ABSTRACT

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Food is a commonality across cultures, families, and backgrounds. Accordingly, agriculture and food production can serve as a means to engage a wide range of audiences in conversations about human use of the environment. Blending agricultural education (AE) and environmental education (EE) frameworks is a promising pathway towards the goals of boosting environmental engagement and support for local agricultural systems among broad public audiences. However, theoretical and empirical contributions are needed to facilitate this work. In this research, we outline the historical context for disciplinary silos between AE and EE and establish a new collaborative structure for scholars in both fields to work together to build agricultural and environmental literacy in support of environmentally sustainable, economically robust, and socially responsible agroecosystems. Using a sociocultural approach, we then examine the relative importance of family demographics, parent views of agriculture, and personal interactions on the part of the learner in predicting youth agricultural literacy in North Carolina.

In particular, we examine youth agricultural literacy in the context of intergenerational engagement with adult caregivers in the daily lives of youth. We surveyed youth and their parents through partnerships with schools and agritourism farms and then used analysis based on classification and regression trees as well as random forest models to examine 525 usable responses. Results indicate that intergenerational engagement between caregivers and youth as well as personal interactions with farmers outweigh other factors such as race, gender, household income, geography, and parental attitudes and behaviors in predicting youth agricultural literacy. These outcomes support initiatives to focus on student-responsive approaches to AE and EE that

can effectively serve a range of audiences as pre-existing knowledge, attitudes, and behaviors do not appear to vary significantly with most commonly-employed demographic indicators. Ultimately, this research will contribute to the literature by creating structures for broader and more collaborative efforts through which to improve agricultural literacy across generations.

Food for Thought: Youth Agricultural Literacy for a Sustainable Future

by
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BIOGRAPHY

Caitlin Reilly grew up in the Blue Ridge mountains of central Virginia where she developed a love for spending time outside and an interest in agriculture early on in her life. She attended Davidson College where she earned a B.S. in environmental studies and worked on the college farm and for the campus outdoors program. She has had the privilege to work in agriculture, land stewardship, and outdoor education in the U.S., Ireland, Panama, Iceland, and Australia. In 2019, Caitlin returned to school at NC State University to earn her M.S. She is passionate about intersections between agriculture and the environment as well as making (but mostly eating) bread and going for long runs. More than anything, Caitlin loves the power of outdoor spaces and shared food to foster good conversations and build community.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

Introduction

Agriculture is a key environmental issue, both because it can be a source of environmental harm and because it offers promising pathways to more sustainably manage resources and promote healthy agroecosystems (Peterson et al., 2017; Poore & Nemeck, 2018). For instance, agriculture can contribute to climate change through highly mechanized production and transportation processes and lead to poor water quality through sediment and chemical runoff (Brown & Funk, 2008; Cohn et al., 2017; Peterson et al., 2017; Pradhan et al., 2018; Rosa-Schleich et al., 2019). However, when sustainably managed, agriculture can contribute to positive conservation cycles in which farmers rely on diversified ecosystems to support healthy crop yields (Pradhan et al., 2018; Rosa-Schleich et al., 2019).

Education is a promising strategy for promoting agriculture that supports healthy agroecosystems (Frick et al, 1991). This is especially true when efforts combine environmental education (EE) and agricultural education (AE) frameworks. While each field has a distinct history, maintains some separate goals, and operates within different scholarly traditions, the fields also share many commonalities. EE and AE both seek to improve public environmental and agricultural literacy with the ultimate goal of engaging a new generation of citizens in informed decision-making related to managing our shared natural resources (Frick et al., 1991; Hollweg et al., 2011). Environmental literacy measures the development of science knowledge, a sense of connection to nature, and the skills and motivation necessary to work towards solutions to environmental problems. (Hollweg et al., 2011). Agricultural literacy, a closely related concept, is the ability to understand, think critically about, and communicate key concepts surrounding systems of food and fiber production (Frick et al., 1991). In addition to the shared

goal of boosting public literacy around issues of natural resources, AE and EE also share important obstacles to achieving this goal. Both fields are struggling to broaden their audiences and meaningfully engage with communities, especially communities of color, who have historically been left out of mainstream conversations about agriculture and the environment (Cole, 2007; Crosley, 2013; Harris & Barter, 2015; Hubert et al., 2000; Kovar & Ball, 2013; Powell et al., 2008; Saul, 2000). Despite efforts to expand the reach of AE and EE, there are still critical gaps hindering engagement with agricultural and environmental issues among broad swaths of the population (Hubert et al, 2000; Kovar & Ball, 2013, Powell et al., 2008). Therefore, many scholars and practitioners continue to push AE and EE fields to think more deeply about accepted norms and practices and develop new approaches that allow for the expansion of current frameworks (Frick et al., 1991; Hubert et al., 2000; Kovar & Ball, 2013; Mayer & Mayer, 1974; Powell et al., 2008).

In this thesis, I identify two major gaps in current scholarship that hinder effective educational initiatives. The first of these is a gap in scholarly frameworks that exists between AE and EE communities. The second gap is a lack of empirical research that facilitates a deeper understanding of current agricultural literacy within the context of potentially influential factors such as family demographics, parent views of agriculture, and personal relationships and interactions. I address the first gap through an examination of AE and EE literature, scholarly traditions, and practitioner norms to provide context for existing disciplinary silos and establish a structure for increased collaboration moving forward. I believe this shift in approach will broaden the scholarly investigative focus of both fields and provide practitioners with a wider range of sources to support their work. I address the second gap through an analysis of agricultural literacy survey data collected from youth and their families in North Carolina with a

particular focus on local food systems. This will allow for better-informed curriculum development in response to patterns in existing agricultural literacy and help educators to predict how learners will interact with ideas presented during new educational experiences based on existing knowledge, attitudes, and behaviors (Dale et al., 2017; Spinola, 2016).

This thesis will address each gap in a separate chapter. The first chapter will seek to answer the following questions *1) What is the historical context that drives current disciplinary silos in AE and EE research? 2) What are potential avenues to increase collaboration across AE and EE fields? and 3) What benefits could be derived from such efforts?* The second chapter will build on this increased understanding of the intersectionality of the two fields to answer the central research question, *What is the relative importance of family demographics, parent views of agriculture, and personal interactions on the part of the learner in predicting youth agricultural literacy as it relates to local food systems in North Carolina?*

The results of each of these chapters will aid AE and EE communities in broadening audiences and developing more effective programming. Agriculture is a key environmental issue and as such it is critical that we begin to shift the conversation to see the two fields as intertwined and develop agricultural and environmental literacy education efforts accordingly.

CHAPTER 2

Agricultural and Environmental Education: A Call for Meaningful Collaboration

Abstract

Blending agricultural education (AE) and environmental education (EE) frameworks is a promising pathway towards the goals of boosting environmental engagement and support for local agricultural systems among broad public audiences. However, thoughtful and intentional collaboration between researchers is needed to facilitate these outcomes. We feel it is important to collapse existing disciplinary walls between AE and EE to effectively reposition both as critical public goods and address inequitable access to environmental and agricultural knowledge among the next generation. In this paper, we outline the historical context for disciplinary silos between AE and EE. We then present a new collaborative structure for scholars in both fields to work together to build agricultural and environmental literacy in support of environmentally sustainable, economically robust, and socially responsible agroecosystems. Ultimately, we aim to create structures for broader and more collaborative efforts through which to improve agricultural and environmental literacy for new generations of learners.

Introduction

Healthy agroecosystems are environmentally sustainable, economically robust, and socially responsible (Peterson et al., 2017). Agriculture is a leading cause of environmental degradation and, by corollary, can be a key area in which to make progress towards environmental sustainability (Peterson et al., 2017; Poore & Nemecek, 2018). Healthy agroecosystems require fewer inputs into the land, allowing farmers to conserve natural resources, limit air and water pollution, decrease the use of herbicides and pesticides, and both retain and enrich soil (Peterson et al., 2017; Rosa-Schleich et al., 2019). This creates a positive

feedback loop in which healthy ecosystems support environmentally sustainable farming practices and allow for decreased environmental degradation (Rosa-Schleich et al., 2019). Because farmers rely on ecosystem services to help produce the food and fiber products they sell, the benefits of healthy agroecosystems are economic as well as environmental (Rosa-Schleich et al., 2019). Accordingly, investments in sustainable land management and solutions to large-scale environmental issues, like urbanization and climate change, are necessary (Brown & Funk, 2008; Cohn et al., 2017). The social impacts of agroecosystems are also important to consider. Thriving agricultural systems prevent scarcity and keep food prices stable, which helps to address food insecurity (Pradhan et al., 2018). These benefits support food equity, which is achieved when all members of a community have access to nourishing and culturally-appropriate food and fiber without exposure to harmful environmental side effects (Smith, 2019). In short, developing and maintaining healthy agroecosystems promotes the long-term economic viability of agriculture, environmental sustainability, and the well-being of people.

Due to the interdependent nature of healthy agroecosystems and environmental sustainability, we need a citizenry that is both environmentally and agriculturally literate. Environmental literacy includes the ability to understand science, a feeling of connection to the environment, and the skills and motivation necessary to work towards solutions to environmental problems (Hollweg et al., 2011). Agricultural literacy, a closely related concept, is the ability to understand, think critically about, and communicate key concepts surrounding systems of food and fiber production (Frick et al., 1991). Although technical and policy solutions exist to support healthy agroecosystems, such as adaptive draining techniques to limit soil and water runoff and incentivized impact mitigation programs that support farmers in making environmentally-friendly investments, the success of these techniques depends on a citizenry that understands,

cares about, and is motivated to support them (Poore & Nemecek, 2018). To protect environmental sustainability, agricultural economies, and community well-being, it is important to foster an understanding of the interdependence of agricultural (e.g. food security) and environmental (e.g. climate change) issues. Accordingly, we need education efforts and associated research that work toward that end.

Despite the overlap between environmental and agricultural literacy, associated fields of research in environmental education (EE) and agricultural education (AE) are rarely combined. The academic silos of these two research fields are visible in separate journals, conferences, and academic departments as well as the limited research collaboration between EE and AE scholars. There are some exceptions, such as EE literature focused on food justice and garden-based learning (Crosley, 2013; Green, 2013; Harris & Barter, 2015; Swan & Flowers, 2015; Walter, 2013) and some scholarly interest in perceptions of sustainable farming among agricultural educators (Hubert et al., 2000; Muma et al., 2011; Muma et al., 2010; Raven et al., 2017). However, systematic and intentional efforts to bring the EE and AE research communities closer together are largely lacking due to limited established frameworks for doing so. This paper seeks to spark increased collaboration by identifying potential avenues for incorporating AE perspectives into EE research as well as the historical, political, and economic challenges of those collaborations. With this purpose in mind, the authors will outline their views of the parallel histories of EE and AE fields, examine the roots of current silos, and identify encouraging trends and possibilities for future collaboration.

