and more in-depth course of study because lessons can be distributed among teachers of different subjects and encompass numerous standards (e.g., Tables S1-S3). A long-term approach can also facilitate durable learning (Bransford et al., 2000; Zelezny, 1999), as well as facilitating hope by helping students see pathways to solutions before they become disillusioned (Gifford, 2014; Ojala, 2012). Hope is a prerequisite for generating conservation solutions (Hobbs, 2013), and acting on them (Ojala, 2012; Stevenson & Peterson, 2015). Accordingly, long-term approaches may ensure children grow into ocean literate adults committed to action.

Third, we suggest that interventions *focus on local marine debris issues* (Table 1, practice 3), and *use experiential learning approaches* to connect place-based learning with the larger global context (Table 1, practice 4). Focusing on local inputs to waterways, whether marine or freshwater, can facilitate a concrete understanding of sources and impacts of marine debris (Tudor & Williams, 2003), as well as leverage benefits of place-based learning, such as strengthening community bonds and building appreciation for the natural world (Sobel, 2004). The local marine debris focus can be linked to the global context through experiential learning, which incorporates action, reflection, conceptualization, and application (Kolb, 1984). Students can participate in local waterway clean-ups (action), which can promote a concrete understanding of the marine debris problem. Reflection after this experience can help students make connections between their local waterways and the global crisis (Brossard et al., 2005). Similarly, students can make local-to-global links (conceptualization) as they generate solutions to a local marine debris or freshwater debris challenge, with teachers guiding students to link their actions to the global marine debris crisis (application) (Brossard et al., 2005; Tuss, 1996). A particularly effective strategy for engaging in experiential education is through citizen science (Thiel et al., 2018). Citizen science is an emerging practice for enhancing classroom teaching (Bonney et al., 2009), developing students' scientific efficacy (Hiller & Kitsantas, 2014), strengthening students' sense of place and critical thinking skills (Jenkins, 2011) and building scientific literacy (Vieira & Tenreiro-Vieira, 2016). Two examples of marine debris-targeted citizen science projects include the *International Coastal Cleanup* (from Ocean Conservancy) and the *Marine Debris Tracker* (sponsored by the NOAA Marine Debris Program), which have connected millions of users from around the world to address marine debris (Thiel et al., 2018). Citizen science with K-12 students has addressed marine debris science on Chilean beaches (Hidalgo-Ruz et al., 2018) and rivers in both Chile (Rech et al., 2015) and Germany (Kiessling et al., 2019). Eastman et al. (2014) suggested that citizen science with students simultaneously supports school curricula, an increased understanding of the scientific process, and environmental management policies, and we agree with this potential.

Helping Students Engage their Parents

Our suggestions for helping students engage their parents or other caregivers build on the central theme of facilitating communication between students and their parents. We recommend utilizing school assignments to *provide and promote space for at-home conversations around marine debris* (Table 1, practice 5) and *encouraging parental involvement in marine debris activities* (Table 1, practice 6). Potential assignments include parental interviews or interactive family activities and also inviting parents to participate in student-led activities including service-learning projects, litter clean-ups or field trips (Duvall & Zint, 2007; Schneller, 2008). Previous IGL research suggests the substance of these activities matter less than the frequency, and that increased family interaction around environmental topics can lead to more pro-environmental attitudes and behaviors among both children and parents (Lawson et al., 2019; Stevenson et al., 2019; Valdez et al., 2018).

Empowering Students to Engage their Communities

Extending the impact of IGL marine debris curricula from classrooms to communities requires targeted efforts to empower young people. Drawing on calls to integrate more activism into environmental education (Chawla & Cushing, 2007; Stevenson, 2007), we first suggest *providing civic engagement training opportunities* for students to maximize community engagement success (Table 1, practice 7). Students can adopt diverse approaches to engaging their communities, including making public service announcement videos (PSAs), giving presentations to local Town Halls and School Boards, writing letters to their local mayors or community leaders, writing editorials for their local papers, and hosting marine debris poetry events. In the classroom, civic engagement training opportunities include real-time political discussions (Shiller, 2013), rehearsing town hall speeches (Kirshner, 2015) and encouraging youth-led efforts involving activism, media, and research as driven by their own interests (Zeldin et al., 2013). Because some adult settings like town hall meetings can be intimidating for young people, we recommend educators support students in several ways. Educators can help students prepare and rehearse presentations; give coaching and feedback without imposing adult views (Kirshner, 2015); help students envision and review what will happen upon their arrival at the venue; encourage young people to bring written and rehearsed notes; and prepare the adult audience for the youth presentation (Derr et al., 2018). Allowing students to choose if and when to engage local officials also encourages positive experiences and empowerment for youth.

A second strategy to empower students is to orient *instruction toward promoting youth decision making-authority and action competence* (Table 1, practice 8). This means letting students think critically about an issue, reflect on how to take action themselves (not as prescribed beforehand), and choose actions supporting their chosen solutions (Breiting & Mogensen, 1999). These steps require a learning environment that is inclusive, prioritizes open dialogue, has group-developed norms centered on respect, and mirrors a broader shift towards full inclusion in the group dynamic (Maine Environmental Changemakers Network, n.d.). Allowing youth to drive decision-making around civic engagement facilitates content mastery (Zeldin et al., 2013), develops agency, belonging, competence (Mitra, 2004; Zeldin, 2004), civic identity (Youniss et al., 1997), enhances community connections (Zeldin, 2004), strengthens emotional wellbeing (Zeldin et al., 2013), and can increase students' confidence (Dworkin et al., 2003).

Providing structural and logistical support for students who are engaging with their communities

Teachers and adults can help students engage their communities *by providing help in overcoming structural barriers to action* throughout the process (Table 1, practice 9). Providing this type of logistical support is critical because youth often face structural barriers linked to lack of transportation and lack of formal standing in public venues (Derr et al., 2018). Teachers can request a dedicated special youth session or time explicitly for youth voice in formal venues such as town halls (Derr et al., 2013; Derr et al., 2018). With the right preparation and support, formal adult settings can be places of high impact for youth (Derr et al., 2013; Derr et al., 2018).

Encouraging youth-adult partnerships (Table 1, practice 10) provides teachers an avenue for sharing efforts to empower youth. Youth-adult partnerships (Y-APs) exist when adults recognize youth as full partners in efforts to address issues youth face (Zeldin et al., 2013). The teachers guiding students as described in this essay represents a necessary but insufficient Y-AP. When teachers pair students with community leaders at the beginning of class projects, those leaders can develop and contribute to Y-APs. Youth-led action supported by diverse community Y-APs promote community change, stimulate critical discourse, and galvanize collective action (Zeldin et al., 2013). Higher levels of mutuality, equity, and respect between the youth and adults typically yield better outcomes for Y-APs (Zeldin et al., 2013). Effective Y-APs can propagate healthy communities by motivating existing community leaders and creating future community leaders, as youth who experience voice and power in intergenerational networks learn to see themselves as powerful civic actors (Flanagan & Christens, 2011) and have a stronger overall sense of community going forward (Evans & Prilleltensky, 2007).

Conclusion and Call to Action

Youth are already taking the lead in many social and environmental movements and are enthusiastically seeking solutions to combat marine debris (Prisco, 2017). For instance, 4th & 5th grade students led a campaign encouraging a styrofoam ban at Dunkin' Donuts (*Dunkin' Donuts: Stop Using Styrofoam Cups*, 2015) and there are many examples of recently-formed youth-led NGOs to protect the ocean (e.g., Jr. Ocean Guardians, Lilly's Plastic Pickup, Ocean Heroes Bootcamp, One More Generation, Heirs to Our Oceans). Accordingly, education for youth-led marine debris solutions has the potential to harness the energy already present among young people and mobilize change, however marine debris curricular experiences must first and foremost be added into school curricula and then should also be purposefully designed to support IGL. Multiple marine debris educational materials are already available for teachers and include the NOAA "Marine Debris Monitoring Toolkit for Educators" (Nally et al., 2018), the University of Toronto "Trash Team" Waste Literacy activities (Rochman Lab, 2020), the Washed Ashore Integrated Arts Marine Debris Curriculum (*Integrated Arts Marine Debris Curriculum*, 2020), and the Duke University Marine Lab's Marine Debris Curriculum for 4th & 5th grade students (DeMattia et al., 2020).

Although our proposed youth-led marine debris solutions educational framework may hold great promise, future research is needed to establish and understand the causal mechanisms for impacts on students, families, and communities. Experimental studies with treatment and control groups of teachers, students, parents, and local civic leaders are needed to test whether youth-led marine debris solutions curricula create the effects hypothesized in this essay. Innovative research designs drawing psychology, sociology, and social contagion approaches (de Lange et al., 2019), could help reveal the mechanisms through which information and motivation move through communities and how kids may drive that information mobilization. Understanding the potential and limitations of the education for youth-led marine debris solutions model can improve youth and community education about marine debris. Only then will we start to uncover, document, and improve the potential for education to move from something "nice to have" to a critical tool for addressing the marine debris crisis and potentially propelling community engagement on other environmental issues.

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Table 1.1. Suggested framework of environmental education (EE) curricula for youth-led marine debris solutions, adapted from intergenerational learning (IGL) content in Lawson et al. (2018) and Duvall and Zint (2007).

Best Practices		**Suggested Action Items for youth-led marine debris solutions** (based on existing EE, youth civic engagement, and IGL literature)	**Recommended Practitioners**	**Reference(s) & Examples**
Helping Students Learn	**1**	**Offer professional development opportunities aimed at nurturing teacher motivation** on ocean conservation, marine life, environmental education, youth civic engagement, or other related topics	School systems, educational leadership agencies, environmental education centers offering teacher programming, etc.	(Istead & Shapiro, 2014; Lawson et al., 2018; Mahler et al., 2018)
	2	**Use long-term and in-depth marine debris lessons or unit plans** • Preferably with repeated contact at least as long as an educational unit (recommended 12 weeks)	Curriculum developers, teachers, professional learning networks of teachers, teaching communities of practice, etc.	(Duvall & Zint, 2007; Lawson et al., 2018)
	3	**Focus on local marine debris issues** • Consider that (it is widely cited that) 80% of marine debris originates from land; therefore, any cleanup will make positive contributions, no matter how far from the coast o Focus on your local waterbodies (e.g., streams, creeks, rivers, lakes, etc.) – even local school grounds will work	Teachers, environmental educators, informal educators, etc.	(Ballantyne et al., 2001; Jambeck & Johnsen, 2015; Lawson et al., 2018; Sutherland & Ham, 1992)
	4	**Incorporate experiential learning elements in the marine debris curriculum** • Action, reflection, conceptualization, and application model (Kolb, 1984) o Citizen science marine debris activities fit well in this cycle	Teachers, environmental educators, informal educators, etc.	(Ballantyne et al., 2001; Kolb, 1984; Moline, 2019; Thiel et al., 2018; Turrini et al., 2018)

Table 1.1 (continued).

Helping Students Engage their Parents	**5**	**Provide and promote space for at-home conversations around marine debris** • Encourage guided conversations at home with parents and caregivers o Teachers can do this directly by including parents in at-home assignments and activities (e.g., TIPS [Teachers Involve Parents in Schoolwork] worksheets in the Duke University Marine Lab Marine Debris curriculum).	Teachers, environmental educators, informal educators, etc.	(DeMattia et al., 2020; Lawson et al., 2018; Lawson et al., 2019)
	6	**Encourage parental involvement in marine debris activities** • Design activities for family engagement (e.g., at-home waste audits, reflection of family consumption patterns of single-use plastic) • Encourage family attendance at field trips and school events (e.g., Science Nights, Talent Shows, Trash Fashion Shows, etc.)	Teachers, environmental educators, informal educators, etc.	(Ballantyne et al., 2001; Duvall & Zint, 2007; Lawson et al., 2018; Sutherland & Ham, 1992)
Empowering Students to Engage their Communities	**7**	**Provide civic engagement training opportunities for students** • Include specific civic trainings (i.e., what is civic voice, understanding public forums, public speaking basics, etc.) • Practice and rehearse different public speaking scenarios so that students can develop confidence and skills	Local civic action partners (non-profit organizations, etc.), curriculum developers, teachers, professional learning networks of teachers, teaching communities of practice, etc.	(Derr et al., 2018; Kirshner, 2015)

Table 1.1 (continued).

Empowering Students to Engage their Communities *(continued)*	**8**	**Promote youth decision-making authority and action competence *(if the students choose to engage in solutions)*** • Build trust among students and their communities • Give students ownership. Let the students decide on the type of community engagement event that they would like to conduct (e.g., giving a formal presentation at their Town Hall vs. making PSA videos vs. hosting a Trash Fashion show, etc.) • Provide areas for student and youth leadership in various activities (e.g., service-project coordinator, PSA video director, project manager, etc.)	Teachers, environmental educators, informal educators, etc.	(Derr et al., 2018; Christens & Dolan, 2011; Jensen & Schnack, 2006; Maine Environmental Changemakers Network, n.d.; Schusler et al., 2009; Schusler & Krasny, 2010; Volk & Cheak; 2003)
Providing structural and logistical support for students who are engaging with their communities	**9**	**Provide help in overcoming structural barriers to action** • Help schedule the event or coordinate a community event organization team • Ensure that all students can get to the event (e.g., organize rides, etc.) • Engage local media outlets at the events to amplify youth voice on a larger-scale	Educational leadership (e.g., Principals, Administrators, School Directors, etc.), teachers, environmental educators, informal educators, etc.	(Derr et al., 2018; Kirshner, 2015)

Table 1.1 (continued).

Providing structural and logistical support for students who are engaging with their communities *(continued)*	**10**	**Encourage ongoing youth-adult partnerships (Y-APs) in learning/addressing marine debris** • Engage local-level adult experts (if possible) to problem-solve alongside the students (e.g., local businesses that are interested in adopting more sustainable practices, local Stormwater manager for the town, Sustainability coordinator for the town – if there is one, etc.) • Use Y-APs to provide training for kids as well as avenues to amplify their voice o Focus adult roles on teaching kids what it is like to be a scientist/leader; focus student roles on exposing adult leaders to new solutions generated by kids	Local civic action partners (non-profit organizations, etc.), curriculum developers, teachers, professional learning networks of teachers, teaching communities of practice, etc.	(Benson et al., 2006; Evans & Prilleltensky, 2007; Flanagan & Christens, 2011; Hamilton & Hamilton, 2005; Shiller, 2013; Zeldin et al., 2013)

Supplementary Material

Table S1. US Next Generation Science Standards that may align with marine debris content (NGSS, 2013).