The Divergence in Scholarship Reflects Distinct Histories

AE and EE have different histories that influence the research content and academic approaches of scholars in both fields. EE is largely rooted in environmentalism (Hungerford,

2009). Nature Study, a precursor to environmental education, began in the late 19th Century as a way to engage students with science in a hands-on manner (Hubert et al., 2000). EE emerged as a discipline from the nexus of Nature Study and the conservation movement in the latter half of the 20th century. It emerged as a response to increasing urbanization and concerns about limited contact with nature among younger generations (Hubert et al., 2000; Hungerford, 2009; Stapp, 1969). The history of EE, and in many cases environmental conservation more largely, is also closely tied to Aldo Leopold's land ethic which deemphasizes the importance of humans in the environmental landscape and infuses ethical considerations into decisions about land and resource management (Callicott, 1999; Leopold, 2004; Piccolo, 2020).

Modern EE, in many cases, attempts to fill a range of educational niches by working to improve scientific literacy, foster curiosity, promote positive youth development, and encourage social-emotional learning (Hollweg et al., 2011; Krasny, 2020; Stern et al., 2014). Examples of current iterations of EE include outdoor science programs like Muddy Sneakers, which covers 5th grade North Carolina science standards in outdoor settings (Muddy Sneakers, n.d.), the Girl Scout Environmental Stewardship program, which highlights positive youth development and social-emotional learning (Girl Scouts of America, n.d.), and Project WET and Project WILD, which provide the framework for classroom-based EE instruction (Association of Fish and Wildlife Agencies, n.d.; Project WET Foundation, n.d.). These organizations, and most other EE programs, have a common goal of encouraging ecological stewardship and promoting pro-environmental behaviors (Hollweg et al., 2011; Krasny, 2020). Although there are efforts among EE practitioners and researchers to move away from an environmentalist framework, tension remains over the role of social action in environmental literacy and the field still reflects an activist history (Hollweg et al., 2011; Hungerford, 2009; Krasny, 2020). The idea of a duty to act

on environmental knowledge may in part stem from the deep sense of moral obligation to the environment that comes with Leopold's land ethic, an approach that still serves as the foundation for much of the modern conservation movement (Callicott, 1999; Leopold, 2004; Piccolo, 2020).

The practice of AE stretches back to the 1800s in the United States predominantly as a method of producing new generations of farmers and agricultural professionals (Hubert et al., 2000; Powell et al., 2008; True, 1929). The Smith-Lever Act of 1914 formalized early AE efforts into the U.S. Cooperative Extension program designed to educate farmers about new practices and align the research of faculty at land-grant institutions with the needs of those working in agricultural production (National Institute of Food and Agriculture, n.d.-a). 4-H, a highly popular national AE program, was originally devised to reach farming families by educating rural youth about developments in agricultural knowledge and new forms of technology (4-H, n.d.). The Smith-Hughes Act of 1917 established federal support for agricultural education in public schools (Camp & Crunkilton, 1985). In 1928 the Future Farmers of America (FFA), today's National FFA Organization, arose out of school-based AE (Camp & Crunkilton, 1985). Even today, AE is deeply tied to the culture of rural America and is focused on building knowledge of and support for agricultural livelihoods (Hubert et al., 2000; Kovar & Ball, 2013; Mayer & Mayer, 1974; Powell et al. 2008).

Starting in the 1970s, agricultural educators began to recognize the importance of increasing the public's understanding of agricultural systems as a means to foster broad public support for agriculture (Frick et al., 1991; Hubert et al., 2000; Kovar & Ball, 2013; Mayer & Mayer, 1974; Powell et al., 2008). While there are many efforts within AE to develop programs focused on improving public agricultural literacy, there is still a significant deficit in knowledge and awareness of agricultural issues among the general population (Hubert et al, 2000; Kovar &

Ball, 2013, Powell et al., 2008). As a result, there have been many calls to expand AE programming to reach broader audiences (Frick et al., 1991; Hubert et al., 2000; Kovar & Ball, 2013; Mayer & Mayer, 1974; Powell et al., 2008). For example, some longstanding AE programs like 4-H and the National FFA Organization have shifted their programs to emphasize leadership development, engaged learning, and the flexible application of participants' skills in a variety of careers beyond production agriculture such as teachers, scientists, health professionals, and veterinarians (4-H, n.d.; National FFA Organization, n.d.). Despite these efforts, popular conceptions of AE remain closely tied to career and technical education as well as to large-scale, conventional production agriculture (Kovar & Ball, 2013; Mayer & Mayer, 1974; Powell et al., 2008).

The substantial differences in the historical purposes and development of AE and EE are still visible in the current scholarship of both academic fields. For example, AE often relies on technological solutions to resource management problems that facilitate economies of scale (e.g. increased yields) rather than advocating for limits to consumption, as is more typical in EE frameworks (Lytos et al., 2020). Another difference centers on the fields' respective views of nature and the way they understand the role of the natural world and its resources. For instance, EE scholars tend to place an intrinsic value on nature and focus on aesthetic appreciation and recreational enjoyment (Fraser et al., 2015; Hubert et al., 2000). This orientation echoes the core ideas of nature and wilderness conservation, which have been central to mainstream environmentalism since the Nature Study movement in the 1800s, and is often still visible in environmental education scholarship and practitioner-focused communication today (Crosley, 2013). For example, the environmental aesthetics framework that some EE scholars support seeks to promote connection to nature through deep relationship building with natural landscapes

based on an eco-centric model that places equal weight on the needs of humans and the health of the environment (Carlson, 2012; Yi, 2019).

The EE orientation to the natural world stands in contrast to the more utilitarian relationships reflected in AE scholarship, which tends to focus on agricultural career preparedness over connections to nature (Hubert et al., 2000; Kovar & Ball, 2013; Mayer & Mayer, 1974; Powell et al. 2008). Preparation for the workforce as the central goal of AE is partially rooted in the Smith-Hughes Act of 1917, which provided the foundation for the National FFA Organization in addition to affording opportunities for vocational teacher training to prepare students across the U.S. for jobs in industry and agriculture (Willis, 2017). An increased concentration on standardized testing within the U.S. educational system has led some AE researchers to reframe the central purpose of the discipline as a supplement to core curriculum academic material in some cases (Dailey et al., 2001), but overall the field remains ingrained in the world of vocational training (Harder et al., 2010; Suvedi et al., 2017).

Other notable differences are the emphasis on action in each field as well as primary audiences for educational initiatives. Though EE scholarship continues to debate the degree to which action is among its goals, most scholars recognize that environmental literacy extends beyond knowledge and skills to include affective and behavioral components (Hollweg et al., 2011; Krasny, 2020; Stapp, 1969; Wheaton et al., 2018). Many EE scholars advocate encouraging civic engagement and activism among learners (Hollweg et al., 2011; Krasny, 2020; Wheaton et al., 2018). A key aspect of this approach is that environmental literacy scholarship is focused on equipping all citizens with the knowledge, dispositions, skills, and motivations needed to promote an environmentally sustainable future (Cole, 2010; Hollweg et al., 2011). Although AE scholarly frameworks have also broadened beyond content knowledge (Mars &

Ball, 2016; Trexler, 2013; Vallera & Bodzin, 2016), their on-the-ground efforts are often still focused primarily on technical knowledge and skills (Bellah et al., 2004; Colbath & Morrish, 2010). Furthermore, AE is not widely incorporated into public education, but rather tends to reach audiences largely composed of student with prior interest in agriculture (Bellah et al., 2004; Colbath & Morrish, 2010). As a result, there is a continued call for researchers to create a viable framework for practitioners to be able to promote agricultural literacy among the broader public (Colbath & Morrish, 2010; Doerfert, 2011; Hess & Trexler, 2011; Meischen & Trexler, 2003; Pense & Leising, 2004; Roberts et al., 2016).

Toward Increased Collaboration

While the fields of AE and EE may sustain different focal areas, each has valuable contributions for mutual improvement in increasing the public's literacy on agricultural and environmental topics. Furthermore, continuing to work in academic silos is preventing real progress towards widespread understanding of agricultural and environmental literacy as critical public goods. EE scholarship has a strong tradition of employing ecological perspectives that encompass interactions between natural and social systems (Kollmuss & Agyeman, 2002; Newhouse, 1990) and targeting affective outcomes to ensure that learning leads to action (Hollweg et al., 2011; Krasny, 2020; Stapp, 1969; Wheaton et al., 2018). This integrated approach to problem-solving could be a valuable contribution to AE, which seeks to incorporate broader environmental stewardship and ecosystem management topics into curricula that were historically focused on more agriculture-specific content (Doerfert, 2011; Roberts et al., 2016). Both AE and EE scholars are working to build holistic research agendas that more effectively incorporate social systems into their analyses. While both fields have some established frameworks for doing so, a collaborative approach would serve to elevate both efforts.

AE scholarship's focus on applied knowledge and skills has important lessons for EE. AE research frameworks are grounded in the realities of food and fiber production, the challenges associated with managing resources, and the hardships of feeding people on a daily basis (Barbieri et al., 2008; Brown & Funk, 2008; Poore & Nemecek, 2018; Powell et al., 2008; Rosa-Schleich et al., 2019). This perspective could benefit EE research in terms of anchoring the visions of environmentalists to the tradeoffs inherent in conserving healthy agroecosystems while also feeding a growing global population (Peterson et al., 2017; Rosa-Schleich et al., 2019). Similarly, seeking out the more utilitarian perspectives of AE scholarship may push EE scholars to think outside of their academic comfort zones in ways that allow their messaging to resonate beyond a scholarly community that is fairly homogenous in its approach to understanding the natural world (Cole, 2007). There is strong support within EE to magnify the field's reach and diversify learners and environmental frameworks (Corcoran & Sievers, 2010; Lewis & James, 2010; Potter, 2010), but there is less momentum among scholars for an EE movement that considers work-based or utilitarian relationships with nature on equal footing with more traditional environmental lenses.

Educators and scholars in both fields are looking to expand their audiences to improve environmental and agricultural literacy among wider segments of the population (Cole, 2007; Crosley, 2013; Harris & Barter, 2015; Hubert et al., 2000; Kovar & Ball, 2013; Powell et al., 2008; Saul, 2000). EE researchers have the opportunity to increase public support for environmental literacy initiatives by contextualizing issues like climate change to be relevant to a variety of audiences, especially groups who have been historically left out of mainstream environmentalism (Cole, 2007; Crosley, 2013; Harris & Barter, 2015; Saul, 2000). Increasing outreach to AE communities could serve to broaden current efforts to diversify the field. AE also

recognizes the need to broaden engagement beyond their traditional audience (Hubert et al., 2000; Mars & Ball, 2016; Powell et al., 2008; Trexler, 2013). AE scholars have repeatedly identified that most people do not know where their food comes from and that continuing to develop agricultural educators among the same segments of the population does nothing to reach the members of the public who need agricultural literacy the most (Frick et al., 1991; Hubert et al., 2000; Kovar & Ball, 2013; Powell et al., 2008). Building bridges between the EE and AE research communities may provide an avenue to identify common scholarly goals as well as reach audiences that are not typically associated with each field.

One limitation to collaboration is the common misconceptions from outsiders that plague both fields. Because agricultural systems often operate at large scales and have significant impacts on ecosystems, those who identify primarily with environmental fields tend to view the AE research community as part of the problem rather than part of the solution to environmental issues (Cleveland et al., 2016; Donahue, 1994; Sharp & Adua, 2009). Agricultural scholars may similarly dismiss EE researchers as unrealistic and lacking a comprehensive understanding of what it means to balance food and fiber production with the needs and burdens (e.g. food insecurity, urban sprawl) of a growing population (Chilson, 1997; Jorgensen, 2011). For example, advocating for environmentally-friendly farming techniques such as integrated pest management may sound like a sustainable solution but such practices are not always profitable or may not be feasible at large scales (Bewsell & Kaine, 2005; Drost et al., 1996; Jarvis et al., 1996; Kabir & Rainis, 2014). EE scholars may not have the practical agricultural knowledge needed to weigh those costs and benefits effectively, thus the need to close the gap between disciplines.

As previously mentioned, both fields also have socially problematic aspects of their scholarly histories and commonly accepted disciplinary frameworks. Thus, we suggest that by

facing these problems together, AE and EE might find common ground. For example, both AE and EE often accept funding from large corporations whose agendas cause harm to both agroecological systems and human communities (Nicole, 2013; Prete & Cournil, 2019). The National FFA Organization has an ongoing relationship with Monsanto (FFA, n.d.; National FFA Foundation; n.d.). While Monsanto uses some language around sustainability, they have long been a primary enemy for many environmentalists; yet they remain a core supporter of AE in the United States (Prete & Cournil, 2019). Similarly, corporations like Duke Energy remain a major funding source for environmental research and sustainability programs while also acting as a Goliath opponent for many energy and environmental justice advocates in the southeastern United States (Duke Energy, 2020; NC WARN, n.d.; Nicole, 2013). Although environmentalists often critique industrial agricultural practices (Mitchell, 2020), and more conservative viewpoints often associated with agricultural communities (Roper, 2020), EE is not exempt from similar criticisms. In many cases, environmental scholars and organizations are only just beginning to reckon with the compromises made by environmentalists to advance their cause that had detrimental impacts on vulnerable and marginalized populations including women, people of color, and LGBTQ+ groups (Asdal, 2003; Gaard et al., 2013; MacGregor, 2017; Meyer, 2001; Sturgeon, 2009).

By working together, both AE and EE will be better equipped to engage with restorative justice lenses and improve norms in scholarship and practice moving forward. This type of reckoning may help both AE and EE to achieve their goals when it comes to representing the diversity of the communities they aim to serve in the demographics of their practitioners and program participants, something they have both struggled with historically (James & McAvoy, 1992; LaVergne et al., 2012; Taylor, 2015; Warren & Alston, 2007). This shared problem could

be a timely opportunity to brainstorm and develop collaborative solutions rather than continuing to individually identify a lack of diversity as an issue and striving separately to create genuinely inclusive environments in mainstream AE and EE organizations. For example, agricultural and environmental educators could create collaborative avenues to recruit participants, practitioners, and scholars from underrepresented identities. They could also use their combined expertise to design culturally responsive curricula that highlight the connections between agricultural systems and environmental management and potential career pathways that require an understanding of both the technical aspects of production the broader concepts of environmental sustainability.

Reductionist lenses, whether applied to AE or EE, fail to see the value of what the other field brings to efforts to promote healthy agroecosystems and strong human communities. This can lead to overlooking disciplinary commonalities, a missed opportunity for collaboration rooted in and perpetuated by myopic research questions framed within disciplinary paradigms (Verschuren, 2001). Improving collaboration between the AE and EE fields, both in terms of research focus and the practitioner culture stemming from the prevailing scholarship, may help to improve our collective academic investigation, deepen our practice, and ultimately allow us to build healthier agroecosystems through promoting an agriculturally and environmentally literate citizenry.

Promoting Collaboration

There are many potential avenues for breaking down silo walls and promoting meaningful collaboration among AE and EE scholars that could generate real progress in the scholarship and practice of both fields. Our recommendations focus on pathways to engage the AE and EE scholarly communities as that is where we are positioned as academic scholars. However, we hope that our call for collaboration is heard at all levels including academic

research, university-level education, extension efforts, school-based curricula, and informal programming. In the authors' opinion, the central premise of any collaboration between AE and EE should be the consideration of agricultural and environmental literacy as intricately connected public goods critical to the education of the next generation of informed and engaged citizens. Literacy related to food systems and the environment is necessary to make informed decisions about personal health, growth of local economies, and community well-being.

One natural entry point for collaboration is to jointly form research questions in an effort to intentionally combat the misconceptions of one another's fields. One example might be to combine expertise to develop learning structures that move beyond singular engagement with small-scale, closed food systems (e.g. school garden programs) and expand the scope of analysis to include the large-scale agricultural structures that feed our nation and the world. This expanded framework for examining food systems could benefit from the accumulated knowledge (content, methodologies, and practices) of AE experts related to engaging students in learning about global food systems in tangible and meaningful ways as well as that of EE scholars embedded in global sustainability efforts. This complementary expertise could yield innovative approaches that are arguably necessary for addressing complex challenges like global food security in the context of a changing climate (Brown & Funk, 2008; Cohn et al., 2017). To do so, it is critical that EE and AE communities develop joint strategic research plans that outline shared goals and design pathways for examining questions that will contribute to both fields.

In addition to working together to identify joint research questions, seeking joint support for our work may offer expansive opportunities that could benefit both fields. For instance, funding opportunities may expand when AE and EE communities work together. One notable example is the National Collaborative for Research on Food, Energy, and Water Education

project which has received funding through the National Science Foundation and the US Department of Agriculture by emphasizing connections between EE and AE approaches (National Collaborative for Research on Food, Energy, and Water Education, n.d.). Additionally, the National Institute of Food and Agriculture (NIFA) has national funding priorities that include climate variability and change, water, and sustainable bioenergy, which can potentially bridge gaps between agricultural and environmental sciences (National Institute of Food and Agriculture, n.d.-b). NIFA is a major funding resource that remains underutilized among EE researchers and provides opportunities to engage with agricultural research communities. Collaborations between AE and EE are necessary to address urgent and complex problems and are well-positioned to answer the identified needs of funding resources that remain largely untapped by our respective communities. However, we must revisit academic structures that penalize rather than incentivize collaborative research if we wish to succeed in bridging AE and EE scholarly communities.

To support these collaborations and spark new ones, scholars should also work to learn about what other fields are doing and take steps to share their findings in other academic communities. This could include attending academic and practitioner-focused conferences in one another's' fields to offer guidance on common challenges or to learn about potential solutions to obstacles faced in one's own work. There is also abundant possibility for developing new collaborative endeavors that fully merge AE and EE worlds such as conferences that actively recruit from both audiences and create space for increased communication among AE and EE communities. Scholars should also look for opportunities to publish in the journals of one another's fields to share promising practices and receive feedback on their field-specific perspective. Ideally, EE and AE scholars should also co-author publications. This partnership

would allow publications to cater to the concerns of both fields and emphasize connections between environmental and agricultural research paradigms, ultimately working to emphasize the interdependence of the fields.

Both AE and EE strive to bridge connections between research and practice. Increased interconnectivity in AE and EE research could also spark practitioner collaboration. Scholars and practitioners from both fields could partner to develop a shared agri-environmental curriculum or learning intervention strategy for use in both formal and non-formal educational settings. This could include a planned dual approach to increasing public literacy in which the EE community outlines the broad implications of climate change while AE provides specific examples of how changes in global climate will have an impact on the everyday lives of average citizens through food and fiber production. Similarly, while water quality can often feel like an abstract issue for students, agriculture provides clear and tangible examples of water usage and opportunities to mitigate impacts on aquatic systems. Because we all engage in and depend on agricultural systems, this framing also provides an opportunity to foster positive action beyond common recommendations such as turning off the faucet and purchasing reusable water bottles.

The ultimate goal of this collaboration is to increase the impact of these two interrelated disciplines by broadening research and practice, amplifying educational efforts, and increasing advocacy and support for overall agroecosystem health. Environmental and agricultural literacy are both functional educational outcomes that are essential to creating a new generation of engaged and informed decision-makers and no effort should be spared to make these critical public goods accessible to students across sociodemographic divides. A reframing of environmental and agricultural literacy as co-dependent and essential public goods could only serve to strengthen arguments pushing for equitable access to AE and EE for students as part of

public education. Increased collaboration with AE scholars is an important step we can take as an EE research community towards meeting this goal.

CHAPTER 3

Family Matters: Intergenerational Influences on Youth Agricultural Literacy

Abstract

Agricultural and environmental literacy are both essential public goods that allow informed decision-making related to individual- and community-level wellbeing. However, mainstream agricultural education (AE) and environmental education (EE) efforts often struggle to reach a broad audience and have failed to recruit and retain diverse educators and program participants. In order to improve pedagogy and curricula to be more culturally responsive, it is important to understand what a broad audience of learners brings to an AE or EE experience. In this study, we measured pre-existing youth agricultural literacy among 525 families in North Carolina. We assessed the relative importance of family demographics, parent views of agriculture, and personal interactions with farmers and parents in predicting agricultural literacy using survey data and analysis based on exploratory classification and regression trees and random forest models. Our findings emphasize the importance of knowing a farmer and regular engagement between parents and youth in predicting agricultural attitudes and behaviors. A lack of demographic variation indicates an interest in local food systems and associated behavioral intentions across a wide range of youth populations. Further, we offer evidence to support efforts to re-examine existing deficit-based AE and EE frameworks and develop student-responsive educational approaches for agricultural and environmental literacy education.

Introduction

In order to tackle complex environmental challenges, we need to invest in environmental literacy among a new generation. Of the many environmental challenges society faces, one intersectional topic is agriculture. Promoting healthy agroecosystems requires an understanding

of biological systems, complex processes like climate change, and social structures that affect food scarcity and equity (Brown & Funk, 2008; Cohn et al., 2017; Peterson et al., 2017; Pradhan et al., 2018; Rosa-Schleich et al., 2019). Though agricultural education (AE) is a distinct field dedicated to studying public relationships to agriculture, agricultural literacy has many parallels with environmental literacy. Both seek to engage a new generation as active and informed participants in managing natural resources and balancing the needs of a global population (Frick et al., 1991; Hollweg et al., 2011). Agricultural and environmental literacy frameworks also both aim to inspire lifelong engagement with these issues through building a strong knowledge base and a positive attitude among learners that leads to informed decision-making and behaviors that support agricultural and environmental systems (Frick et al., 1991; Hollweg et al., 2011; Kovar & Ball, 2013; Krasny, 2020; Powell, 2008).