NGSS Science & Engineering Practice (SEP)	**Examples at matched grade level (3-5)**
Asking Questions & Defining Problems	• Ask questions about what would happen if a variable is changed. • Identify scientific (testable) and non-scientific (nontestable) questions. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. • Use prior knowledge to describe problems that can be solved. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.
Developing and Using Models	• Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. • Develop and/or use models to describe and/or predict phenomena. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.
Planning and Carrying Out Investigations	• Evaluate appropriate methods and/or tools for collecting data. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
Analyzing & Interpreting Data	• Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. • Analyze data to refine a problem statement or the design of a proposed object, tool, or process. • Use data to evaluate and refine design solutions.
Using Mathematics and Computational Thinking	• Organize simple data sets to reveal patterns that suggest relationships. • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.

Constructing Explanations and Designing Solutions	• Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • Apply scientific ideas to solve design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.
Engaging in Argument from Evidence	• Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. • Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. • Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect. • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.
Obtaining, Evaluating, and Communicating Information	• Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence. • Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices. • Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices. • Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. • Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.

Table S2. Text of selected North Carolina state standards (NCSCOS – North Carolina Standard Course of Study) that may be easily tied to marine debris education (Instructional Services, North Carolina Department of Public Instruction, 2010).

Subject	**NCSCOS Standard**	**Text**
Science	4.L.1.1, 4.L.1.3	*Give examples of changes in an organism's environment that are beneficial to it and some that are harmful;* and *Explain how humans can adapt their behavior to live in changing habitats.*
English Language Arts	4.R.7	*Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.*
Math	4.NBT.5	*Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers.*
Social Studies	4.G.1.3	*Exemplify the interactions of various peoples, places and cultures in terms of adaptation and modification of the environment.*
Technology	4.TT.1	*Use technology tools and skills to reinforce classroom concepts and activities.*
Art	4.V.3.3	*Create art using the processes of drawing, painting, weaving, printing, stitchery, collage, mixed media, sculpture, ceramics, and current technology.*

Table S3. Image of University of Toronto Trash Team's Curriculum Connections demonstrating how their lessons are tied to marine debris educational standards in Ontario, Canada **(**Rochman Lab, 2020)**.**

Grade 5 Curriculum Connections

U of T Trash Team Lesson Plans created in 2019/2020

Adapted from The Ontario Curriculum Grades 1 - 8:

- Science & Technology http://www.edu.gov.on.ca/eng/curriculum/elementary/scientec18currb.pdf
- Social Studies http://www.edu.gov.on.ca/eng/curriculum/elementary/social-studies-history-geography-2018.pdf

Lesson 1 - Plastics Cycle

Grade 5 - Science and Technology	
Forces Acting on Structures and Mechanisms	1.1, 1.2, 3.4
Properties of and Changes in Matter	1.1, 3.2, 3.3, 3.4, 3.5
Conservation of Energy and Resources	1.1, 2.2, 2.4, 2.5, 3.2
Grade 5 - Social Studies	
The Role of Government and Responsible Citizenship	B1.1, B2.5, B2.6, B3.2, B3.4, B3.7, B3.9

Lesson 2 – Watersheds and their Relationship to Litter

Grade 5 - Science and Technology	
Forces Acting on Structures and Mechanisms	1.2, 2.2, 2.5, 3.2, 3.4
Properties of and Changes in Matter	1.1, 1.2, 2.3, 3.2
Conservation of Energy and Resources	1.1, 2.2, 2.5
Grade 5 - Social Studies	
The Role of Government and Responsible Citizenship	B2.3

Lesson 3 – Impacts of Plastic on Ecosystems

Grade 5 - Science and Technology	
Forces Acting on Structures and Mechanisms	1.2
Properties of and Changes in Matter	2.2, 2.3, 2.5, 2.6
Conservation of Energy and Resources	1.1, 2.2, 2.5

Lesson 4 – Solutions to Plastic Pollution

Grade 5 - Science and Technology	
Properties of and Changes in Matter	1.2
Conservation of Energy and Resources	1.1, 2.2, 2.5
Grade 5 - Social Studies	
The Role of Government and Responsible Citizenship	B1.1, B1.2, B2.1, B2.2, B2.4, B2.5, B2.6, B3.1, B3.2, B3.4, B3.5, B3.7, B3.9

CHAPTER 3: Let's talk about it: Family discussions promote pro-environmental behaviors in children on the topic of marine debris

This chapter is not yet published but will target the journal *Environmental Education Research.*

Abstract

The environmental challenge of marine debris can be extremely complex and multi-faceted, therefore mobilizing to effectively innovate and subsequently adopt technologies or supportive policies can be difficult. Generating public support for environmental initiatives is the crux of initiatives to address marine debris. In considering ways to build broad-based public support for environmental solutions, engaging youth holds promise. In this study, we investigate how a diverse set of cognitive, psychological, social, and demographic factors predict environmental behaviors related to marine debris among 450 children (ages 8-11) and their parents from North Carolina, USA. Children's perceived behavioral control, family marine debris discussions, and child family-related norms, in that order, predicted engagement in marine debris reduction behaviors. In contrast to existing research, we did not detect influences from multiple factors identified as important in influencing child behavior, such as child knowledge, discussions with peers at school, peer-level norms, parent marine debris behavior, nor any demographic variables. This study demonstrates the unique ways in which promoting youth agency, family discussions, and family norms may promote pro-environmental behaviors among children. Accordingly, we recommend that environmental education programs consider emphasizing the importance of building youth agency and promoting family conversations and interactions around the environment. Guiding marine debris behavior changes may prove to be an effective strategy for ameliorating and abating the existing marine debris crisis by incorporating intergenerational learning dynamics such as family discussion, one empowered child and family at a time.

Introduction

Scientific and technological research has advanced rapidly to address pressing environmental challenges, but solutions have proven elusive, largely because of social barriers to action. These include personal political ideology (Dunlap & McCright, 2008), personal and social identity (Iyengar & Westwood, 2015), and systemic barriers such as those within organizations, the overall inertia of economic systems, and lack of vision needed to prioritize solutions (Bergquist et al., 2019). Challenges such as climate change, marine debris, and sustainability can be extremely complex and multi-faceted (Bergquist et al., 2019), but as the United States government recently highlighted, many actionable solutions are available (Executive Order, No. 13990, 2021). For instance, in the case of marine debris, the solutions are relatively simple: keep waste out of waterways (prevention) and remove what is already there (remediation). What is complex, on the other hand, is generating the social mobilization among voters and their representatives needed to effectively innovate and subsequently adopt technologies and supportive policies (Guilbeault, Becker, & Centola, 2018). As technical solutions to environmental challenges work best when paired with socially supported institutions (Ostrom, 1990), generating public support for environmental initiatives is necessary to prompt change regarding marine debris (Vince & Stoett, 2018).

In considering ways to build broad-based public support for environmental solutions, engaging youth holds promise for multiple reasons. First, existing research demonstrates that children’s influence on their parents can be impactful in a variety of contexts ranging from product purchases (Flurry & Burns, 2005) and technology understanding (Baily, 2009) to energy conservation (Boudet et al., 2016) and climate change (Lawson et al., 2019). Secondly, early intervention matters, as young children are open to environmental ideas and often have stronger environmental attitudes than their parents (Allen, Wicks, & Schulte, 2013; Craig & Allen, 2014). Establishing environmentally-friendly attitudes and behavior patterns in childhood can lead to more pro-environmental behaviors later in life (Eagles & Demare, 1999). Third, engaging youth in solutions also holds promise because, unlike adults, children seem to readily engage with challenging environmental topics, even when they are controversial. For instance, political affiliation is consistently one of the most powerful predictors of support for environmental topics among adults, including regarding climate change (McCright & Dunlap, 2011), environmental justice, oil pipeline developments (Karol, 2019), and overall environmental protections (Dunlap, Xiao, & McCright, 2001; Pew Research Center, 2020). Evidence suggests that this polarization is due to powerful filters such as political ideology and cultural worldviews that heavily influence the way adults seek out and interpret scientific information, leading to divides in collective environmental and political behaviors like voting patterns (Egan, 2020). In contrast, likely because children are still forming their political ideologies and worldviews, research has found that children engage with environmental learning independent of these forces (Stevenson et al., 2014). Finally, as marketing efforts have shown repeatedly, young people may have significant influence over adults (Flurry & Burns, 2005; Wilson & Wood, 2004). This has recently been supported by environmental education research showing similar youth influence on their parents (Lawson et al., 2019a) and even their local political officials (Hartley et al., 2021a).

Consequently, efforts to establish pro-environmental behavior patterns, such as through environmental education (EE; Derr, Chawla, & Mintzer, 2018), may set young learners on a trajectory of life-long support for environmental solutions, as well as provide a pathway for building similar support among adults in their lives. Accordingly, understanding factors that may encourage environmental action among children may be helpful in building both immediate and long-term support for environmental solutions.

Predicting children's environmental behaviors

Predicting behavior is difficult among adults and youth alike. Indeed, the disconnect between effectively shifting environmental knowledge and attitudes into subsequent environmental behaviors is one that has puzzled conservationists, scientists, and environmentalists for decades (Heberlein, 2012). Measuring environmental behaviors has proven particularly challenging among younger age groups due to limitations in survey instruments and methods of measuring children's attitudes (Larson et al., 2011), but some factors have been identified as predicting behavior, including those measured at multiple individual levels, such as cognitive (e.g., knowledge) and psychological (e.g., behavioral control), and social levels (e.g., family dynamics and norms), and in relation to a broader contexts (e.g., demographics).

Individual-level factor: cognitive (knowledge)

Often one of the most studied factors explored in the context of environmental education among children is knowledge. Knowledge is a broad term that could include system knowledge (e.g., ecological knowledge), action-related knowledge (e.g., what can be done to address environmental challenges), and effectiveness knowledge (e.g., what solutions will be most effective) (Frick et al., 2004). Though it is widely accepted that one cannot change human behavior exclusively via information delivery (Gifford & Nilsson, 2014; Heberlein, 2012; Sterling, 2010; Stern, 2011), people of all ages (including young people) need a baseline knowledge and understanding about a topic before they can act on it (Krasny, 2020). Accordingly, although early assumptions in EE research contest that building knowledge would lead to care, which would in turn lead to behavior (K-A-B models: Krasny, 2020) have been widely critiqued as inadequate (Courtenay-Hall & Rogers, 2002; Heimlich & Ardoin, 2008; Kollmuss & Agyeman, 2002), several recent environmental education literature reviews show that knowledge is a key outcome in EE research and evaluation (Ardoin et al., 2018; Stern et al., 2014). Knowledge has been shown to both interact with more affectual outcomes such as environmental attitudes and concern to predict behavior (Alp et al., 2006; Heimlich & Ardoin, 2008), as well as contribute to environmental concern or hope, which when combined, can in turn predict environmental behavior (Stevenson et al., 2018; Szczytko et al., 2019).

Individual level factor: psychological (behavioral control)

Another key individual factor in predicting environmental behavior among young people is behavioral control, or the belief that an individual can execute a behavior (Ajzen, 2002). Closely related to the concept of self-efficacy (Bandura, 1993), behavioral control is supported by the theory of planned behavior (TPB; Ajzen, 1991), a widely used social-cognitive model of human behavior (including with young audiences) that underscores how beliefs, attitudes, norms, and behavioral control predicts intended and observed behavior (de Leeuw et al., 2015). Both self-efficacy and behavioral control include components of control over the behavior itself, as in having the agency and ability to carry out a specific behavior (Ajzen, 2002). In short, research suggests that individuals are more likely to engage in a behavior when they think they will be successful (Krasny, 2020). Especially in the context of young audiences, behavioral control may be particularly important, as young audiences may not have as much control over their daily actions as adults (Tsang et al., 2012). Several studies have shown the importance of behavioral control or the similar construct of self-efficacy in predicting environmental behaviors of young people (Bamberg & Möser, 2007; Hines et al., 1987).

Social-level factors: family dynamics and norms

Drawing on sociocultural learning approaches (Vygotsky, 1978) a large body of evidence supports that children's environmental perceptions and behaviors can be influenced by interactions with others. One way to conceptualize this interaction is simple discussion with others, and several studies have shown that discussing environmental topics with classmates, peers, and family members can boost child environmental attitudes and behaviors among young people (Lawson et al., 2019b; Stevenson et al., 2016; Valdez et al., 2018). For instance, Valdez et al. (2018) found that discussing climate change with family and friends was a predictor of adolescents' climate change-related behaviors. One key finding from these studies is that discussion seems to support environmental engagement independent of the views of their discussion partners, suggesting that young people are leveraging these discussions to form their own opinions rather than mimicking the views of others (Lawson et al., 2019b; Stevenson et al., 2016; Valdez et al., 2018). For instance, Stevenson et al. (2019) found frequency of discussion among friends and family about climate change concern to be secondary predictors after children's own acceptance of human-caused global warming, but still impactful. In all, these studies highlight that family discussions can help promote young people's environmental beliefs and behaviors.

One reason that discussion may be key to boosting environmental engagement among young people is that it may activate social norms, or the common behaviors and social beliefs observed. Social norms can impact environmental behaviors because people often imitate what others around them do (Krasny, 2020). This might include *descriptive norms* (what you see others do or hear them say – actual behaviors), *injunctive norms* (what you *think* others do or say – expectations of others' behaviors), or *subjective norms* (expectations others have for what *we* do or say) (Cialdini et al., 1991; Cialdini, 2007; Krasny, 2020). Norms have been shown to be powerful predictors of behavior among children in several contexts. For instance, in a study on climate change, social norms were the strongest direct predictor of climate change action among youth, and indirect predictor of efficacy and certainty (Busch et al., 2019), and social norms among children as young as pre-school-aged may influence their playground risk-taking behaviors and other behaviors with their peers (Morrongiello et al., 2013). Similarly, other research supports the influence of peer and family norms among younger children in various contexts such as nutrition among 4^{th}-6^{th} graders (Cullen et al., 2001), health behaviors among 6^{th} graders (Kinsman et al., 1998), and group-dynamic behaviors among preschoolers (Chang, 2004). However, little exploration has been conducted on norms among young children in relation to environmental issues.