More specifically, agricultural literacy is the ability to understand, think critically about, and communicate key concepts related to systems of food and fiber production (Frick et al., 1991). Like environmental literacy, it is an essential public good because it allows members of the public to make decisions that support their personal health, local agricultural economies, and environmentally sound communities (Frick et al., 1991; Kovar & Ball, 2013; Powell, 2008). As such, it is important that we understand the pre-existing knowledge, attitudes, and behaviors that learners bring to AE and environmental education (EE) experiences so as to be able to more effectively build capacity around environmental and agricultural literacy. Further, EE and AE are also both struggling to relate their message to a proportional representation of communities who have historically be left out of mainstream conversations about agriculture and the environment (Cole, 2007; Crosley, 2013; Harris & Barter, 2015; Hubert et al., 2000; Kovar & Ball, 2013; Powell et al., 2008; Saul, 2000). Therefore, many scholars and practitioners continue to call for

the development of new and more effective strategies to expand AE beyond its current forms in order to reach new audiences and foster engagement with agriculture among previously overlooked communities (Frick et al., 1991; Hubert et al., 2000; Kovar & Ball, 2013; Mayer & Mayer, 1974; Powell et al., 2008). This work necessitates an investment in understanding what perspectives and frameworks underrepresented groups hold related to natural resources, rather than assuming a deficit of knowledge and interest around agricultural issues for communities who have long been left out of the conversation (Ahteensuu, 2012; Harris & Barter, 2015; LaVergne et al., 2011; Nadkarni et al., 2019).

Two learning theories foundational to EE – namely Constructivism (Piaget, 1952; 1954) and Sociocultural Learning Theory (Vygotsky, 1998) – would suggest that successful public AE campaigns require a recognition that context matters, both in terms of learning setting and what the learner brings to the experience. In general, Constructivism emphasizes that learners enter new experiences with pre-existing knowledge and attitudes, which shape how they interpret new information (Barrouillet, 2015). Similarly, Sociocultural Theory emphasizes the ways in which learning is socially constructed and mediated by those with whom the learner interacts (Gajdamaschko, 2015; Vygotsky, 1998). For instance, a learner may approach an AE experience differently if they grew up on a farm than if they grew up in a more urban environment. This is both because their prior experiences and knowledge may shape how they interpret new information (Constructivism) and because they may be learning in community with those from similar agricultural backgrounds (Sociocultural Theory). Constructivist and sociocultural lenses when applied to children's learning highlight the importance of considering how a learner's background may influence what they bring to an agricultural learning experience (Barrouillet, 2015; Gajdamaschko, 2015).

Sociocultural and constructivist theoretical traditions are also reflected in responsive teaching models, which may be particularly effective at reaching diverse groups of learners (McGlynn & Kelly, 2018; O'Leary et al., 2020). Responsive teaching asks educators to acknowledge students' pre-existing ideas and interests in order to shape learning experiences to meet the particular needs of different groups (Jaber et al., 2019; McGlynn & Kelly, 2018; O'Leary et al., 2020). It is not a one-size-fits-all approach, but rather emphasizes meeting students where they are and building on what they know and what excites them about a topic (Jaber et al., 2019; McGlynn & Kelly, 2018; O'Leary et al., 2020). Pre-existing ideas and knowledge are often based on family dynamics, previous community connections, and learner identity (Jaber et al., 2019; McGlynn & Kelly, 2018; O'Leary et al., 2020). Culturally-responsive and student-responsive teaching models are gaining traction in the world of STEM (science, technology, engineering, and math) education, partially as a recognition that a one-size-fits all approach is inadequate for serving all students (McGlynn & Kelly, 2018; O'Leary et al., 2020).

A key component of embracing responsive teaching models is breaking from the mode of deficit model thinking that continues to dominate many educational approaches. Though trends are moving away from an "empty vessel" model that treats a learner as a blank slate upon whom one can deposit knowledge (Rodriguez, 2012), many educational fields, including EE and AE, have long assumed ignorance as the central driver of limited engagement (Ahteensuu, 2012; Bak, 2001; Nadkarni et al., 2019; Sturgis & Allum, 2004). Referred to as a deficit model, this line of thinking suggests that a lack of visible engagement in mainstream science fields and public discussions is due to limited knowledge and associated negative attitudes (Ahteensuu, 2012; Bak, 2001; Nadkarni et al., 2019; Sturgis & Allum, 2004). This deficit thinking can lead to assumptions in AE and EE that underrepresented groups simply need access to information and

educational opportunities in order to promote engagement (Ahteensuu, 2012; Nadkarni et al., 2019). Responsive educational frameworks, by contrast, would ask us to consider what aspects of agriculture and the environment are important and familiar to groups who appear to be participating in mainstream AE and EE at lower rates and then shift our education and communication frameworks accordingly (Ahteensuu, 2012; Nadkarni et al., 2019; McGlynn & Kelly, 2018; O'Leary et al., 2020).

AE and EE, despite many efforts, have struggled to recruit and retain a diverse population among both students and educators (Cole, 2007; Crosley, 2013; Harris & Barter, 2015; LaVergne et al., 2011; LaVergne et al., 2012; National Research Council, 2009; Warren & Alston, 2007). This is true for racial diversity, gender diversity, and a diversity of cultural and geographic backgrounds (LaVergne et al., 2011; LaVergne et al., 2012). While AE and EE are aware of this problem and continue to work towards establishing new programs and recruitment strategies aimed at increasing diversity among learners and teachers, change continues to be slow (Cole, 2007; Crosley, 2013; Harris & Barter, 2015; LaVergne et al., 2011; LaVergne et al., 2012; Warren & Alston, 2007). However, low participation in mainstream AE and EE does not necessarily indicate a deficit in knowledge or interest related to agriculture and the environment. In fact, girls often demonstrate more pro-environmental attitudes than boys (Stevenson et al., 2013; Szczytko et al., 2020) and some studies demonstrate that white youth do not possess a stronger sense of connection to nature than young people of color (Szcytko et al., 2020). Therefore, a consideration of how pre-existing agricultural literacy varies across demographic variables could support efforts to shift practices and norms within AE and EE away from deficit models and towards responsive approaches.

In addition to demographics, another way to acknowledge learner context is by considering how family norms may shape a child's understanding of the world, as parents wield a considerable amount of influence in their children's lives (Bergen et al., 2016; Kharuhayothin & Kerrane, 2018). Intergenerational learning frameworks, or the process of one generation influencing the learning of another (Bottery, 2016), have been applied to a range of subjects including development of reading skills and eating behaviors among young children (Bergen et al., 2016; Hofferth & Sandberg, 2001; Scaglioni et al., 2008; Slater & Tiggemann, 2016) as well as the formation of environmental literacy and climate change concern (Buffel et al., 2013; Iwaniec & Curdt-Christiansen, 2020; Lawson et al., 2019; Mead et al., 2012; Stevenson et al., 2019). Intergenerational learning can occur in multiple ways. On the one hand, children may pick up specific ideas or attitudes that their parents hold and are passed down through conversation, behavior mimicking, or intentional lessons (Kharuhayothin & Kerrane, 2018). Accordingly, it is possible that children's views of agriculture reflect those of their parents. Through community networks, parents may also serve as a connection point to other intergenerational relationships that can have profound impacts on how a child interacts with the world (Patacchini & Zenou, 2016; Windzio, 2015). In the context of AE, it may be particularly important to understand how familiarity with adults in agricultural industries may shape how children approach learning about agriculture. Additionally, regular engagement across generations that values a child's contributions, may help a young person feel empowered in learning and thinking for themselves (Gonida & Cortina, 2014; Wang & Eccles, 2012; Wang et al., 2011). Educational literature supports the important role that parental involvement plays in supporting a range of youth outcomes including academic achievement and self-esteem (Cotton & Wikelund, 1989; Henderson & Mapp, 2002; Roman et al., 2008). In an EE context,

discussions with family and friends can predict environmental engagement among youth, often regardless of parents' particular views on the topic (Stevenson et al., 2019; Valdez et al., 2018). This might suggest that interactions with parents could support agricultural learning independently of parent agricultural literacy levels.

This study aims to support responsive teaching approaches to AE by better understanding how agricultural literacy may vary across several potential contextual drivers among youth in North Carolina, USA. Specifically, we measured variations in agricultural literacy related to family demographics, parent views, and personal interactions related to intergenerational engagement and agriculture. Our intention was to acknowledge the multifaceted nature of a child's identity and the socially and culturally-embedded environment in which they operate on a daily basis so as to be able to understand the complex factors that may shape agricultural literacy. Our central research question is *What is the relative importance of family demographics, parent views of agriculture, and personal interactions on the part of the learner in predicting youth agricultural literacy in North Carolina?* The authors feel that by exploring this question, we will be able to support future research that aims to think deeply about the role of demographic data and intergenerational factors in influencing agricultural literacy as well as contribute to efforts to create more effective and more inclusive EE and AE fields that respond to who learners are and what they bring.

Methods

SAMPLE

In this study, we surveyed youth and their parents. We focused our sample on youth ages nine to twelve for several reasons. This age range is often the target of both formal and informal AE and EE learning because research indicates that youth tend to care about resource

management issues more than older generations (Funk & Hefferon, 2020; Ballew et al., 2018), perhaps because they stand to bear the brunt of the consequences for environmental inaction (Hansen et al., 2013). In addition, youth in this age range are often beginning to form independent opinions about complex topics yet are open to receiving new information to inform their ideas because their worldviews and ideologies are less cemented than older groups (Stevenson et al., 2014). We sampled families visiting agritourism farms as well as students in classroom settings in grades four through six, along with their parents. Each of the six agritourism farms where we sampled included educational activities, hands-on agricultural experiences, children's recreational activities, and an on-site store. All were located in North Carolina, USA. One farm was located in western North Carolina, three in the central region, and two in the eastern portion of the state. For school-based data collection, we partnered with 47 North Carolina teachers located at 42 schools across the state to distribute both youth and parent surveys (see Data Collection section for details on sampling procedures).

In our sample, nearly half (45%) of the families reported living in small towns, 23% live in suburban areas, another 23% in rural areas, and 9% in large cities. Of the parents surveyed, a similar proportion (43%) grew up in small towns, 28.5% in rural areas, 17.5% in suburban areas, and 11% in large cities. Slightly less than half (43%) of the students in our sample identified themselves as girls, 56% as boys, and 1% stated that they identified in another way. Most (71%) of parents self-identified as white, with fewer identifying as Native American (1%), Asian (6%), Black (8%), Latino (5%), less than 1% as Pacific Islander, and 4% as multi-racial. A small portion (4%) of respondents chose not to disclose their race and 1% indicated that they held a racial identity not available on our survey. The U.S. Census Bureau reports the racial breakdown of North Carolina as a whole to be: 71% white, 1.5% Native American, 3% Asian, 22% Black,

10% Latino, less than 1% Pacific Islander, and 2% multiracial (U.S. Census Bureau, 2019). This suggests that our sample was roughly representative of the state racially, although we likely underrepresented Black and Latino communities to some degree. About one third (32.5%) of parents had completed a 4-year college degree, 26% held a postgraduate degree, 16% had some college experience without a degree, 13% held a technical degree, and 13% had a high school degree or lower level of schooling. Many parents (35%) chose not to share their political affiliation on the survey. Among those who chose to respond, 28% of our sample identified as conservative or moderately conservative, 15% as independent, 1% as libertarian, 18% as liberal or moderately liberal, and 3% as other. One quarter (25%) of families in our sample have a household income of less than $50,000 per year, 31% have a household income between $50,000 and $100,000 per year, and 44% have an annual household income of $100,000 or more. The median household income in North Carolina between 2015 and 2019 was $54,602 per year (U.S. Census Bureau, 2019).

VARIABLES & INSTRUMENT

This study employed two related instruments. One survey instrument was implemented with youth and the other with parents. For the purposes of this study, parents are defined as adult caregivers with legal responsibility for the youth respondent. Both instruments were pilot tested and validated (Brune, et al., 2020c) and have served as the data collection method for two published studies to date (Brune et al., 2020a; Brune et al., 2020b).

In this study, we defined youth agricultural literacy as knowledge, attitudes, and behaviors related to local food systems in North Carolina. These are represented as the three main dependent variables. We measured knowledge with nineteen items that gauged the respondent’s understanding of agricultural systems, with a focus on local North Carolina

agriculture. We measured youth attitudes with four items using five-point Likert-type scales (1=strongly disagree to 5=strongly agree) that assessed respondents' ideas about agriculture and local food such as whether it is good for the environment or whether local foods taste good. We similarly measured youth behavior with seven items that asked respondents to rate the likelihood that they will engage in behaviors such as asking their parents to visit a farm for U-pick produce or talking to adults that are not their parents about issues related to local food and agriculture using five-point Likert-type scales (1=very unlikely to 5=very likely).

Our independent variables included family-level demographics, parent views around agriculture, and personal interactions with famers and family. For demographics, we asked students to self-report age, gender, and race. On the parent survey, we asked parents to self-report age, gender, race, educational attainment, political affiliation, household composition (number of parents and children), household income, the type of area where they currently live (rural, small town, suburb, or large city), and the type of are where they grew up. While we asked both parents and youth to self-report race, responses to this question among youth did not match community demographics, which suggested that youth found self-identifying their own race difficult. Therefore, we included parent race as a variable in our models, but not youth race. While this may underrepresent multi-racial families (in which parents and youth are not the same race), we believe this allowed us to work with more reliable racial data and still provides us with important information about the ways in which race may intersect with intergenerational learning and agricultural literacy.

To measure parents' views related to agriculture, we employed a series of scales similar to those found on our youth survey. We measured parent attitudes identically to how we measured youth attitudes. In addition, we measured parent subjective norms around local food

and agriculture with four items on five-point Likert-type scales (1=strongly disagree to 5=strongly agree) that gauged perceptions around the purchasing preferences of others (e.g. most people who are important to me would approve of me buying local foods). We also measured parents' intended behavior as it relates to support for local food systems. Once again, we used Likert-type scales on six items in which respondents indicated the likelihood (1= very unlikely to 5 = very likely) that they would engage in different behaviors such as visiting a farmers' market or looking at food labels to aid in purchasing decisions. In order to measure intergenerational engagement in families, we asked youth about the frequency of their interactions with their parents around academics, extracurricular activities, home cooking practices, and food purchasing decisions, again using a 5-point scale (1=never to 5=always). We also asked youth to self-report if they personally know a farmer.

Finally, respondents were asked to record their initials, their birthday, their child's initials (parents only), and their child's birthday (parents only). Surveys administered in a school setting also asked respondents to identify the teacher and school with which they are associated. This allowed parent and youth surveys to be matched for intergenerational analysis without violating the overall anonymity of survey responses.

DATA COLLECTION

Data collection took place in two distinct phases – on farms, and in schools. The first data collection method occurred via intercept surveys at agritourism sites among families visiting a farm on their own time for recreational purposes. We sampled in both the Fall and Spring to capture peak agritourism seasons. We administered surveys on paper or iPads according to respondent preference. The digital and paper surveys were identical and we used Qualtrics on the iPads to administer the digital version of the survey. Researchers intercepted families with youth

in the sampling criteria at the entrance to the agritourism site in order to administer surveys before they participated in the farm experience. We asked at least one youth and one parent in each family to fill out the survey. Our data set from farm-based intercept sampling contains 288 family units.

The second method of data collection for this study took place in schools via partnerships with 47 fourth through sixth grade teachers. We recruited these teachers via an email sent to teachers state-wide through a North Carolina Department of Public Instruction listserv. We trained participating teachers on survey administration and implemented the surveys in their classes digitally through Qualtrics. Teachers invited parents associated with these students to participate in the survey via classroom messaging apps, emails, and papers sent home with students (i.e. the routine communication channels teachers use). Teachers had the option to administer parent surveys digitally by sending a Qualtrics link to parents or by sending paper copies of the survey home, which were then mailed back directly to the researchers. In all cases, surveys for youth were administered in English while parent surveys were available in English and Spanish. Researchers manually added any completed paper surveys to the Qualtrics database. While there may be some bias in terms of which teachers are inclined to participate in the study, students were assigned to their classes via normal school district protocols with no consideration of this research, ensuring that there is not a self-selection bias among participants. Our data set from school-based sampling contains 237 family units. In total, we analyzed 525 family units from both methods of data collection.

DATA ANALYSIS

We cleaned all our data by removing surveys that were less than 70% complete or surveys without identifying information (initials and birthdays). We developed composite scores

for youth attitudes, behaviors, and intergenerational learning metrics as well as parent attitudes, subjective norms, and behaviors by adding responses on Likert scales together for each respondent. We generated composite scores for youth knowledge by recoding correct answers to one and incorrect answers to zero and then adding all items together for each youth respondent. When respondents did not complete all items associated with the attitudes, behaviors, or subjective norms sections, we did not calculate a respective composite score for that respondent. We matched parent and youth survey responses via initials and birthdays to allow for intergenerational analysis, combining youth and parent datasets by adding parent responses as additional variables to the matching youth data. Finally, we inputted a clean and recoded dataset into R with youth responses matched with parent responses as the new unit of analysis.

Classification and regression trees were the primary mode of analysis for this study. This method relies on Classification and Regression Tree (CART) data analysis using in R software (Core Team, 2021). Regression trees work by iteratively dividing a sample into two binary groups in order to generate subsamples with similarities in terms of outcome variables (Breiman et al., 1984; Ma, 2005). In other words, they begin by identifying the independent variable that best splits the data into two groups based on the dependent variable (e.g. which factor best determines high and low agricultural knowledge?). In our recursive and conditional partitioning approach, this process continues until there are no remaining ways to split the data in a statistically significant manner, thereby providing multiple pathways to different dependent variable outcomes (Breiman et al., 1984; Ma, 2005). This creates a prioritization of variables based on

where the data splits that illustrates what factors are exerting significant levels of influence over outcomes in different combinations (Brieman et al., 1984, Ma, 2005).

In this case, we generated three regression trees that will illustrate pathways to youth agricultural knowledge, attitudes, and behaviors as predicted by groups of the independent variables described in table 1. Independent variables fell into the three categories of our research question: family demographics, parent views, and personal interactions across generations on the part of the learner. In addition, we included two measures to account for the context in which we collected various sections of our data. A small amount of the pre-survey data was collected after COVID-related school closures (n=23). Therefore, a COVID variable was included in the models for these survey responses to test for any difference in that subset of the data due to the different conditions in which it was collected. We also accounted for treatment group because our data was collected on farms and in schools. This variable allowed us to account for the less random nature of sampling families visiting a farm on their own time as compared to sampling through schools. Although the data analysis for this paper did not involve different treatment groups within the school-based data collection, the youth involved in this study received different learning interventions as part of other research initiatives. These groups (namely, structured, semi-structured, and control) are also included within this in case there was any inadvertent

effect on pre-existing student knowledge, attitudes, and behaviors based on those randomized categories.

Table 1. Independent variables included in models for analysis.

Category	Independent Variables	Response Coding
Personal Interactions	Intergenerational engagement between youth and parents	6 (least engagement) to 30 (most engagement)
	If youth know a farmer personally	1=yes, 2=no, 3=don't know
Family Demographics	Youth gender identity	1=boy, 2=girl, 3=other identity
	Parent race	1=Native American, 2=Asian, 3=Black, 4=Latino, 5=Pacific Islander, 6=white 7=no response, 8=other identity, 9=multiracial
	Current geographic location (urban/suburban/rural)	1=rural, 2=small town, 3=suburb, 4=city
	Parent geographic origins (urban/suburban/rural)	1=rural, 2=small town, 3=suburb, 4=city
	Parent educational attainment	1=high school or less, 2=some college, 3=technical degree, 4=4-year college degree, 5=postgraduate degree
	Parent political affiliation	1=liberal, 2=moderate liberal, 3=libertarian, 4=conservative, 5=moderate conservative 6=independent, 7=no response, 8=other
	Family household income	0=less than $50,000/year, 1=between $50,000 and $100,000/year, 2=more than $100,000/year
Parent Views	Parent attitudes towards local food systems	3 (most negative) to 15 (most positive)
	Parent subjective norms related to food systems	4 (least influence) to 20 (most influence)
	Parent purchasing behavior	6 (lowest level intention to support local food systems) to 30 (highest level intention to support local food systems)
Data Collection Context	Data collection timeline (pre or post COVID-19 related school closures)	0=pre-COVID 1=during COVID
	Treatment group	1= school-based structured, 2=school-based semi-structured, 3=school-based control, 4=farm-based unstructured

Regression trees may be especially important when examining socially-embedded variables like race, gender, or family culture that interact in hard-to-predict ways (Ma, 2005; Moon et al., 2016). This stands in contrast to multiple linear regression, which focuses on a single relationship to predict a dependent variable. Instead, regression trees develop a hierarchy of variables that influence an outcome without isolating independent variables to explain a dependent one (Breiman et al., 1984; Ma, 2005). In linear regressions, any hypothesized interactions or non-linear relationships must be accounted for *a priori* in building the model. It is not reasonable to assume that we can predict the complexity of interactions that may occur to influence relationships between intersecting identity factors and equally complicated outcomes such as knowledge, attitudes, and behaviors. Regression trees allow for a recognition of this complexity because interactions are not limited and emerge as part of the analysis process (Breiman et al., 1984; Ma, 2005; Moon et al., 2016). As such, regression trees allow for a more ecological approach to an issue and are a valuable analytical tool when examining demographic and descriptive variables that intersect in different ways to influence individual outcomes (Davidson & Bush, 2016; Ma, 2005; Moon et al., 2016). Regression trees have been employed in this manner to explore academic achievement in community colleges, fruit consumption among young adults, interest in math and computer science among college students, scientific achievement, bullying, residential water conservation, and youth connection to nature (Cutts et al., 2013; Davidson & Bush, 2016; Depren, 2018; Kitsantas et al., 2012; Lohrman et al., 2017; Moon et al., 2016; Szczytko et al., 2020). A secondary advantage to regression tree analysis is that it provides a visual representation of subdivisions in data that can be helpful in interpreting results among a range of audiences (Davidon & Bush, 2016; Szczytko et al., 2020). While regression trees are not particularly common in educational research, they may be an especially

effective approach for education researchers because of their ability to more easily consider complex interactions between explanatory variables (Davidson & Bush, 2016; Ma, 2005).