In considering injunctive norms, a key predictor of environmental behaviors among children may be the environmental attitudes and behaviors of their parents, however research around the influence of parent behaviors among children's behaviors is mixed. A large body of research supports profound influences of parents on their children on multiple topics, including choosing to eat organic foods, purchasing environmentally friendly products, curtailing electricity use, and handling waste responsibly (Gotschi, Vogel, & Lindenthal, 2010; Grønhøj, 2007; Grønhøj & Thøgersen, 2012). Additionally, Grønhøj and Thøgersen (2009) found that family socialization exerts significant influence on the children's pro-environmental orientations. Similarly, Lawson et al. (2019b) found that in addition to family discussions, parent climate change behaviors were predictive of children's climate change-related behaviors. However, in this case, researchers did not find a moderating effect between discussion and parent behaviors, suggesting that discussion and injunctive norms (e.g., reported parent behaviors) worked independently to predict child environmental behavior.

In the context of how social factors predict environmental behavior among young people, several questions remain underexplored, particularly around how learning may shift as children age. For instance, in some studies among adolescents and older children, levels of peer discussion were more impactful than levels of family discussion on environmental attitudes and behaviors (Lawson et al., 2019b), and extensive evidence points to how peer norms influence teen decisions about their own health behaviors (Perkins, 2002). On the other hand, researchers found strong influences of family norms regarding children's diets among younger children (Cullen et al., 2001). Therefore, examining the role of peer and family environmental norms among younger age groups may help to unveil whether or not there is a "turning point" in age wherein youth environmental behaviors are predicted more strongly by family norms at a young age but switch to being predicted more by peer norms as they reach adolescence and older ages (e.g., Grønhøj, 2007; Grønhøj & Thøgersen, 2009; Lawson et al., 2019b). Understanding this dynamic could inform environmental education programming, as it could guide at what ages parent and/or peer interactions are most impactful.

Contextual and demographic factors

In addition to individual and social factors, other contextual factors, such as those represented by demographics, may help shed light on how to best engage young learners in environmental action that is culturally and contextually responsive. Several studies have found that demographic factors such as age, gender, income, or race can predict environmental behavior among children. For instance, Uyeki and Holland (2000) found that younger respondents showed higher scores than older respondents for reducing growth of the human species in prioritization of the environment. Gender has been shown to have varied influences on children's environmental behavior (Alp et al., 2006; Davidson & Freudenberg, 1996; Tikka, Kuitunen, & Tynys, 2000; Yilmaz et al., 2004), with recent evidence suggesting that environmental education may particularly benefit girls, including girls of color (Stevenson et al., 2021). Though not commonly studied among children, income has been linked to environmental behavior among adults (Whillans & Dunn, 2015), acknowledging that structural barriers to behavior are often powerful and difficult to overcome (e.g., access to recycling services, time to participate in community activism). However, some contemporary work among children shows that demographics are not typically strong predictors environmental attitudes or behaviors (Clark et al., 2020; Lawson et al., 2019a), particularly when controlling for factors such as outdoor activity participation or using analytical techniques that account for the complex interactions between individual, psychological, social, and demographic factors (Szczytko et al., 2020). These recent findings work against the long-held notion of deficit models in educational outreach, which myopically purport that a lack of engagement with environmental topics is associated with a lack of knowledge or lower levels of interest in environmental topics among certain groups of people (Ahteensuu, 2012; Nadkarni et al., 2019). Accordingly, we suggest that there is a need to keep examining the roles that a variety of demographic factors may or may not play in youth environmental behaviors to better understand how young people participate in environmental conversations and help educators design responsive ways to keep young people learning and engaged.

Study context and research questions

Taken together, these studies paint a complex picture of youth environmental behaviors in which multiple factors shape how youth engage with environmental solutions, including awareness and knowledge of issues, behavioral control, social norms, and structural and demographic factors. Though this area of research is rich, few studies consider these multiple factors together, which can contribute to understanding the relative importance of each. In particular, research on the role of family context is an emerging, but potentially fruitful area of research. In this study, we investigate how a diverse set of factors predict environmental behaviors related to marine debris among 450 elementary children (ages 8-11) and their parents from North Carolina, USA. Specifically, we examine cognitive factors (e.g., knowledge), psychological factors (e.g., behavioral control), and a variety of social factors (e.g., discussions with classmates, peers, and family; peer and family descriptive norms; and family injunctive norms) while controlling for several demographic factors (including gender, race, locale [e.g., urban, rural], and income).

Drawing on previous research discussed above, we offer five hypotheses related to predictors of pro-environmental behavior related to marine debris among elementary school children. Consistent with established research on the importance of internal factors of knowledge and behavioral control (Krasny, 2020), we predict that knowledge of marine debris and behavioral control related to marine debris actions will be positively related to child marine debris behaviors (hypothesis 1). Secondly, as suggested by previous research on social predictors of behavior (Lawson et al., 2019a; Lawson et al., 2019b), we predict that discussions with classmates, friends, and family; peer and family descriptive norms; and parent behavior will be positively related to child marine debris behaviors (Lawson et al., 2019a; Lawson et al., 2019b). As several studies that have considered both internal and social factors together support a limited predictive power of knowledge on behavior when considered in the context of social factors (Busch et al., 2019) we hypothesize social factors will be stronger predictors of child marine debris behaviors than cognitive factors (hypothesis 3). Fourth, because studies with younger children suggest that families shape children's behaviors (Gotschi et al., 2009; Grønhøj, 2007;

Grønhøj & Thøgersen, 2012), we predict that family-related social factors will be stronger predictors of child marine debris behaviors than peer-related social factors (hypothesis 4). As previous research is mixed on the role of demographic factors in predicting behaviors, we control for them in this study.

Methods

Marine Debris as study context

We chose marine debris because it aligns well with educational science standards in many developed nations, including regional and localized standards such as the University of Toronto's Trash Team in Ontario, Canada (Rochman Lab, 2020). Marine debris curricula also lend themselves well towards children making connections to solutions, as the debris, its sources, and its immediate clean-up solutions are highly visible (Tudor & Williams, 2003) where children live. The widespread nature of the problem makes it both urgent and relevant to teachers and children, and it also means that children can directly address the problem with visible and tangible results (Hartley et al., 2015) in both formal and informal learning environments.

Data Collection: Recruitment and Sampling

Our focus for this study is on elementary-aged children, as this age group has been shown to take strong interest in the environment (Chawla, 1988), even more so than their older middle- and high-school aged peers (Wojtowicz, 1995). They also have keen skills in applying complex environmental concepts (Craig & Allen, 2014; Langevin et al., 2013). We chose to include young children from across North Carolina, USA, rather than focusing on coastal communities, as the majority of single-use plastic marine debris inputs into the ocean come from land-based sources (Jambeck et al., 2015).

We used multi-stage (i.e., hierarchical) sampling (Cole et al., 2001; Ericson & Gonzalez, 2003), wherein we first recruited teachers; and through teachers, recruited children; and through children, recruited parents. First, we utilized a North Carolina Department of Public Instruction listserv reaching all public school science teachers to advertise the study to teachers across the entire state. Teachers were invited to participate in a professional development program related to marine debris (DeMattia, Quattrone, & Harshbarger, 2017) and also invited to participate in this study. Next, teachers distributed parent consent and child assent forms, and in this way, we recruited children in participating teachers' classes and associated parents. Consent for minors to participate was granted by the participating students' parent/legal guardian, and consent for non-minors to participate was self-granted. We followed this procedure during both the 2018-19 and 2019-20 school years, resulting in a sample of 540 unique family units consisting of one to three parental figures and at least one child either in 4^{th} or 5^{th} grade (i.e., 8-11 years old). For the purposes of this study, we define a family unit as containing at least one child in 4^{th} or 5^{th} grade and at least one parental figure, which could include parents (e.g., biological, adoptive) and/or guardians (e.g., grandparents, foster parents).

Over the 2018-19 and 2019-20 school years, 43 teachers from 35 different schools across 20 counties participated in the study during the 2018-2020 school years. Of those 20 counties, 10 (50%) were coastal counties, 3 (15%) were from mountain-region counties, and 7 (35%) were from the Piedmont (inland) area of North Carolina; and 11 (31%) of schools were in counties classified as rural (Geverdt, 2015). We surveyed 2,075 4^{th}/5^{th} grade children associated with the 43 participating teachers. From these children, we were able to recruit 695 parent responses. The majority of parent responses represented one parent answering for one child, but some families had two parents (n = 93) or three parents (n = 3) respond and one family unit had one parent with two child respondents. In addition, four of the child responses associated with matching parent responses were incomplete. After data cleaning and pairing, we had 540 complete family-unit responses. Children respondents' self-reported as 49% male (1% other); parent respondents ranged from 26-78 years of age, were 22% male, and 76% Caucasian. One average, parents reported household incomes higher than the median for the state of North Carolina (75% of reported incomes were higher than $50,000; North Carolina median household income = $54,602; U.S. Census Bureau, 2020).

Instrument Development

We developed parent and child instruments by adapting previously published environmental literacy tools (Lawson et al., 2019a; Lawson et al., 2019b; Stevenson et al., 2013) to a marine debris context and relying on expert review to generate new measures when necessary. First, to measure marine debris behaviors (our dependent variable), we modified a Climate Change Behavior scale (Lawson et al., 2019b; Stevenson & Peterson, 2015) to include behaviors specific to marine debris. The question asked, "*How often do you do the following activities?*" (e.g., "Use a reusable water bottle" and "Refuse to use plastic straws at home or in restaurants"), and children were asked to respond on a five-point scale ranging from "Never" to "Every chance I get." Our internal variables included marine debris knowledge and behavior control. To measure children's knowledge of marine debris, we developed a series of questions to assess whether children knew how long it takes for certain items to break down (e.g., a disposable diaper), with choices of timeframes (e.g., (a) less than 3 months; (b) 1-5 years; (c) 10-30 years; (d) 100-600 years; (e) never breaks down. To address behavioral control, we asked, "*How much do you agree with the following statements?,*" and followed with items parallel to the behavior scale (e.g., "If I wanted to, I could use a reusable water bottle," etc.).

Independent variables related to social predictors of behavior included discussion with others, peer- and family-related norms, and parent marine debris behaviors (i.e., injunctive norms). To measure discussion, we asked children, "*In the last year, how often have you done the following?*," followed by "discussed marine debris at school during class," "discussed marine debris with your friends outside of class," and "discussed marine debris with your family." Children could respond with never, once, two or three times, four or five times, or more than five times. To measure peer and family norms, we asked children their level of agreement (totally disagree, disagree, not sure, agree, totally agree) with six items: "my family thinks that I should take care of the environment," "my family usually takes care of the environment," and "my family thinks that taking care of the environment is important," along with parallel statements substituting "my friends for "my family." Lastly, to measure parent behavior, we included the same behavior scale on the parent survey instrument as on the child survey instrument. For all Likert-type questions, we also included images of thumbs to accommodate our younger audience, as shown in Figure 3.1. In addition to these constructs, we asked respondents to self-report demographic information. We asked children to self-report gender, race, and age, and parents to self-report gender, race, income, and the distance they lived from the beach.

In June 2018, we conducted pilot testing of the child instruments with three classes of central North Carolina 4^{th} grade children (n = 56). A member of the research team visited pilot classrooms in person, but we used a Qualtrics survey link to administer the survey online. On the Qualtrics survey, children were given the opportunity to provide comments on anything that they found confusing or difficult to understand. They also discussed the survey with the researcher afterwards, providing feedback about specific questions, wording, or question design formats that were confusing to them. Select children from each class then participated in a follow-up cognitive interview to help refine items and improve clarity (Desimone & Floch, 2004). One specific aspect of pilot testing was determining the optimal format for the Likert-type questions. Children in the pilot group were randomly split into two groups – half receiving a version with a 5-point scales and half receiving a version with 11-point scales. Analysis of those surveys revealed that a 5-point Likert survey was more intuitive for our young audience. We also found each scale to have acceptable internal consistency (Cronbach, 1951) (all pilot α above 0.68), and to all be single factor scales after running confirmatory factor analyses (all items in each of the two scales had factor loadings of at least 0.56; Comrey & Lee, 2009). For final item wording, reliability, and validity statistics, see Tables 1-4.

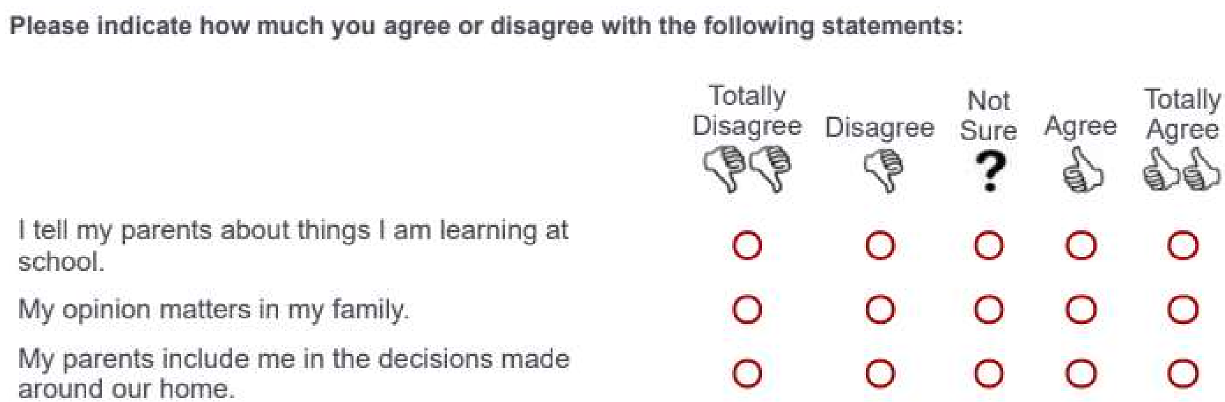

Figure 3.1. Example of 5-point level of agreement Likert-scale "thumbs model" for use with children in younger grades.

Data Collection

Teachers facilitated data collection for this study in the beginning of the 2018 school year (June – September) and the beginning of the 2019 school year (June – September). A total of 43 teachers participated in data collection over two years, with some participating in both years (n = 15), and some working in teacher-pairs, which represented 64 total classrooms of children (control: n = 24; treatment: n = 40). The majority of teachers were associated with a single class of elementary children (average class size = 18-20), but 5 participating teachers taught entire grade levels, some teaching as many as 256 children per year. We provided participating teachers with a digital packet containing consent forms for children and parents, data collection protocol, and links to the surveys. Teachers administered the child surveys during class time. Online surveys were available for children and parents in either English or Spanish. To engage parents, teachers employed multiple strategies that best suited their needs and communities; some sent home emails with a link, others sent home paper letters with a link, and others had parents participate in-person online when they came to the school for Parent-Teacher Night at the beginning of the year. Two to three weeks after the distribution of the electronic surveys, we followed-up with teachers to mail them paper copies of the surveys as needed for parent distribution. At that point, teachers sent parents printed packets with a survey, letter, instructions, and a pre-addressed, stamped envelope in the parent's native language. Return envelopes were addressed to the research team.

Analysis

For knowledge, we scored responses based on how close they were to the correct answer (Szczytko et al. 2019). For instance, in the case of disposable diapers, the correct timeframe was 100-600 years. To score these knowledge responses, we took the absolute value of the difference and subtracted that value from the maximum score on the knowledge scale of 23. In this manner, child scores could range from 0 (maximum distance from correct answers) to 23 (all correct answers). To generate composite scores for each of our variables of interest measured with Likert-type scales, we added each item-level score. Child marine debris questions regarding family and peer norms for children showed a range from *Disagree* (1) to *Totally agree* (5) with composite scales for both family and peer questions ranging from 3-15. The marine debris behavior questions for both children and parents ranged from *Never* (1) to *Every chance I get* (5) with a range of composite scores from 0-30. Child behavioral control also ranged from *Totally disagree* (1) to *Totally agree* (5) with a cumulative scale for all questions of 7-35. We included child sex/gender; rurality of the children' school; and both race and parental household income as reported by parents. Although we acknowledge that child and parent race are not always the same, parent race was used as a proxy for family race since student-reported race was inconsistent with school and community demographics, and results from our pilot tests showed that students struggled with racial self-identification. Prior to statistical analysis, we collapsed parent race into dichotomous variables (white = 1, non-white = 0) due to small sample size. We also collapsed school locale classification (rural = 1, non-rural = 0).

To test our hypotheses, we used multiple linear regression to model child marine debris behaviors as a function of individual factors (child knowledge and behavioral control); social factors (discussion about marine debris with peers, parents, and classmates; peer and family norms; parent behaviors); and demographic factors. This approach allowed us to test for positive relationships between cognitive factors and behavior (H1) and social factors and behavior (H2) as well as compare the relative strength of relationships between cognitive and social factors (H3) as well as peer versus family-related factors (H4). Finally, inclusion of demographic predictors allows us to control for potential relationships with child behavior. We used teacher as a random effect to account for the nested sample design. All data analyses were conducted using STATA 14.2.

Results

Child knowledge was roughly 66% accurate, with an average score of 15.15 (sd = 3.35). Family discussions about marine debris were most frequent ($\mu = 2.28$; sd = 1.50), followed by discussions in school (μ = 2.02; sd = 1.25) and discussions with peers (μ = 1.78; sd = 1.16). Average scores for child family norms were 12.2, representing general agreement in family support for marine debris behaviors (sd = 0.09; maximum score of 15 representing a response of "totally agree" for each question), whereas average scores for child peer norms were slightly lower at 10.82 (sd = 0.097). Average marine debris behavior responses for children were 20.39 (sd = 0.020; maximum score of 30 representing a response of "Every chance I get" for each question) with a higher average score for parents of 23.98 (sd = 0.23). On average, child behavioral control scores were 29.37 (sd = 0.19; maximum score of 35). All scales independently showed acceptable reliability and validity, with Cronbach's alpha levels at acceptable levels (child family norms: 0.82; child peer norms: 0.85; child behavior: 0.67; parent behavior: 0.82; child behavioral control: 0.84; Tables 1-4, respectively). Principal component factor analysis revealed peer and family norms loaded onto single factors (α = 0.85 and 0.82, respectively; Table 3.1), as did parent behaviors and child behavioral control, with factor loadings all greater than 0.4 (Tables 3.1-3.4). Child marine debris behaviors factor-loaded into two factors – information seeking and sharing behaviors (children: α = 0.69) and individual behaviors (children: α = 0.51) (Table 3.2). All parent behaviors loaded into one scale (α = 0.82; Table 3.3). Lastly, child behavioral control loaded into one scale (α = 0.84; Table 3.4).

The regression model predicting child marine debris behavior based on independent and control variables explained 25% of the variance in child marine debris behaviors in the sample (Table 3.5; $F(13, 659) = 18.31$, $p < 0.001$). Four statistically significant factors that predicted youth environmental behaviors related to marine debris emerged from the results, in order of influence: (1) children's personal sense of behavioral control ($\beta = 0.213$, $p < 0.001$), (2) family discussions on the topic ($\beta = 0.207$; $p < 0.001$), (3) family-related marine debris norms (β =

0.099; $p < 0.001$), and (4) families that self-reported as having below the NC median income (β = -0.074; p = 0.038).

We found partial support for Hypothesis 1: child marine debris behaviors were positively-related to child behavioral control (β = 0.213, $p < 0.001$; Table 5), but not child knowledge (β = -0.005, p = 0.874). We also found partial support for Hypothesis 2, wherein frequency of marine debris discussion was positively related to child marine debris behaviors when discussions were with family (β = 0.207; $p < 0.001$), but not with peers (β = 0.060; p = 0.202) or at school (β = 0.266; p = 0.119). Also included in the social factors of Hypothesis 2 were norms; we found that family-level norms were strong predictors of child marine debris behavior (β = 0.099; $p < 0.001$), but peer-level norms were not detected as predictors (β = 0.033; p = 0.426).

Finally, parent marine debris behaviors did were not detected to predict child marine debris behavior (β = 0.055; 0.130). We also found partial support for Hypothesis 3, as social norms such as family marine debris discussions (β = 0.207; $p < 0.001$) and child family-related norms (β = 0.099; $p < 0.001$) were stronger predictors of child marine debris behaviors than cognitive factors such as knowledge, which was not detected to be statistically significant (β = -0.005, p = 0.874). We found partial support for Hypothesis 4, as social factors such as discussion with family (β = 0.207; $p < 0.001$) were stronger predictors than discussions with peers (β = 0.060; p = 0.202), and family-level norms (β = 0.099; $p < 0.001$) were stronger predictors of child behavior than peer-level norms, which were not detected as significant (β = 0.033; p = 0.426). However, the family influence only held for discussion and norms, as parent marine debris behavior was not a predictor of child marine debris behavior. Of all the significant predictors of child marine debris behaviors, child behavioral control and family discussions were the strongest predictors of child marine debris behaviors, followed by child family-related marine debris norms (β = 0.213, 0.207, 0.099, respectively; see Table 5). Though not a hypothesized relationship, families that reported an income below the median NC income ($50,000) has children less likely to engage in marine debris behavior (β = -0.074; p = 0.038). No other demographics were significant predictors of children's marine debris behavior..

Discussion

This study demonstrates that focusing EE programming on building youth agency and emphasizing discussions at home may be more effective at promoting youth environmental behavior than focusing on knowledge, despite a decades-long emphasis on knowledge as a key EE outcome (Ardoin et al., 2018; Stern et al., 2014). Results from this study support a large body of literature suggesting that drivers of environmental behaviors are complex (Heberlein, 2012; Krasny, 2020; Stevenson et al., 2018; Szczytko et al., 2019), but that psychological and social factors might be the most important influencers of environmental behaviors among young people. In particular, these results highlight four statistically significant factors that predicted youth environmental behaviors related to marine debris, in order of influence: (1) children's personal sense of behavioral control, (2) family discussions on the topic, (3) family-related marine debris norms, and (4) family income below the NC median income. The first three results are consistent with most EE frameworks and reform-based teaching practices (Ahteensuu, 2012; Nadkarni et al., 2019), which emphasize social learning and connecting children's learning to real-world contexts. Therefore, we recommend that if EE practitioners or educators want to support environmental behaviors among young people, then they need to empower their students' sense of control and autonomy as well as continue promoting young people's interactions with each one another, their families, and their communities. Much of these needs are addressed by teaching social-emotional skills (Gueldner, Feuerborn, & Merrell, 2020), the core of which emphasize connection: recognizing and managing emotions, communicating effectively, working with others, and controlling impulses, for example. Luckily, the pedagogical recommendation to focus on such social-emotional learning is already being practiced in formal educational spheres (Peterson et al., 2018), particularly in early childhood and elementary settings, and is being increasingly adopted among EE leaders, as teachers and educators alike have been increasingly encouraged to frame their teaching around social-emotional learning practices and learning within social contexts (Gueldner, Feuerborn, & Merrell, 2020). Framing EE programming with social-emotional learning may prove one way to encourage development of the major predictors found in this study: children's behavioral control, family discussions on the topic, and family-related norms.

Our results highlight the importance of building agency among youth to encourage pro-environmental behaviors, which will likely have benefits for the youth themselves as well as the communities in which they live. Behavioral control as tested in our study is closely related to the concepts of self-efficacy (Bandura, 1993) and agency, which suggest that individuals are more likely to engage in a behavior when they think they will have success in carrying out the behavior (Krasny, 2020). Although the concept of empowering young people to utilize their agency and behavioral control in decision-making processes is not new (Unicef United Kingdom, 1989), many recent EE guidelines, frameworks, and leaders have recommend integrating more agency and activism into EE (Chawla & Cushing, 2007; Stevenson, 2007), including a call for an increase in strategies for developing agency among young people (Derr et al., 2018; Hartley et al., 2021b). Designing EE programs that aim to empower young peoples' sense of agency and confidence (including behavioral control) in environmental action can provide multiple benefits for the young people themselves, such as facilitating content mastery (Zeldin et al., 2013), a sense of belonging and competence (Mitra, 2004; Zeldin, 2004), and emotional wellbeing and confidence (Dworkin et al., 2002; Zeldin et al., 2013). Further, efforts to build youth agency can support development of civic identity (Youniss et al., 1997) and strengthen their community connections (Zeldin, 2004), which may translate to benefits for the wider community.

Our study adds to other similar evidence that building youth agency may also promote action among youth (Zeldin et al., 2013). In practice, techniques that may build agency include encouraging children to think critically about a topic, then reflect on strategies for taking action themselves (not as prescribed by teachers or facilitators beforehand), and subsequently choose actions supporting their selected solutions (Breiting & Mogensen, 1999). Additionally, as an adult facilitator, this looks like intentionally encouraging truly meaningful involvement of young people (Elsen & Ord, 2021), such as operating as a "facilitator" instead of a leader, and deliberately including young people as co-designers, co-researchers, or co-developers of solutions (Kirshner, 2008) to enhance children's sense of agency and behavioral control. Especially on the environmental topic of marine debris, empowering child behavioral control may also look like an incorporation of service-learning projects such as local waterway cleanups to model future marine debris-related behaviors that children could participate in. Youth environmental activism has been on the rise and has united young people across the globe in recent years (Elsen & Ord, 2021), making now the perfect time for EE leaders, program/curriculum designers, and practitioners alike to consider if and how they are incorporating the development of child agency and behavioral control into their work.

In addition to promoting youth agency, our study highlights the importance of family discussions and family-related norms as standout predictors of children's marine debris behaviors, suggesting that encouraging environmental conversations at home may be one simple and effective way to promote environmentally-friendly behaviors among children. For example, encouraging child pre-environmental behaviors may look like simply looking for ways to make environmentally friendly practices part of the family context, which would shift family-related norms on the issue. In the case of marine debris, this can be as easy encouraging parents to let their children see them pick up trash or use re-usable water bottles. Further, our research shows that the simple act of *just talking to kids about environmental topics* (in this case, the environmental topic of marine debris) really matters, particularly among families with young kids (i.e., this study explored behaviors of children as young as 8-10 years old). Notably, the expertise or content level of the conversation may matter less than the simple exchange of talking and listening itself. In fact, the act of parents interacting with their children and reinforcing their environmental interests can help give their children the support that they need to grow into environmental stewards (Chawla, 2009). Impactful parenting may involve being more of a learning partner than a teacher or task-master (Camarata, 2017; Lawson et al., 2019b). We recommend future work exploring the power and potential of this simple, unstructured, and unscripted parental involvement in children's environmental interests and behaviors.

In line with research that points to intergenerational learning as a way to support environmental behaviors (Duvall & Zint, 2007; Lawson et al., 2019a), our results suggest that the examples families set in the development of norms and discussion behaviors likely support environmental behaviors among young children. Further, this study suggests that at least among elementary-aged children, parents may be more influential than peers, which is likely explained by strong relational bonds (Craig & Allen, 2015) between parents and children and is consistent with evidence on the importance of families in shaping a host of behaviors among children (e.g., recycling and reuse behaviors [Matthies et al., 2012]; consumption of organic products [Gotschi et al., 2009]; and general environmental behaviors [Collado et al., 2017]). As previous research has identified that peer-related environmental norms are influential in shaping behavior among adolescents (Grønhøj, 2007; Lawson et al., 2019b), our study may be helping to hone in on a "turning point" among youth at which point their environmental behaviors are predicted more strongly by family norms at a young age, but switch to being predicted more by peer norms as they reach adolescence and older ages. Indeed, although our study on elementary-aged children only detected statistical significance for family-related norms and discussions, Valdez et al. (2018) found that adolescents' behaviors were impacted by *both* family and peer influences. In sum, the consistent importance of family dynamics in predicting children's environmental behaviors points to a need to continue to recognize and explore these dynamics. Further, practitioners may consider incorporating activities that engage parents, such as utilizing school assignments to provide and promote space for at-home conversations around marine debris (e.g., parental interviews) and encouraging parental involvement in marine debris activities (e.g., home waste audits, marine debris clean-ups, or field trips) (Hartley et al., 2021b). Previous IGL research suggests the substance of these activities matter less than the frequency, and that increased family interaction around environmental topics can lead to more pro-environmental attitudes and behaviors among both children and parents (Lawson et al., 2019b; Stevenson et al., 2019; Valdez et al., 2018).