We also used random forest models as a secondary form of analysis to confirm results of regression trees (Beaulac & Rosenthal, 2019; Hardman et al., 2012; Hayes et al., 2015). Because CART analysis can be highly variable, random forest analysis uses repeated sampling to provide a comparison point for results of regression trees (Beaulac & Rosenthal, 2019; Hardman et al., 2012; Hayes et al., 2015). By running the data over and over, random forest models indicate the probability of different outcomes by calculating the proportion of times a certain result is generated (Beaulac & Rosenthal, 2019; Hardman et al., 2012; Hayes et al., 2015). Discrepancies between the results of random forest models and regression tree models could indicate that a regression tree is showing certain outputs due to chance (Beaulac & Rosenthal, 2019; Hardman et al., 2012; Hayes et al., 2015). When results of random forest analysis support the findings of a regression tree analysis, it can confirm that the data splits identified in the tree did not occur by chance, but are representative of the data sample more largely (Beaulac & Rosenthal, 2019; Hardman et al., 2012; Hayes et al., 2015). In our analysis, we used conditional partitioning methods to grow the trees and forests in order to account for the differences in the number of potential cut points between more continuous variables and binary variables.

Results

Youth received an average knowledge score of 9.47 (SD=4.33) out of a possible nineteen points, indicating that many young people are unfamiliar with information about local agricultural systems. The lowest scoring youth answered zero questions correctly and the highest scoring youth answered all nineteen questions correctly. The average attitude score was 16.23 (SD=2.51). Youth scores ranged from six to the maximum of twenty. This suggests that overall,

youth in this study had positive attitudes towards local foods and agriculture. Finally, the average behavior score among youth was 22.44 (SD=5.70). Results included individuals with both the lowest and highest possible scores. Our models included many independent variables but two that we found to be consistently important were if youth know a farmer and intergenerational engagement between parents and children. Just over half (52.17%) of youth indicated that they personally know a farmer, 34.78% indicated that they did not know a farmer, and 13.04% stated that they were not sure if they know a farmer. In terms of intergenerational engagement, youth on average scored 22.47 (SD=3.81) on a scale that ranges from six points with the least possible engagement between parents and youth to thirty points, or the maximum level of regular engagement. Actual student responses ranged from nine to thirty points.

Overall, results of this study emphasize the role of personal interactions, both in terms of intergenerational engagement with parents and in terms of personal connections to farmers, in influencing pre-existing youth agricultural literacy among North Carolina students. This is particularly true in terms of attitudes and behaviors in which personal interactions outweighed family demographics and parent views in predicting youth agricultural literacy. In these models, intergenerational engagement between youth and parents was significantly tied to youth agricultural literacy and whether youth personally know a farmer also emerged as a key predictor. The intended behavior of parents was a significant predictor of youth behavior but not of youth attitudes or knowledge. Parent attitudes and subjective norms were not significant in any of the models. No family demographic data was significant in predicting youth attitudes or behavior. Data collection format had a significant effect on youth knowledge scores, with youth surveyed on farms scoring significantly lower than youth surveyed at school. The geographic area in which their family lives and their parents' political affiliation also emerged as predictors

of youth knowledge. Overall, however, students scored poorly on the knowledge questions and appear to have limited understanding of agricultural systems so these factors may have limited predictive power when considered in this context. No other demographic variables (race, gender, household income, parent educational attainment, parents' geographic origins) were significant predictors of youth agricultural literacy in any capacity.

We found several factors to be related to youth agricultural knowledge. Data collection mode was the primary indicator of youth knowledge outcomes, with geographic location and parent political affiliation as secondary predictors (Figure 1). Data collected with youth in schools yielded significantly higher knowledge scores than data collected with youth during informal agritourism visits (mean: 7.54, SD: 4.49). This may simply be due to a difference in focus and expectations in attention given the different environments. While treatment groups one, two, and three are functionally the same for the purposes of this study, there may be some effect from different teachers and classroom settings among youth respondents that led to the secondary split by treatment in the data. Youth in treatment two who live in small towns had higher knowledge scores (mean: 14.48, SD: 2.77) than those from rural areas, suburban areas or large cities (mean: 11.72, SD: 2.47). Youth in treatment groups one and three whose parents indicated that they are liberal, moderately liberal, libertarian, or have a non-listed political affiliation, had higher knowledge scores (mean: 12.83, SD: 2.84) than youth with parents who see themselves as conservative, moderately conservative, or independent, as well as those who chose not to disclose their political affiliation (mean: 10.83, SD: 2.85). The random forest model (Figure 2) emphasizes the role of data collection setting as a predictor of youth agricultural

knowledge. All other variables have very little predictive power, which suggests that youth knowledge is not highly variable across demographic or interpersonal factors.

Figure 1. Results of the regression tree model for youth agricultural knowledge. Structured, semi-structured, and control categories indicate groupings within the dataset not related to this analysis. Regardless, the response setting associated with these groupings is significant.

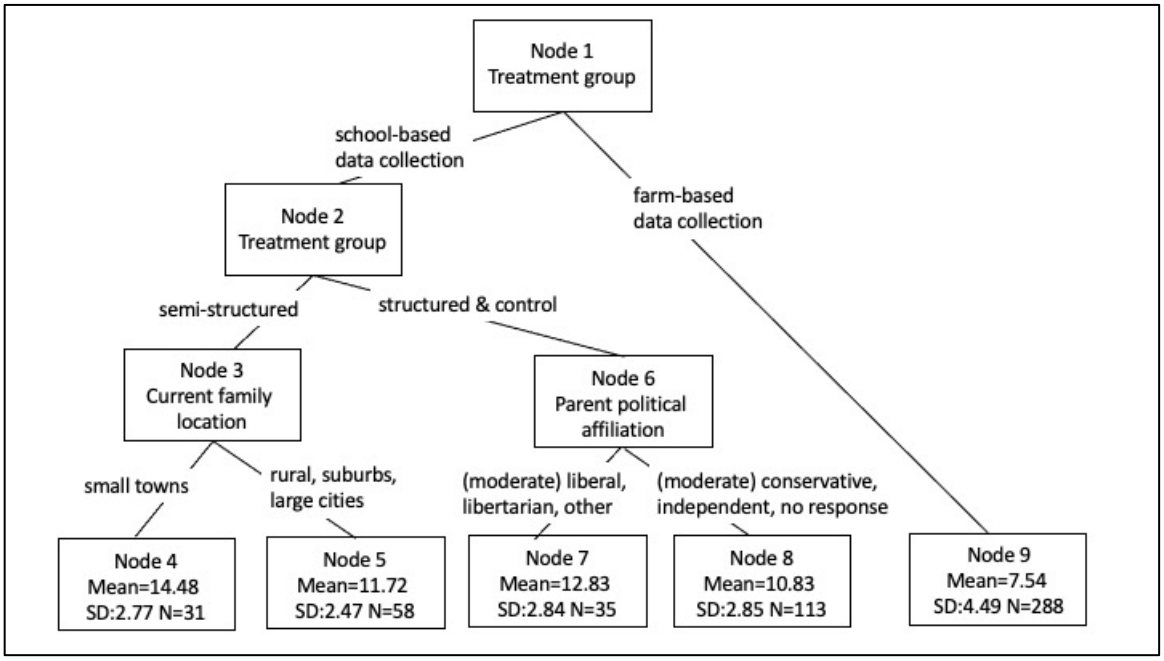
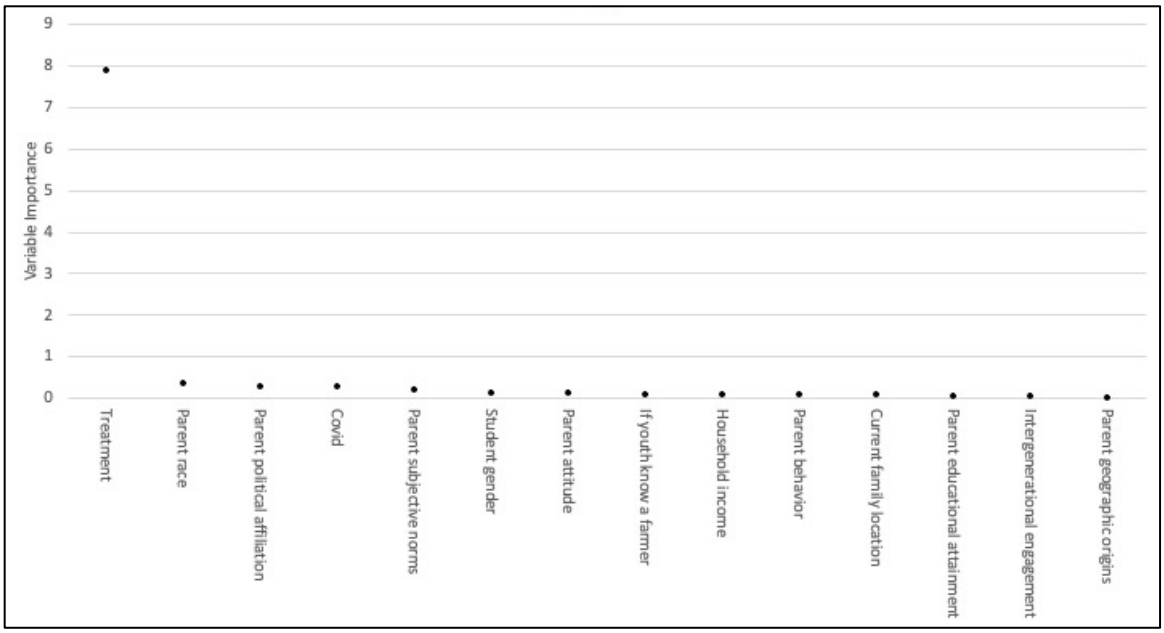


Figure 2. Results of the random forest model for youth agricultural knowledge. Independent variables are listed on the x-axis, with variable importance in the model indicated on the y-axis.



The youth attitudes regression tree model (Figure 3) demonstrates that knowing a farmer is the primary factor predicting positive attitudes towards agriculture and local foods among youth. Youth who indicated that they personally know a farmer had more positive attitudes than those who indicated that they did not know a farmer or were not sure. Within these two groupings, intergenerational engagement also predicted youth attitudes. Youth with very high levels of intergenerational engagement (greater than 24) who also knew a farmer had the most positive attitudes (mean: 17.64, SD: 2.25) and those who knew a farmer but had lower levels of intergenerational engagement (24 or less) had slightly less positive attitudes (mean: 16.59, SD: 2.32). Among students who did not indicate that they knew a farmer, those with higher levels of intergenerational engagement (greater than 20) had more positive attitudes (mean: 15.88, SD: 2.47) than those with lower levels of intergenerational engagement (20 or less) (mean: 14.66, SD: 2.21). These results indicate that the confluence of high levels of intergenerational engagement and knowing a farmer are likely help foster positive agricultural attitudes among youth. The random forest model for attitudes (Figure 4) supports the primary importance of

knowing a farmer and the secondary role of intergenerational engagement in its prioritization of variables.