Though not hypothesized, results related to family income of children's environmentally-related behaviors suggest future research is warranted in this area. That families reporting incomes below the North Carolina median income (less than $50,000) had children reporting lower levels of marine debris behavior may point to the intersection of income and time availability of parents. Some of this may be explained by our specific measuring of behaviors. For instance, family income may impact children's ability to own and use reusable water bottles and containers. Additionally, family income could encroach on parents' available time to have at-home discussions with their children. For example, a parent working two jobs – a statistic which has recently seen a spike in America (da Costa, 2017) – to make ends meet at home might not have as much time for discussions as parents making a similar income at only one job. Research supports that hourly vs. salaried workers report less frequent pro-environmental behaviors, and that when adults subscribe to "time is money" beliefs, that they reduce their pro-environmental behaviors (Whillans & Dunn, 2015). Future studies interested in the role of family dynamics in predicting youth behavior could consider continuing to examine the role of income, or measuring how many hours per week each parent works, or how much time parents are able to spend with parents talking about schoolwork or other topics.

Aside from income, the limited demographic predictors on environmental behaviors are encouraging, as these results seem consistent with work emphasizing that differences in environmental engagement are likely attributable to experiences rather than something inherent in demographics themselves. For instance, Szczytko et al. (2020) found that outdoor experiences are better predictors of connection to nature than demographics, which is consistent with other leading research findings on race & park visitation (Scott & Lee, 2018, Xiao et al., 2018). One interpretation of these results is that existing measures of family dynamics may better explain the complex drivers of behavior than other commonly-cited factors influencing pro-environmental behavior, including demographics. It is likely that demographics serve as proxies for complex social contexts, and at least in this case, family dynamics may better measure this complexity than measures of gender or race, for instance. Future research should continue examine the roles that a variety of demographic factors may or may not play in youth environmental behaviors to better understand how young people participate in environmental conversations and help educators design responsive ways to keep young people learning and engaged. Other strategies for examining these questions around demographic predictors of behavior may include using data analysis strategies such as regression tree analyses that account for these unpredictable and complex interactions present in social and family contexts (Szczytko et al., 2017).

Conclusions and future research

This study adds to research on complex predictors of environmental behaviors by emphasizing the importance of building youth empowerment via sense of behavioral control and promoting family conversations and interactions around environmental topics such as marine debris. In particular, this study demonstrates that children's behavioral control, family discussions, and family norms may promote pro-environmental behaviors among children, providing a unique lens particularly into predictors of behaviors for younger-aged children (8-10 years old). Specifically, results highlight much more family influence than peer influence on young children's marine debris behaviors. However, as parental behaviors themselves were not detected to be statistically significant predictors of student behavior, our results therefore counter the old adage that "actions speak louder than words," signifying instead that parents simply talking about marine debris may be enough to activate positive marine debris behaviors among their children.

Although EE programs (and education programs in general) frequently target young people, this research coupled with other similar studies put forward that EE and formal educational programming targeting behavioral change among children may be better served by engaging entire families or, minimally, formally encouraging family discussions around the environmental topic at hand. In practice, practical applications of encouraging family discussions around the environmental topic at hand could look like including at-home intergenerational activities and family-level conversations, which have proven effective at building environmental engagement among parents through their children (Boudet et al., 2016; Duvall & Zint 2007; Williams et al., 2017). Also, our results purport that empowering youth agency could have impacts on behavior, and in practice that could look like giving children more autonomy and voice in their solutions-seeking decisions (Derr et al., 2018; Jensen & Schnack, 1997), as well as supporting and facilitating but not prescribing their methods of taking action (Kirshner, 2015). Accordingly, we recommend incorporating similar agency-building and intergenerational strategies for educational programs that aim to influence marine debris-related behaviors. These findings suggest that promoting youth agency and emphasizing the family dynamic may provide a unique window of influence on environmental behavior. Guiding marine debris behavior changes via increased discussion through intergenerational learning may prove to be an effective strategy towards ameliorating and abating the existing marine debris crisis, one empowered child and family at a time.

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Table 3.1. Item[a] factor loadings[b] for Child Marine-Debris Related Norms Scale (n = 691, α = 0.85)[c]

			Factor Loadings	
Item	**Mean**	**SD**	**Family-Related α = 0.82**	**Peer-Related α = 0.85**
My family thinks that I should take care of the environment.	4.01	0.953	0.87	
My family usually takes care of the environment.	3.93	0.945	0.83	
My family thinks that taking care of the environment is important.	4.25	0.895	0.87	
My friends think that I should take care of the environment.	3.45	1.01		0.86
My friends usually take care of the environment.	3.49	0.938		0.89
My friends think that taking care of the environment is important.	3.78	0.974		0.89

[a] Each item associated with a 5-point agreement Likert scale ranging from (1) *Totally disagree* to (5) *Totally agree*.
[b] PCF indicated an optimal two-factor solution that accounted for 75% of the variance
[c]KMO Measure of Sampling Adequacy: 0.827 (Cerny & Kaiser, 1977)

Table 3.2. Item[a] factor loadings[b] for Child Marine-Debris Related Behaviors Scale (n = 691, α = 0.67)[c]

Item	**Mean**	**SD**	**Information seeking and sharing α = 0.69**	**Individual behaviors α = 0.51**
Talk with my family about ways to solve environmental problems.	2.74	1.46	0.81	
Talk with my friends about ways to solve environmental problems.	2.32	1.42	0.75	
Try to learn things that I can do to solve environmental problems.	3.12	1.34	0.69	
Refuse to use plastic straws at home or in restaurants.	2.70	1.40	0.56	
Use reusable grocery bags when we go grocery shopping.	2.97	1.24		0.61
Use a reusable water bottle.	3.22	1.05		0.79
Use reusable containers instead of plastic containers.	3.32	1.16		0.67

[a] Each item associated with a 5-point frequency Likert scale ranging from (1) *Never* to (5) *Every chance I get*.
[b] PCF indicated an optimal two-factor solution that accounted for 48% of the variance, with two factors containing Eigenvalues $\geq$ 1.0
[c]KMO Measure of Sampling Adequacy: 0.752 (Cerny & Kaiser, 1977)

Table 3.3. Item[a] factor loadings[b] for Parent Marine-Debris Related Behaviors Scale (n = 691, α = 0.82) [c]

Item	Mean	SD	Factor loadings α = 0.82
Talk with my family about ways to solve environmental problems.	3.07	1.16	0.83
Talk with my friends about ways to solve environmental problems.	2.78	1.18	0.83
Try to learn things that I can do to solve environmental problems.	3.32	1.12	0.82
Refuse to use plastic straws at home or in restaurants.	3.37	1.47	0.66
Use reusable grocery bags when we go grocery shopping.	3.63	1.30	0.66
Use a reusable water bottle.	3.51	1.51	0.57
Use reusable containers instead of plastic containers.	4.27	0.87	0.63

[a] Each item associated with a 5-point frequency Likert scale ranging from (1) *Never* to (5) *Every chance I get*.
[b] PCF indicated an optimal two-factor solution that accounted for 88% of the variance, with two factors containing Eigenvalues $\geq$ 1.0
[c]KMO Measure of Sampling Adequacy: 0.856 (Cerny & Kaiser, 1977)

Table 3.4. Item[a] factor loadings[b] for Child Marine-Debris Behavioral Control Scale (n = 691, α = 0.84)[c]

Item	Mean	SD	Factor loadings α = 0.84
If I wanted to, I could talk with my family about ways to solve environmental problems.	4.11	0.97	0.75
If I wanted to, I could talk with my friends about ways to solve environmental problems.	3.87	1.18	0.73
If I wanted to, I could try to learn things that I can do to solve environmental problems.	4.26	0.91	0.74
If I wanted to, I could refuse to use plastic straws at home or in restaurants.	3.92	1.19	0.63
If I wanted to, I could use reusable grocery bags when we go grocery shopping.	4.30	0.10	0.75
If I wanted to, I could use a reusable water bottle.	4.46	0.91	0.74
If I wanted to, I could use reusable containers instead of plastic containers.	4.45	0.84	0.75

[a] Each item associated with a 5-point agreement Likert scale ranging from (1) *Totally disagree* to (5) *Totally agree*.
[b] PCF indicated an optimal two-factor solution that accounted for 63% of the variance, with two factors containing Eigenvalues $\geq$ 1.0
[c]KMO Measure of Sampling Adequacy: 0.870 (Cerny & Kaiser, 1977)

Table 3.5. Regression results of model predicting child marine debris behavior based on marine debris scales and control variables (*n* = 667).
Note: Data were collected between September 2018 and January 2020 from 4th and 5th grade public school classrooms across the state of North Carolina.

	Child marine debris behavior		
Predictor Variables	***B***	***β***	***p-value***
Child knowledge	-0.009	-0.005	0.874
Child behavioral control* **	**0.224**	**0.213**	**0.000**
Child norms: Family*	**0.219**	**0.099**	**0.029**
Child norms: Peers	0.067	0.032	0.426
Parent behavior	0.049	0.055	0.130
Family marine debris discussions* **	**0.731**	**0.207**	**0.000**
Peer marine debris discussions	0.272	0.060	0.202
School marine debris discussions	0.266	0.063	0.119
Control Variables			
Child sex/gender	0.301	0.029	0.397
Parent race	0.291	0.233	0.504
Rural/Urban status (school)	0.248	0.022	0.528
Income			
Below Median Income*	**- 0.982**	**- 0.074**	**0.038**
Prefer not to answer			
Constant	6.59		
N	673		
R^2	0.265		
R^2 adjusted	0.251		

Coding for all variables was as follows: Sex/Gender: 0 = Male, 1 = Female. 2 = Other; Race: collapsed to 0 = Non-white, 1 = white; Income: collapsed to roughly above or below NC Median Household Income ($54,602) at 0 = above $50,000, 1 = $0 - $49,999, 2 = Prefer not to answer; Non-Rural = 0, Rural = 1.
**p*<0.05
** p < .01.
****p* < 0.001.

CHAPTER 4: Youth can promote marine debris concern and policy support among local voters and political officials

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Abstract

Many of the most sweeping social movements throughout history have been youth-led, including those related to environmental challenges. Emerging research suggests youth can build environmental concern among parents via intergenerational learning, in some cases overcoming socio-ideological differences that normally stymie attempts at collective action. What has not been studied is the potential for youth to also influence adults outside their immediate families. This study based in North Carolina, USA, explores the potential of today's young people as environmental change-agents in their communities on the topic of marine debris. Specifically, this evaluation examines responses from voters and local officials after participating in youth-led civic engagement events. After engaging with a youth-led civic engagement event, voters and local officials completed a retrospective pretest survey that asked questions about levels of marine debris concern and their likelihood of supporting a local marine debris ordinance. Young people encouraged both concern and policy support among both voters and officials, and that concern and policy support increased independently of whether adults were voters or officials, liberals or conservatives, or knew the students personally. Further, participation in the youth-led engagement event reduced political differences in marine debris concern. This study suggests youth can play a critical role addressing marine debris challenges by promoting support for marine debris management policy, and doing so across political barriers.

Introduction

Political solutions to environmental problems have long proven elusive. Although overall adult concern for and prioritization of environmental issues have increased in the United States over the last decade, environmental progress is often stymied by wide partisan gaps (Pew Research Center, 2020). In fact, political ideology has been shown to be a more prominent factor in predicting one's environmental attitudes than the weight of scientific evidence on environmental issues (Dunlap & McCright, 2008). This may be because political affiliation is a key aspect of many people's personal and social identity (Iyengar & Westwood, 2015) – as the politicization of environmental protection has been woven into political ideologies, and therefore, in many cases, individuals' personal identities. For instance, a small but significant number of US citizens have switched their self-labeled ethnicity, religion, sexual orientation, or class to better align with their political affiliations (Egan, 2020), and polls suggest the same could be true with the environment. In the United States, support for environmental issues has become partisan, with 85% of surveyed Democrats prioritizing the protection the environment, while only 39% of surveyed Republicans shared the sentiment (Pew Research Center, 2020). These challenges associated with identity politics are compounded by adults and older Americans simply caring less about the environment than youth (Ballew et al., 2019). Taken together, identity politics and age can make political action to protect the environment challenging, or in some cases impossible (Egan, 2020).

Though this polarized context paints a bleak picture for generating solutions for environmental challenges, the perspectives and activism of youth may offer hope. While adults are polarized in their views on environmental issues, young people are less so. Several recent polls highlight how Millennials and GenX-ers are polarized on a host of issues, but less so when it comes to climate change and renewable energy (Funk & Hefferon, 2020). Youth may hold more united views on environmental topics than adults because their worldviews and political ideologies are developing alongside their knowledge of environmental science, making it less likely that younger audiences will reject scientific facts because of already cemented political ideologies (Stevenson et al., 2014). Further, youth have the most to gain by investing in a sustainable future (Ballew et al., 2019). Indeed, future consequences of inaction, such as climbing global temperatures and associated impacts, will be most felt when the youth of today reach adulthood, and older generations will no longer be alive (Hansen et al., 2013). Perhaps for these reasons, we see evidence of high levels of engagement on environmental topics among younger generations. Youth prioritize and care deeply about environmental topics (Funk & Hefferon, 2020), as demonstrated by the commitment displayed by "Little Miss Flint," Amariyanna Copeny, representing her Michigan, USA, community in its water crisis at age 8 and Greta Thunberg leading the globe towards climate solutions at age 15 (Marris, 2019), among others. Youth can and are politically active in responses to environmental change, and as historian Wesley Hogan (2019) notes, the future of democracy is in the hands of today's young people, who do not have to wait until they are of voting age to be politically impactful.