Figure 3. Results of the regression tree model for youth agricultural attitudes.

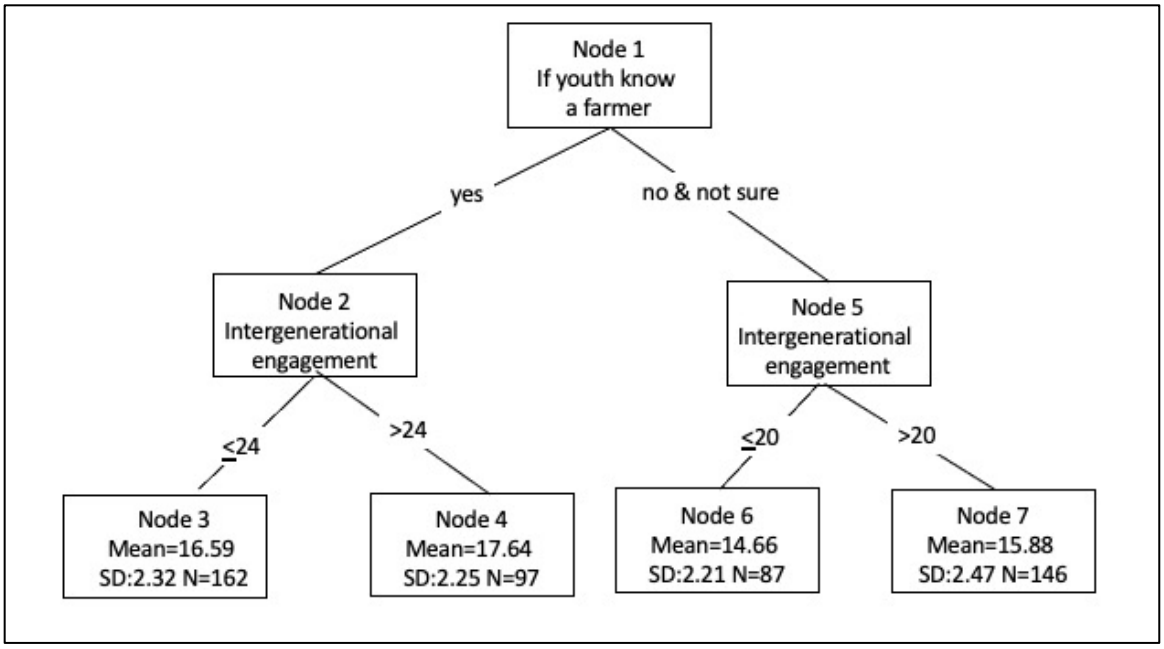
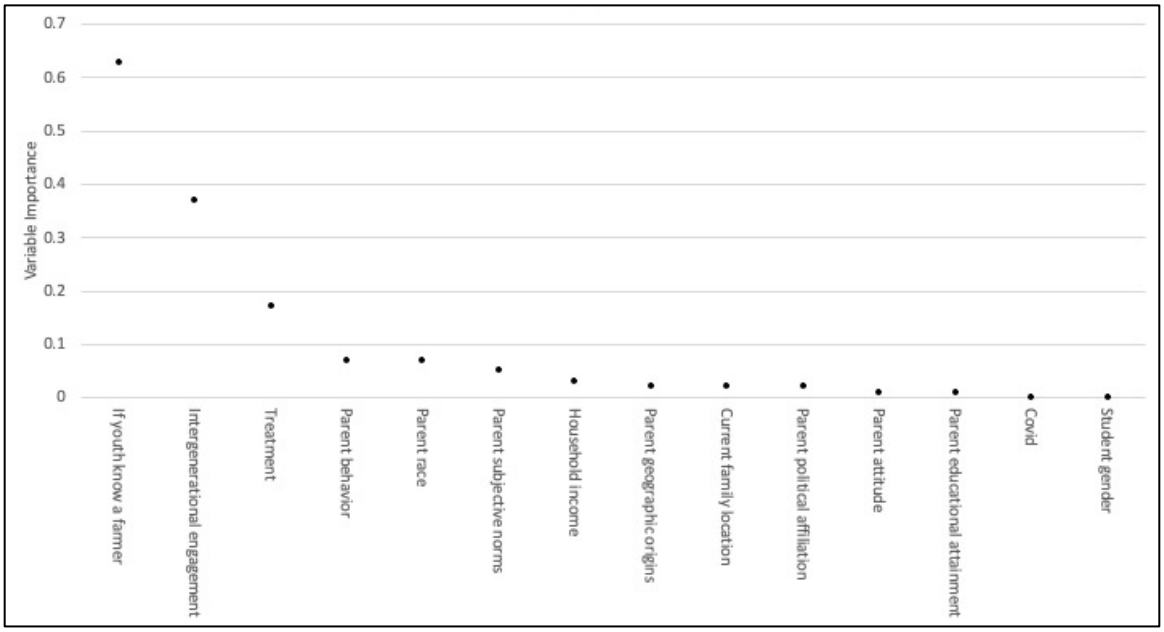


Figure 4. Results of the random forest model for youth agricultural attitudes. Independent variables are listed on the x-axis, with variable importance in the model indicated on the y-axis.



Youth intended behavior related to food and agriculture was also predicted by intergenerational engagement (Figure 5). Youth with slightly lower levels of intergenerational engagement (29 or less) demonstrated lower levels of intention to participate in behaviors that support local food systems. Within this group, youth who personally know a farmer had higher behavior scores (mean: 23.39, SD: 5.32) than those who did not indicate that they know a farmer. However, even among youth who do not know a farmer, those with higher levels of intergenerational engagement (greater than 20) had higher behavior scores (mean: 21.81, SD: 5.27) than those with lower levels of intergenerational engagement (20 or less) (mean: 19.43, SD: 5.11). Youth with very high levels of intergenerational engagement (greater than 29) whose parents indicated high levels of intention to support local food systems (greater than 26), had the highest behavior scores of the youth sample (mean: 33.45, SD: 2.30). Youth with very high levels of intergenerational engagement (greater than 29) whose parents reported lower levels of intention to support local food systems (26 or less) had slightly lower behavior scores (mean: 23.36, SD: 6.52). The random forest model shows intergenerational engagement as the most important predictor of behavioral intention scores with knowing a farmer as the second most

important factor. Other variables, including the intended behavior of parents, were less important in the random forest models (Figure 6).

Figure 5. Results of the regression tree model for youth behavioral intentions related to agriculture and local food systems.

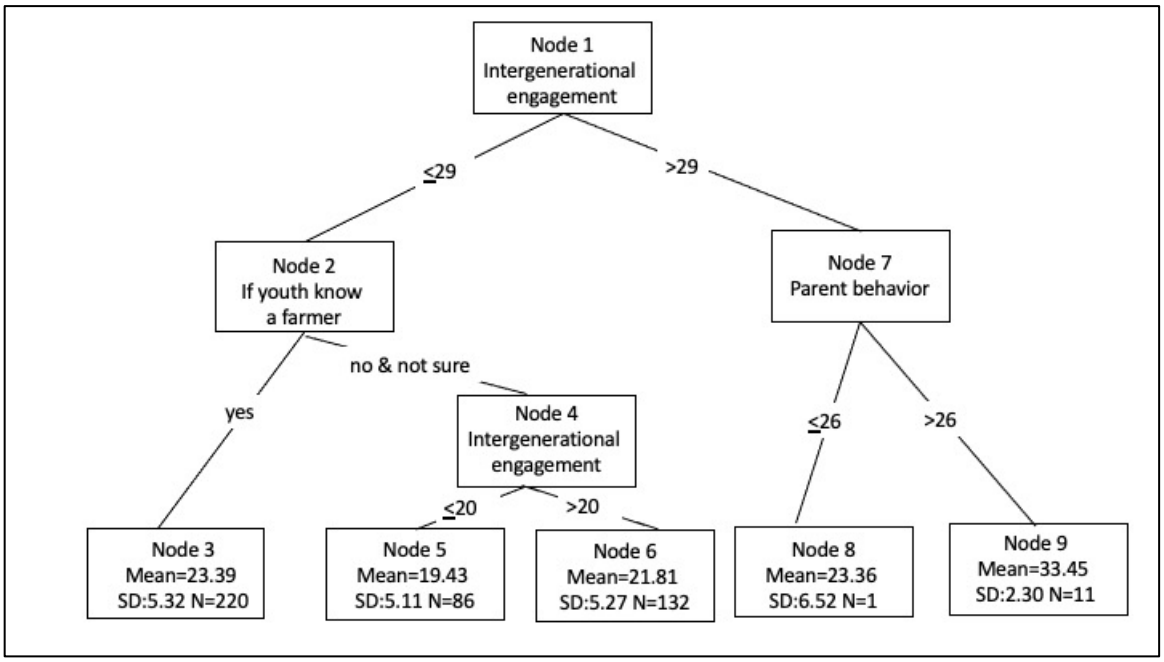
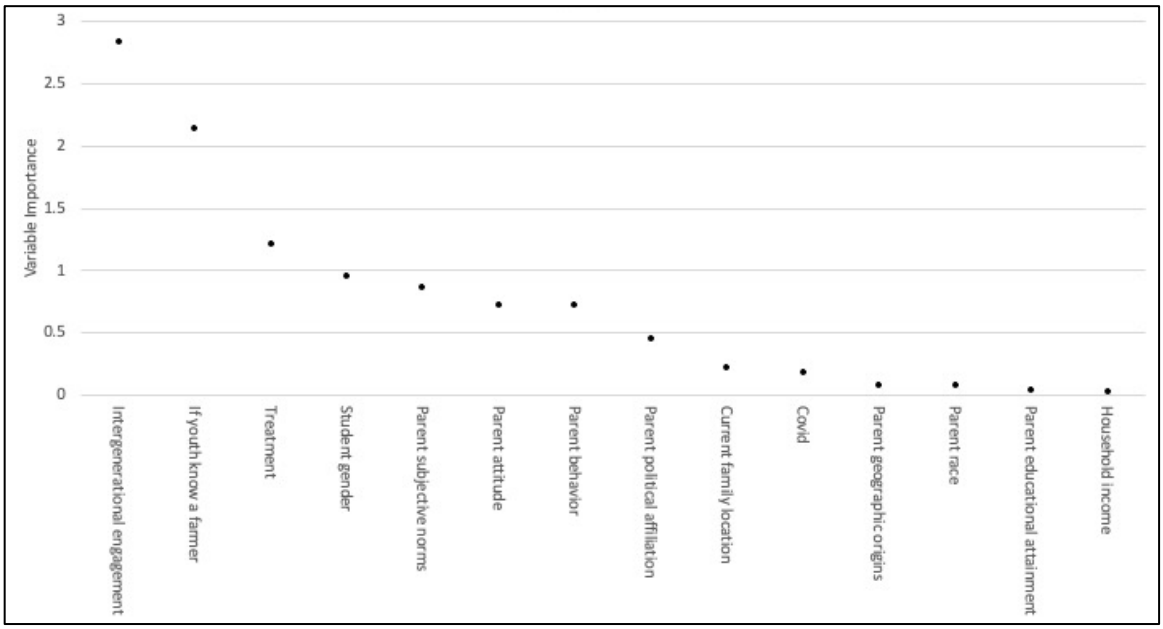


Figure 6. Results of the random forest model for youth behavioral intentions related to agriculture and local food systems. Independent variables are listed on the x-axis, with variable importance in the model indicated on the y-axis.