Environmental youth activism may be uniquely situated to transcend ideological barriers to adult commitment on environmental solutions, as youth may inspire adults to join them. The phenomenon of adults learning from children is described as intergenerational learning (IGL), or the bi-directional transfer of knowledge, attitudes, or behaviors from children to their parents and vice versa (Duvall & Zint, 2007; Bottery, 2016). Several studies have documented how this process can work particularly well for environmental issues (Duvall & Zint, 2007). Youth may serve as embodied reminders of future impacts of today's policies, thereby making the future impacts of environmental problems more tangible for adults (Bulc et al., 2019). Further, wanting what is best for future generations may offer the common ground needed to overcome political polarization (Lawson et al., 2019). For instance, when children discussed their climate change education programming with their parents, parents were found to have gains in climate change concern – and this effect was largest among politically conservative parents who initially had the lowest levels of climate change concern (Lawson et al., 2019). It is well established that young learners benefit from engaging in the political process through increased agency, competence (Mitra, 2004; Zeldin, 2004), and self-confidence (Dworkin et al., 2003; Jensen & Schnack, 1997). It is quite possible that youth political participation not only benefits the youth themselves, but the entire political process, by inspiring action among older generations (Williams et al., 2017) and providing a pathway to overcoming barriers to political progress related to partisan polarization (Lawson et al., 2019).

Background

Existing IGL research suggests youth can influence adult environmental perceptions and behaviors within their families. Evidence includes several quasi-observational studies in which youth-targeted environmental education programs have been associated with parental knowledge, attitudes and/or behaviors in the contexts of water pollution (Uzzell, 1994), air pollution and litter (Ballantyne et al., 2001), watersheds (Sutherland & Ham, 1992), and flood resilience (Williams et al., 2017). Notably, at least two experimental studies have found causal evidence that youth-led conversations at home have inspired both energy saving behaviors (Boudet et al, 2016) and climate change concern (Lawson et al., 2019) among parents. Further, as noted above, the influence that youth have over parents' climate change concern overcame political polarization, offering an uncommonly found pathway to political progress on environmental challenges (Lawson et al., 2019).

More research is needed to understand if and how young people influence adults outside of their family units. Behavior changes typically spread through personal relationships (Centola 2021), and as youth bridge generational gaps and develop personal relationships both within and beyond their family units (e.g., with teachers, coaches), they may be well-positioned to drive broad acceptance of new ideas within communities. Attributes of personal relationships that can help drive the spread of behaviors and ideas, such as trust and communication frequency, are typical of family relationships (Centola, 2021), and may help explain the increasingly strong evidence in support of youth’s influence over parents. Indeed, several studies have found that frequency of discussion between youth and parents has been shown to be a predictor in increasing environmentally friendly behaviors (Ojala, 2015; Stevenson et al., 2019; Valdez et al., 2018). Specifically, studies have shown that students discussing climate change with family and friends was one of the biggest indicators of their climate change behavior (Valdez et al., 2018), and that frequency of discussion with friends and family was the second strongest predictor of climate change concern among students, with family having more influence than friends (Stevenson et al., 2019). Accordingly, youth may have a larger influence over adults with whom they have closer personal relationships. Several qualitative studies have found support for youth influence outside the family context, such as in Australia, where children led their communities to act more sustainably (Stuhmcke, 2012); in 11 communities in Thailand, where students researched deforestation and forest degradation and then brought the results of their investigations to local community members (Gallagher et al., 2000); and in Mexico, where local community leaders responded positively after students publicly participated in beach clean-up and natural area rehabilitation efforts (Schneller, 2008). Furthermore, Thew (2018) found that when youth have high levels of agency, their policy suggestions are generally well-received by adults in political spheres. Although these findings for levels of youth influence outside of the family context are promising, little quantitative research has examined how youth may influence adults in their communities beyond their parents (e.g., neighbor, soccer coach, Twitter follower, etc.).

Other critical questions include the degree to which youth can influence a specific group of unaffiliated adults: local officials. While local officials may have more immediate influence on policy than other community members, they have been found to be less likely to work across partisan divides for fear of appearing weaker to voters (Iyengar & Westwood, 2015). This may be especially true in the United States, where environmental issues have become partisan issues (Pew Research Center), and the politicization of environmental protection makes the compromises required for political action challenging (Egan, 2020). While the gap between environmental protection and political action may be large, youth-led environmental IGL may help bridge the way for local officials. Qualitative instances of youth influencing their local officials have been found, such as youth-made climate change video screenings contributing to officials taking next steps towards climate solutions in the Philippines (Haynes & Tanner, 2015) and youth environmental activism contributing to community solutions towards environmental challenges in Hawai'i (Volk & Cheak, 2003); however, no studies have been conducted quantitatively or explored how youth may influence perspectives on environmental issues and policy among local officials. Finally, as highlighted by the rise of virtual engagement with the onset of COVID-19, research on the mode of student engagement (e.g., in-person versus virtual) may be beneficial. Virtual learning poses multiple problems including adding unnecessary complexity to the learning process (Pan, 2010), negative effects on students' motivation, and a lack of peer interaction (Aliane et al., 2010), but given the increasing norm of both educational and civic processes occurring virtually, understanding the degree to which youth can influence adults even when in-person interactions are not possible would be valuable.

We began addressing these research gaps with a particular focus on whether young children (aged 8-10), with no formal political power, might motivate adults. Specifically, we examined how community events led by young children around marine debris may inspire marine debris concern and support for policies to address marine debris among both voters and local officials. We chose the issue of marine debris for several reasons. First, marine debris is an emerging environmental challenge and poses significant threats to coastal ecosystems (Riggs et al., 2011). Second, it is a compelling environmental cause for young people to champion (Hartley et al., 2015) because the problem is highly visible, persistent, and concrete solutions like trash reduction are readily apparent (Torres et al., 2019). Further, a recent study found that environmental advocacy videos on the topic of marine debris were able to reduce attitude and behavioral gaps between partisan groups (Jennings et al., 2020). Engaging with younger audiences on marine debris therefore provides a promising approach to address a pressing environmental issue and to empirically evaluate the community impacts of political activism led by young children (Ballantyne et al., 1998; Duvall & Zint, 2007; Lawson et al., 2019). In this context, we tested 5 hypotheses:

(1) all adults would report increased concern for marine debris and support for policies to address marine debris after participating in a youth-led event,

(2) changes would not be as strong for local officials as for voters,

(3) pre-existing personal relationships with youth presenters would predict larger gains in marine debris concern and support for policies to address marine debris,

(4) adults who attended in-person youth-led civic engagement events would show greater gains than those who watched online public service announcement (PSA) videos made by youth, and

(5) political polarization around marine debris concern and support for policies to address marine debris would lessen among all adults after engaging with the youth-led event.

Methods

Study Context

This study was based throughout coastal, piedmont, mountain, urban, and rural counties across North Carolina, USA and examined changes in marine debris concern and support for policies to address marine debris among voters and local officials after participating in youth-led civic engagement events focused on marine debris. These youth-led engagement events were designed by 8–10-year-olds as part of a year-long marine debris curriculum over the 2018–19 and 2019–20 school years. As part of the marine debris curriculum, students developed civic engagement events for their local officials and community adults that were either in-person (e.g., formal presentations at their local town hall meetings) or virtual (e.g., public service announcement videos). In-person events included talent shows, poetry nights, student art exhibits, and formal in-person presentations to local Town Halls and School Boards. Virtual events included production and dissemination of virtual public service announcement videos (PSAs). In each case, teachers supported their students in preparing the events, but the events themselves were student-designed and delivered. For instance, in the case of the video PSAs, students first watched examples of other video PSAs and then designed their own. The curriculum included activities to help students research relevant facts about marine debris, develop talking points to communicate the issues of marine debris to others, create a script and storyboard for the PSAs, and film the PSAs (DeMattia et al., 2020). The freely-available marine debris curriculum and complete descriptions of the activities can be found on the Duke University Marine Lab Community Science website (DeMattia et al., 2020). Specific examples of youth-made marine debris PSA videos are available on YouTube (Hartley, n.d.).

Instrument Development

We measured levels of marine debris concern (hereafter as "MD concern") and support for marine debris-related ordinances (heretofore "MD policy support") with a retrospective pre/post survey (Moore & Tananis, 2009). After development of an initial survey, we asked 11 Town Managers, City Planners, and Local Officials to pilot the survey and provide feedback to strengthen its relevance, applicability, and usefulness for communities. Based on feedback from these pilot sessions, we made adaptations to the language and overall structure of the surveys. In the final version of the survey, we asked respondents to consider their level of MD concern, both before and after the student presentations with a five-point Likert style scale. We asked: "*Consider your level of concern about marine debris. What was your level of concern BEFORE the student presentation*?" and "*What is your level of concern NOW, after the student presentation?*" Response options ranged from not at all concerned to extremely concerned. Similarly, we asked: "*Consider the likelihood of your supporting an ordinance in your county to address marine debris. How likely were you to support such an ordinance BEFORE the student presentation?* and "*How likely are you to support such an ordinance NOW, after the student presentation?*" Response options ranged from extremely unlikely to extremely likely. We also asked respondents to self-report race, gender, political affiliation, and whether or not they knew the students previously.

Data Collection

In order to recruit local officials and local voters we paired intercept surveys at in-person engagement events with an active recruiting strategy for local officials via email. At the events, we conducted intercept surveys of attendees (voters and officials) by handing out a small post-card with a link to an online survey. There were eight youth-led, in-person events in the 2018-2019 school year, including a beach clean-up, talent show, art show, fashion show, local School Board meeting, a presentation at a brewery, and two school plays written and directed by the students on the topic of marine debris. We supported teachers and students in advertising the youth-led civic engagement events via flyers posted in the community, social media posts, emails sent to school families from the teachers and principals, emails sent to local officials from the county where the event was taking place, and press releases run by local news outlets.

Though more events were planned in the 2019-20 school year, all but one (a town hall meeting) were cancelled in response to the COVID-19 pandemic. As a result, students refocused their efforts on PSAs which could be delivered online. For the student-generated video PSA events, we focused our efforts on recruiting local officials. This online recruitment represents a different pathway than the intercept method, but was necessary because online PSAs did not have an in-person mechanism to engage local officials during COVID-19. To supplement recruitment of local officials, we developed a list of mayors, school board officials, town hall members, local soil, water, & conservation officials, county commissioners, city council members, school Superintendents, and members of Environmental Affairs Boards (where applicable) from all 100 counties in North Carolina. We searched county and municipal websites for email addresses, and where there were no email addresses provided, we followed up by phone to gather contact information. We drew from this list to directly invite local officials to all in-person events. When possible, we emailed officials a link to the student-developed PSA video(s) from their own county and a link to the survey. In counties where there were no participating students, we sent local officials a link to a YouTube channel with a sampling of PSA videos from students across the state, as well as a link to the survey.

In total, we contacted 1,984 local officials via email for online PSA "events." For the in-person events, we handed out approximately 300 survey cards to in-person attendees. For both in-person and online events, 172 adults (65 voters and 107 local officials) completed a retrospective-pretest survey that asked questions about levels of their MD concern and the likelihood of their MD policy support (generating a response rate of approximately 22% for voters and <1% for local officials). Of these, 37 voters attended an in-person event, 22 interacted with the video PSAs, and 6 did both. In terms of local officials, most (89) interacted virtually only, with 7 attending in-person events, and 11 doing both. Community voters and local officials received the same survey, but were asked if they were a local official or not in the survey.

Retrospective pretest methods are commonly used because they allow research addressing temporal changes to occur with only one data collection event (Allen & Nimon, 2007; Gouldthorpe & Israel, 2013), making them a "simple, convenient, and expeditious method" for assessing programmatic effects of an intervention (Pratt et al., 2000, p. 347). This approach, however, has well known limitations centered on recall bias and social desirability bias (Gouldthorpe & Israel, 2013). We believe the former is relatively small given respondents were asked to recall their views over a relatively short time period of less than one hour (Gouldthorpe & Israel, 2013). To the degree social desirability bias existed, it would require interpreting overall program impacts with caution (hypothesis 1), but would not affect hypotheses 2-5 which dealt with relative change in MD concern and MD policy support.

Data Analysis

To test hypothesis 1, we used paired t-tests that compared means of pre- and post-engagement event levels of MD concern and MD policy support for the whole sample. To test hypotheses 2-4, we used a multiple linear regression to model change in levels of MD concern and MD policy support as a function of whether the adult was a local official or not (hypothesis 2), if adults knew the students previously (hypothesis 3), and type of engagement event attended (in-person, PSA video, or both; hypothesis 4). We also controlled for pre-test MD concern or MD policy support in the associated models with respect to ceiling effect (Allison, 1990; Dalecki & Willits, 1991), self-reported sex (male vs. female), race (White vs. Non-White), and political orientation (liberal, conservative, or independent/other). Because we included respondents from various parts of the state, we also included distance from the coast as a co-variate in the models, but as it was not significant in either model nor was it central to our hypotheses, we excluded it. Similarly, as most local officials attended virtual events, we examined the variance inflation factor (VIF) as a measure of co-linearity between voters versus officials and event type, and found VIF levels were well below the acceptable levels of 4 (MD concern: mean VIF = 1.28; MD policy support: mean VIF = 1.28; O'brien, 2007). Finally, we tested hypothesis 5 using a t-test to compare mean polarization in MD debris concerns (i.e., mean MD concern among liberals minus mean MD concern among conservatives) before and after engagement with the youth-led events. We compared pre- and post-engagement polarization on MD policy support using the same approach. To test variation of levels of political polarization in hypothesis 5, we removed responses from participants who selected "independent/other" from analysis and only considered liberals and conservatives as binary politics variables on opposite ends of the political spectrum. All analyses were conducted using STATA 14.2. Relatively small sample size (*n* = 161) in this study dictates caution when interpreting non-findings. Specifically, with limited statistical power some relationships not detected in this study may be both statistically and socially significant in a study based on a larger sample. This, however, means that relationships that were detected would likely be found in subsequent studies, potentially with large effect sizes.

Results

Respondents were relatively evenly distributed in terms of political identification (liberal = 35%, conservative = 37%, independent/other = 28%), being a voter or local official (62% local officials), and gender (55% female). The average age of respondents was 57 years (SD = 13.1, ranging from age 23 to 89), most identified as White (87%), and most did not previously know the students participating in the engagement events (91%). Demographically, our sample was fairly representative in terms of gender, as 51.4% of residents are female (US Census Bureau, 2019), but over-represented White, older adults in North Carolina, as only 70.6% of North Carolinians identify as White, and the average age is 38.7 (US Census Bureau, 2019). However, these measures more closely align with the demographic make-up of elected officials in North Carolina, as elected officials generally are older and more White than the general population, including in North Carolina, where 99% of state legislators were White in 2015, and the average age was 59 (NCSL, n.d.). In terms of political affiliation, it is possible that our sample over represents independents, as only 17% reported not being affiliated with Republicans (41%) or Democrats (43%) (Pew Research Center, n.d.). However, it should be noted that the proportion of unaffiliated voters in North Carolina, and nationwide, is increasing (Tippett, 2020), so our sample may not deviate from the population as much as available population data would suggest.

We found support for hypotheses (1) that all adults would report increased concern for marine debris and support for policies; (2) that changes would not be as strong for local officials as for community adults; and partial support for (5), that political polarization would lessen among all adults. Specifically, polarization decreased around marine debris concern, but differences were not detected for polarization in support of policies to address marine debris. We did not find support for hypotheses (3) that pre-existing personal relationships with youth presenters would predict larger gains in MD concern; nor MD policy support (4) that adults who attended in-person youth-led civic engagement events would show greater gains than those who watched online public service announcement (PSA) videos made by youth.

We found support for hypothesis 1, as adults exhibited 12.5% more MD concern and 12.2% more MD policy support after engaging with the youth-led civic engagement events. Marine debris concern increased from 3.93 (sd = 0.77) to 4.42 (sd = 0.66; t = -9.63, p < .0.001) after community members participated in the events. Similarly, MD policy support increased from 3.92 (sd = 1.022) to 4.40 (sd = 0.85, t = -8.56, p < 0.001) after community members participated in the events.

We also found partial support for hypothesis 2, as both voters and officials had similar gains in MD concern, but voters had bigger gains than officials in terms of MD policy support. Marine debris concern for local officials increased by almost 9 percentage points (mean change = 0.44/5, sd = - .62) whereas MD concern among voters increased by approximately 13 percentage points (mean change – 0.65/5, sd = 0.60; Figure 4.1). Though different in magnitude, the regression model suggests only a weak statistical difference between these gains in MD concern between voters and officials (beta = 0.148, p = 0.097; Table 1a). We found stronger differences among voters and local officials for MD policy support, with nearly 8 percentage points gained among officials (mean change = 0.39/5, sd = 0.60) and an increase of nearly 13 percentage points among voters (mean change = 0.64/5, sd = 0.95; Figure 4.1). The regression model also supported that officials had smaller increase in MD policy support than voters (beta = -0.263, p = 0.020; Table 4.1b).

Results did not support hypothesis 3 because we did not detect relationships between MD concern and pre-existing personal relationships with youth presenters (Table 4.1a) or MD policy support (Table 4.1b). Similarly, we did not find support for hypothesis 4 because type of event (i.e., in-person vs. virtual) was not related to changes in MD concern or MD policy support (Table 4.1a-b). Women expressed higher levels of MD concern than men (beta = 0.248, p = 0.001; Table 4.1a), and we found a similar, but weak, difference associated with MD policy support (beta = 0.194, p =0.052; Table 4.1b). The MD concern model explained more variance in data ($R^{2adjusted}$ = 0.480, $F(8, 151) = 19.40$, $p < 0.001$; Table 4.1a) than the MD policy support model ($R^{2adjusted}$ = 0.384, $F(8, 151) = 13.50$, $p < 0.001$; Table 4.1b). Although not a part of our hypotheses, we also note from the regression that women were more likely than men to increase MD concern (beta = 0.248, p <0.001), and there was a similar, but weaker relationship between gender and changes in MD policy support, with women increasing more than men (beta = 0.191, p = 0.06).

Finally, we found partial support for Hypothesis 5, as polarization between liberals and conservatives decreased around MD concern but not for MD policy support. That is, liberals' and conservatives' MD concern levels came closer together after the intervention, but liberals and conservatives remained relatively polarized over MD policy support. With MD concern, liberals and conservatives were polarized on their pre-test responses, with conservatives less concerned (mean = 3.69, sd = 0.518) than liberals (mean = 4.36, sd = 0.518). Both groups increased MD concern levels after participating in youth-led events, with MD concern levels of conservatives (post-test mean = 4.33, sd = 0.36) approaching those of liberals (mean = 4.64, sd = .37). Differences between liberal and conservative MD concern levels were significantly smaller in the post-test (mean difference = 0.30; sd = 0.33) than the pre-test (mean difference = 0.67; sd = 0.35; $t = 5.808$, $p < 0.001$). A similar, though not statically significant, pattern occurred for MD policy support as differences in support levels were smaller in the post-test (mean difference = 0.39; sd = 0.39) than the pre-test (mean difference = 0.49; sd = .43; $t = 1.21$; $p = 0.226$) (Figure 2).

Discussion

Previous research has found experimental evidence for how youth can shift familial adult's environmental concern and behavior, such as in the context of climate change (Lawson et al., 2019) and energy saving behaviors (Boudet et al., 2016). Similarly, mixed methods and qualitative research suggest youth shape conversation and perceptions around environmental topics among adults outside their immediate families (Haynes & Tanner, 2015; Vaughan et al., 2003; Volk & Cheak, 2003). However, to our knowledge, this is the first quantitative evidence of youth influence outside their families, and the first to specifically examine how youth can impact local officials' approaches to marine debris. We found increases among all groups of adults for both MD concern and MD policy support, and despite the nuances we discuss below, our results point to a clear and powerful role for youth in shaping adult perceptions of marine debris and participation in political processes to address marine debris.

Though we found that the influence of youth-led engagement seems to extend well beyond the family unit, different responses across adult groups highlights a need for future research to understand the mechanisms of youth influence. Social change most profoundly occurs through strong social ties among friends, family, and neighbors (Centola, 2021), which helps explain results from previous studies demonstrating the influence of youth within their families (Lawson et al., 2019; Williams et al., 2017). However, we found that adult marine debris concern and policy support increased regardless of whether the adults knew students or not, and even whether the events were in-person or virtual. That youth seemed to have this impact may reflect that youth have greater accessibility and approachability than adults, which combined with their genuine empathy and concern for the environment and the issues impacting it (Young et al., 2018), may make them trusted messengers to adults (Peterson et al., 2019). Our research design pointed local officials to videos made by youth in their own jurisdictions, and these local connections may also help explain the youth's influence, as locally framed messaging seems to be effective in engaging adults on even controversial issues such as climate change (Evans et al., 2014). Furthermore, considering that approximately half of the videos were viewed after local lockdowns occurred due to COVID-19, the connections created by virtual videos may have been amplified by the scarce nature of community connections at the time (Antonello et al., 2020). Our finding that officials were less changed by youth presentations than their community adult counterparts is perhaps not surprising – given officials must operate within the structural systems of government and represent the will of their constituents (Staerklé, 2015).

This study builds on previous research within households (Lawson et al., 2019), to suggest that youth can reduce polarization over environmental issues in communities. Community members from both political parties increased in their overall levels of marine debris concern after the youth presentations, but conservatives shifted most, shrinking partisan gaps in marine debris concern. This finding is particularly promising since political partisanship has historically been a major factor in attitudes about the environment and, as a national priority among the public, holds one of the largest partisanship gaps (Pew Research Center, 2020). Future research is needed to unravel the mechanisms allowing youth voices to build consensus in politically divided adult spaces. As highlighted above, youth may be a more trusted information source than adults (Peterson et al., 2019), and bring a level of enthusiasm that adults find compelling (Young et al., 2018). These characteristics may help explain why youth presenters were compelling enough to impact the levels of MD concern among their local community adults, reducing political polarization seen in the pretests. Weaker impacts from youth on policy support than concern seem reasonable, given policy support emerges from a complex political milieu including funding and pressure from lobbyists (Vesa et al., 2020). Building a shared concern about marine debris represents a baseline need for productive policy negotiation (Vince & Stoett, 2018) from which bipartisan support for marine debris policy can be developed. Given the small sample size and short timeframe of our study, we encourage future researchers to continue to explore how youth may impact environmental policy support, particularly where longitudinal efforts can address policy development and implementation that often takes several years.

Our results also suggest that youth may effectively impact community members regardless of gender or race. Dozens of studies have found that women care about the environment more than men (McCright, 2010; Xiao & McCright, 2012), and our results were consistent with these findings, as women were more likely to increase MD concern and support for MD policies. Race was not a significant predictor in any models, a finding that reflects research demonstrating that people of color are equally as supportive (Mohai, 2003) if not more supportive than White Americans on environmental, climate, and energy policies (Ballew et al., 2020; Leiserowitz & Akerlof, 2010). However, these results should be interpreted with caution, as our sample sizes among people of color were low and led to groups that were too small to examine without collapsing racial categories. We acknowledge that people of color are not a monolithic group, and therefore future research with larger sample sizes is needed to facilitate stronger inference about specific racial groups. Accordingly, future research could also investigate interactions between race of the youth presenter and race of the participating adults. Other studies have demonstrated that having adult role models is highly impactful for young learners in increasing motivation and achievement (Connell & Wellborn, 1991; Martin & Dowson, 2009; Midgley et al., 1995; Ryan & Deci, 2000; Skinner & Belmont, 1993), and that youth of color particularly benefit from role models of the same race (Egalite et al., 2015). Future intergenerational learning research may investigate if similar relationships exist in the opposite direction from youth to adults, where adults are more likely to listen to young people that look like them.

Conclusion

In conclusion, our results suggest that youth participation in environmental politics may help galvanize immediate political action among current voters and decision makers. Youth voices may also be able to transcend adult partisan divides, given youth can decrease polarization around marine debris management. As research on both the dynamics of intergenerational learning and strategies to address marine debris continue to emerge rapidly, there are multiple avenues for future research. Youth are already taking the lead in many social and environmental movements and are enthusiastically seeking solutions to combat marine debris (Prisco, 2017). Accordingly, designing environmental education curricula that taps into this demonstrated appetite for civic engagement (on the topic of marine debris or otherwise) may help to harness the solution-seeking energy already present among young people and inspire adults to follow where the young people are leading. Innovative research designs drawing on psychology, sociology, and social contagion (de Lange et al., 2019; Centola, 2021), could help reveal the mechanisms through which information and motivation move from youth to their communities, and how kids may drive that information mobilization. As with most research conducted during the global pandemic, we acknowledge the need for research outside the context of COVID-19. Pressures on local officials' time and priorities related to serving their communities during the pandemic could have rendered youth impacts larger because they were a welcome respite, or dampened youth impacts by rendering their work on marine debris relatively less urgent in the context of a pandemic. Similarly, relatively low response rates among local officials may indicate our results are biased toward the perspectives of officials most concerned with opinions of their youth constituents or engaged with local schools or marine debris management issues. These officials are important because they are most likely to act on the marine debris issue, but future studies could mitigate the potential bias using sampling methods linked to high response rates (e.g., in-person interviews; Manfreda et al., 2008). Nonetheless, this study suggests youth-led marine debris education programming can positively impact adults (including local policy-makers and decision-makers). Perhaps most importantly, youth influence seems poised to overcome long-standing divisions that continue to stymie political progress on environmental challenges.

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Table 4.1a. Regression results of model displaying factors predicting **differences in marine debris concern** after engagement with the youth-led civic engagement events.				**Table 4.1b.** Regression results of model displaying factors predicting **differences in levels of marine debris policy support** after engagement with the youth-led civic engagement events.		
	Marine Debris Concern			**Support for Marine Debris Policy**		
Variable	***B***	**SE**	***β***	***B***	**SE**	***β***
Pre-event levels	-0.599***	0.055	-0.685	-0.452***	0.048	-0.613
Event attendance: PSA video (virtual)	*(reference variable)*			*(reference variable)*		
Event attendance: In-person	0.090	0.120	0.050	0.189	0.151	0.090
Event attendance: Both	0.070	0.133	0.031	0.004	0.169	0.001
Gender	0.248***	0.079	0.189	0.191	0.099	0.125
Race	-0.113	0.120	-0.056	-0.117	0.150	-0.050
Politics: Liberal	*(reference variable)*			*(reference variable)*		
Politics: Conservative	-0.046	0.097	-0.034	-0.089	0.115	-0.057
Politics: Independent/Other	-0.013	0.100	-0.009	-0.203	0.125	-0.118
Previous Relationship with Students	0.007	0.170	0.003	-0.068	0.216	-0.023
Local Official or Voter	-0.148	0.089	-0.109	-0.263*	0.112	-0.166
Constant	2.701***	0.292		2.293***	0.313	
N	160			160		
R^2	0.510			0.419		
R^2 adjusted	0.480			0.384		

Table 4.1a-b. Regression results of models predicting difference in marine debris concern (Table 1a) and support for marine debris policy (Table 1b) after engagement with the youth-led civic engagement events.
Note: Data were collected between March 2019 and October 2020 survey results from 4th and 5th grade public school civic engagement events and youth-developed PSA videos across the state of North Carolina.
Coding for all variables was as follows: Event attendance: 1 = Video; 2 = Community Event; 3 = Both; Sex/Gender: 0 = Male, 1 = Female. 2 = Other; Race: collapsed to 0 = Non-White, 1 = White; Politics: collapsed to 1 = Liberal; 2 = Conservative; 3 = Independent/Other.
**$p < 0.005$.

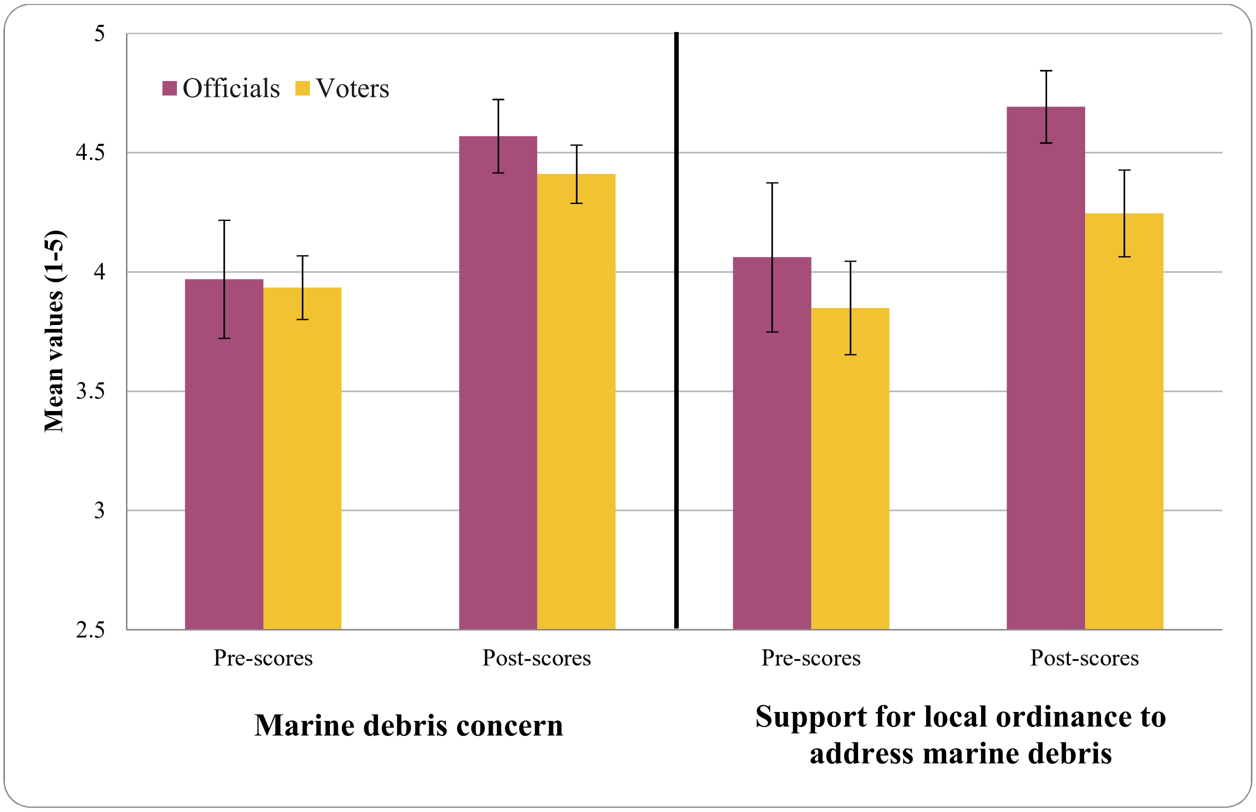

Figure 4.1. Levels of marine debris concern or support for local ordinance (respectively), shown for local officials vs. regular voters. Retrospective-post questions posed on a 5-point Likert scale were "Consider your level of concern about marine debris. What was/is your level of concern BEFORE/AFTER the student presentation?" with a scale of 1-5 (1 = extremely unconcerned; 5 = extremely concerned) and "How likely were/are you to support such an ordinance BEFORE the/NOW, after the student presentation?" with a scale of 1-5 (1 = extremely unlikely; 5 = extremely likely). Error bars represent 95% confidence intervals.

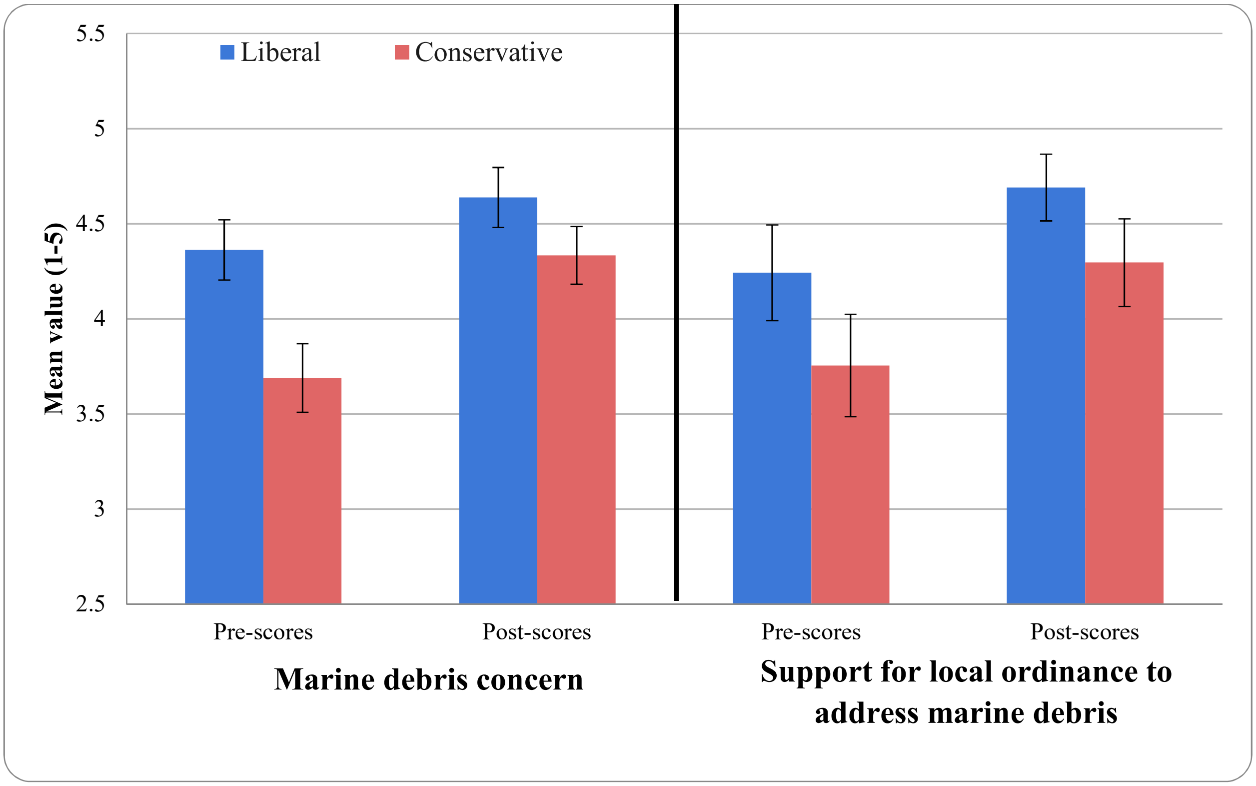

Figure 4.2. Levels of marine debris concern or support for local ordinance (respectively), shown for groups of political affiliation. Retrospective-post questions posed on a 5-point Likert scale were "Consider your level of concern about marine debris. What was/is your level of concern BEFORE/AFTER the student presentation?" with a scale of 1-5 (1 = extremely unconcerned; 5 = extremely concerned) and "How likely were/are you to support such an ordinance BEFORE the/NOW, after the student presentation?" with a scale of 1-5 (1 = extremely unlikely; 5 = extremely likely).

CHAPTER 5: Conclusion
Kid Superheroes: Saving the Planet, One Environmental Issue at a Time!

This blog post was written for the National Oceanic and Atmospheric Administration (NOAA)'s National Marine Sanctuaries Program *Clean Beaches Week* (July 1-7, 2021) as a collaboration with Duke University Undergraduate Student summer interns in 2021. I was a mentor for the blog post, which was published online.

Miller, L., Jaffe, J., Hartley J. M. (1 July, 2021). Kid Superheroes: Saving the Planet, One Environmental Issue at a Time! National Oceanic and Atmospheric Association, National Marine Sanctuaries Program blog; https://sanctuaries.noaa.gov/news/jul21/clean-beaches-week.html

Superheroes are all around us, but they aren't wearing capes or running at super speed. Instead, they're passionate kids, using their voices and demanding to be heard, especially when it comes to sparking environmental change. This Clean Beaches Week (July 1-7), we're sharing examples of how kids are making a difference in their communities (and beyond,) as evidenced through research by Nancy Foster Scholar, Jenna Hartley.

Figure 5.1. Fourth and fifth grade students from Wrightsville Beach Elementary School in Wilmington, North Carolina organized a school-wide beach sweep to collect trash in Spring 2019. Over 350 people attended, including two local news channels. Photo by Hank Carter.

All over the world, youth are making a difference in impacting adult attitudes and improving the environment. In Thailand, after learning about forest degradation in their classes, students created change through organizing tree plantings and speaking up against forest burning. Within the United States, the NOAA Ocean Guardian School Program has empowered students to push for environmental policy change. Through this program, Adams Elementary students advocated for the "Skip the Straw" campaign at a Santa Barbara City Council Meeting. In turn, council members were so moved that they enacted a plastic straw ban.

These noteworthy kids demonstrate the power of intergenerational learning (IGL), the bi-directional transfer of knowledge across generations. IGL has the potential to initiate a chain reaction in which youth learn about environmental issues from their teachers and can then spread this knowledge to their peers and adults, both within and beyond the family unit. Through this process, people of all ages can work together to tackle environmental issues.

Okay, we see that youth can teach adults about environmental issues, but how much of an impact do they really make?

Jenna Hartley, a NOAA Dr. Nancy Foster Scholar, has set out to answer this question. As a former classroom teacher and environmental education specialist, Jenna believes deeply in the power of young people in creating environmental and community solutions. Jenna also recently served a two-year term in the Education Seat on the Sanctuary Advisory Council for Monitor National Marine Sanctuary, working alongside site staff to consider innovative approaches to marine science education. Jenna is currently completing her PhD research at North Carolina State University under the advisorship of environmental education researcher Dr. Kathryn Stevenson. Jenna's research examines the role of students as environmental change-agents in their communities, specifically on the topic of marine debris and plastic pollution.

Stemming from this research, Hartley and her colleagues recently conducted a study that found a quantitative increase in adults' levels of concern about marine debris and support for a marine debris ordinance following youth presentations. Hartley and her research team discovered that young people were able to bring together typically-polarized political identities, through both in-person events and virtual outreach methods such as youth-led public service announcement (PSA) videos. "These findings are really encouraging, especially for kids to know that they have power," said Hartley. Even educators and parents should understand that kids can have a really important voice in their communities."

Figure 5.2. Fourth and fifth grade students attended a Fuquay-Varina Town Hall meeting with the mayor and Board of Commissioners after presenting on the topic of marine debris. Photo courtesy of Jenna Hartley.

Figure 5.3. A student from Wrightsville Beach Elementary helps out on a beach clean-up. Photo courtesy of Jenna Hartley.

By speaking up and sharing their opinions and behaviors with adults, students are able to affect environmental policy. As the mayor of Fuquay-Varina, John Byrne, said after hearing one of the youth presentations at a Town Hall meeting, *"We've got to use things sensibly. It's deeper than just plastics. 'Where do we want our world to be 50 years from now?' ... We learned a lesson today from our young people."*

It takes a village. Let's find out how YOU fit into this superhero narrative!

Students: Activate your kid powers today by learning as much as you can about the environment and sharing your knowledge proudly with the world! Some fun ways to initiate change in your community include making PSA videos, giving formal presentations to adults in political venues (i.e., your town or City Hall meetings), or even just having conversations about marine debris at the dinner table. Beach clean-ups are also a great way to get your community actively involved in making a difference. If you don't live near the beach, you can clean up trash around any local waterway!

Figure 5.4. Two students from Isaac Dickson Elementary School take part in an outdoor clean-up. Photo courtesy of Jenna Hartley.

Teachers: Kid powers can't come to life without your help! Support students and amplify their voices by helping them craft PSA videos in class, hosting poetry nights, or organizing any other event that helps students reach adults. Be creative and implement engaging elements that target your students' interests. To use the activities used in this study, see the free marine debris curriculum developed by the Duke University Marine Lab.

One fifth grade teacher, Crystal Holland, added some friendly competition to a cleanup event to get her students engaged. "We did our river clean-up and had a blast. I made it a contest between our two fifth grade classes and I couldn't believe what they found," said Holland.

The clean-up took place right by their school, and students and teachers alike were amazed by the plethora of debris collected. Ms. Holland's river clean-up shows that you don't need to travel far to make an event meaningful. Change can be made just around the corner, and that's exactly where it should start.

Parents and Community Members: Empower the kids of your community by listening. Their superhero voices can speak only as loud as you're willing to hear. Be open to conversations that challenge your own thinking, and spread what you learn to others.

Looking for programs to get you started?

There are several NOAA programs related to youth engagement with environmental science and policy. Here are three to consider:

- Ocean Guardian School Program - Ocean Guardian schools commit to the conservation of local watersheds, the world's ocean, and special ocean areas, like national marine sanctuaries. Students can partake in critical learning projects and opportunities related to sustainability and conservation.

- Bay Watershed Education and Training (B-WET) Programs - K-12 educators and students can gain an authentic experiential learning experience through meaningful watershed educational experiences.
- Marine Debris Program - Citizens can receive funding for their marine debris projects, and projects can focus on marine debris removal, prevention, and research.

There's no need to fear, the superhero kids are here!

Environmental issues such as marine debris present ongoing challenges, but with a little help from adults, superhero kids can save the day. To learn more about Hartley's study and how kids had a positive impact in their local communities, read the article published in Frontiers in Political Science.

Lauren Miller and Jackie Jaffe are students at Duke University and are DukeEngage interns for the Duke University Marine Lab Community Science Initiative. Jenna Hartley is a PhD Candidate at North Carolina State University and a NOAA Dr. Nancy Foster Scholar.

Additional Links:

Duke University Marine Lab Community Science Initiative

Duke University Marine Lab Marine Debris Curriculum

Youth Empowerment in Thailand

Students Stop Single-Use Plastic at its Source

The Next Generation of Guardian for Our Ocean

NOAA Ocean Guardian School Program

NOAA B-WET Program

NOAA Marine Debris Program