Discussion

Findings indicate that while many of the young people in our sample have positive attitudes and behavioral intentions related to agriculture, educators still have a significant amount of work ahead of them when it comes to providing North Carolina youth with a strong understanding of local food systems. Relatively positive attitudes and high levels of intention to participate in agriculture-friendly behaviors is consistent with environmental literacy research that has shown that children generally have positive feelings toward the environment and want to help protect it (McBeth et al., 2008; Stevenson, 2013). However, youth knowledge of agriculture appears to be low overall and our model identified the context in which respondents answered survey questions as the primary indicator of knowledge level, which limits the applicability of knowledge-specific findings. This finding is supported by literature which suggests that the immediate environment of survey respondents, and associated distractions, can have an effect on carless responses and data quality (Biemer & Lyberg, 2003; Meade & Craig, 2012).

Cultural markers of political affiliation and geographic location may shape agricultural knowledge among youth, but future research should examine this finding further as the relationships we found were relatively weak. Specifically, while parent political affiliation and family geography appeared in the regression tree as predictors of knowledge, they were not particularly important in the random forest model. Though weak predictors, it is possible that parent political affiliation and family geography do shape agricultural knowledge to a certain degree as both of these demographic categories are typically key predictors for a host of viewpoints. For example, although the political landscape is constantly shifting, prioritization of environmental issues in Congress is often tied to party lines (Dunlap & Allen, 1976; Karol, 2018). While Republicans often represent pro-business and small-government interests,

Democrats tend to be more inclined to implement environmental regulations that may limit profits in industrial sectors (Dunlap & Allen, 1976; Karol, 2018). While studies show that the majority of Americans are concerned about the environment, priorities at the congressional level appear to be somewhat present among voters as well – those who lean Democrat are more likely to be supportive of action on environmental topics like climate change than those who lean Republican (Funk & Hefferon, 2018). Politics, and associated viewpoints, are often correlated with geography (Parker et al., 2018; Savat, 2020). In fact, proximity to cities may be a key predictor of not only party loyalty at the ballot box, but of opinions on key social issues such as regulations on business, reproductive rights, and immigration (Parker et al., 2018; Savat, 2020). Accordingly, these strong cultural markers at the family level may also shape what children know about agriculture. However, 43% of our sample self-reported as living in small towns and so smaller sample sizes among families from other geographic categories may have influenced these findings. The overall low knowledge outcomes and the dependency on survey setting of our model are further limitations to the importance of geography and politics in our results. In addition, as our survey focused on North Carolina-specific agricultural knowledge, scores may reflect limited localized knowledge rather than low understanding of general agricultural concepts. Developing more accurate measures of place-specific youth agricultural knowledge and examining the role of place-based learning for this metric should be avenues for future research among AE and EE scholars.

As youth who knew farmers and regularly engaged with their parents on a range of topics are likely to care about agricultural issues and are inclined to act on those feelings, AE programming may benefit from supporting and maximizing those relationships. Though it seems that youth engagement with families and farmers is instrumental in shaping agricultural literacy,

the act of engagement may be more important than the content. As in our study where parent views of agriculture seemed unimportant in predicting youth agricultural attitudes or behaviors, parents' specific opinions on climate change seem unimportant in shaping the climate change concern of their children (Lawson et al., 2019). Rather, it may be the act of discussing the topic that gives students the skills and confidence they need to form their own opinions (Lawson et al., 2019). This finding is encouraging for expanding AE programming beyond those from agricultural backgrounds. Additionally, although the specific agricultural views of parents may not be important, agricultural experiences – such as knowing a farmer – do seem key in shaping youth agricultural literacy. Taken together, it seems likely that children from all backgrounds may be primed to engage in AE and would benefit from opportunities for personal engagement with farmers through educational programming. Educators should also aim to support intergenerational engagement between the youth which whom they work and parents in order to foster positive attitudes and behaviors related to agriculture. One promising avenue for promoting contact with farmers and intergenerational engagement is agritourism, or the act of visiting a working farm for recreational or educational purposes (Barbieri et al., 2019). Many researchers are enthusiastic about opportunities for informal agricultural learning in this setting through school field trips or as part of family-based recreation (Barbieri et al., 2019). Our results indicate that agritourism, which promotes interactions between farmers and the public and is marketed to appeal to multiple generations within a family unit may be a particularly promising pathway to building agricultural literacy.

In contrast to the importance of interactions with family and farmers, demographic level data were not highly predictive of youth agricultural literacy, which highlights additional opportunities for responsive programming. It is well documented that AE and EE programming

does not typically reach diverse audiences (Cole, 2007; Crosley, 2013; Harris & Barter, 2015; LaVergne et al., 2011; LaVergne et al., 2012; National Research Council, 2009; Warren & Alston, 2007). As agricultural literacy was stable across nearly every measure of family-level demographics, this lack of diversity in participation is likely not due to lack of interest or understanding on the part of underrepresented groups. Instead, barriers to participation in programming may include narrow definitions of both the environment and environmental issues on the part of mainstream EE, limited efforts to contextualize material to be relevant to multiple audiences, and an unnecessary divide between environmental justice issues and mainstream EE (Arora-Jonsson & Agren, 2019; Lewis & James, 1995; James & McAvoy, 1992). Further, environmental organizations and funders remain demographically monolithic, especially in terms of race, which influences the ability to create change on the ground in EE programs (Arora-Jonsson & Agren, 2019; Johnson, 2019; "Survey Shows", 2019). Our results may point to opportunities to improve cultural competency and promote inclusive communication strategies. Our findings are part of a larger call to action to do better when it comes to creating culturally-responsive programming and spaces where a wide range of students and educators are able to meaningfully connect to educational material and one another.

With this goal mind, this study offers evidence to contradict deficit models which suggest that groups who are less visible in EE and AE are not interested or invested in agricultural or environmental topics (Ahteensuu, 2012; Nadkarni et al., 2019). Employing regression trees as an analytical tool allowed us to outline multiple pathways to agricultural literacy outcomes, which accounts for the interaction between aspects of learner identity and family context (Breiman et al., 1984; Ma, 2005). For example, youth who indicated that they do not know a farmer are still likely to have positive agricultural attitudes when they also had high levels of engagement with

their parents. Similarly, students without the very highest levels of intergenerational engagement still displayed behavioral intention to support agricultural systems when they personally knew a farmer. These findings support the need for a nuanced understanding of data that does not draw straight lines between predictors and outcomes without first considering other contextual factors (Breiman et al.,1984; Ma, 2005; Moon et al., 2016). Results also emphasize the importance of student-responsive approaches that allow learning to be tailored to prior experiences and ideas that may arise from a range of contextual factors (Ahteensuu, 2012; Nadkarni et al., 2019; McGlynn & Kelly, 2018; O'Leary et al., 2020).

This study does have several limitations that offer opportunities for future research. In relation to the place-based focus of our knowledge models, the study was set entirely within North Carolina. As such, caution should be used when applying results and conclusions to other regions or contexts. Another consideration in examining our findings is the global COVID-19 pandemic, which was occurring during the course of this study. While it did not directly impact the collection of the data, experiencing such a catastrophic phenomenon cannot be discounted as an influence on all those involved in this work and will certainly set it apart from research performed at other times. Finally, this study only analyzed a snapshot of agricultural literacy and future research should examine how variables related to learner identity and family context may shape outcomes from learning interventions. Results from such efforts would provide further insight into AE and EE curricular design and help identify promising pathways for addressing existing inequities associated with AE and EE. Our analysis strategy offers an alternative method for examining these questions and we hope that future research will continue to work towards capturing the complexity of intersectional identities and family context in data collection and analysis. In particular, because regression trees are underutilized as an analytical tool in AE and

EE research, our analysis provides a methodological roadmap for future research that positions environmental and agricultural literacy as socially-embedded and considers the entire sociocultural landscape of the learner prior to a learning intervention.

Conclusion

This study found interpersonal interactions with farmers and parents to be more predictive of youth agricultural literacy than family demographics or parent views of agriculture. This was especially true for attitudes and behaviors related to local food systems. These results emphasize the importance of connecting youth to farmers as part of the educational process. Our findings also highlight the role parents play in shaping youth agricultural literacy, not in terms of behavioral or attitudinal mimicry, but because regular engagement related to a range of topics including school content and extracurricular activities are positively connected to pro-agricultural attitudes and behaviors among youth. Based on the lack of predictive power of demographic variables in our models, we support calls to move away from deficit models when approaching issues of diversity in AE and EE. Instead, we urge AE and EE scholars and practitioners to reexamine existing frameworks that may be driving a lack of engagement among diverse audiences. We also found regression trees and random forest models to be promising analytical pathways for examining data related to complex topics like identity and family context.

CHAPTER 4

Practitioner-Focused Thesis Conclusion

Our world is facing a series of critical environmental issues including climate change, deforestation, and limited access to clean water. Environmental education is an important part of the solution to these problems as it can help the public better understand complicated environmental subjects and become engaged in solutions in their communities. One environmental topic that doesn't always receive a lot of attention is agriculture, even though it intersects with nearly every environmental challenge we face. Farmers must adapt to shifting temperatures and weather patterns, available farmland is shrinking as urban areas expand, and resources must be carefully managed as we work to create equitable access to nutritious and culturally-appropriate food.

One way that educators can support sustainable agriculture is by promoting collaboration between environmental and agricultural education communities. Though both researchers and practitioners in these fields often operate separately, they have a lot to learn from one another. For example, agricultural educators have extensive knowledge related to making decisions about natural resource management in the context of running a business and meeting the needs of a growing population. This could be an important lesson for the environmental education world, which isn't always as grounded in the realities of tradeoffs between long-term sustainability and more immediate outcomes like profit and crop yield. On the other hand, environmental educators tend to be good at connecting environmental themes across a range of different topics and at fostering deeper connections to nature among students. This could help agricultural educators in their efforts to move away from a vocational training mindset and towards broader public engagement.

Another intersection between agricultural and environmental education is the difficulty they both experience in recruiting and retaining diverse educators and program participants. Neither field has always done a good job of including people of color, LGBTQ communities, people with disabilities, and other marginalized communities in their work. Sometimes this leads people to assume that those who are less visible in mainstream environmental and agricultural education organizations and programs don't care about the issues or simply don't know enough to realize that they should care. This is called "deficit thinking." The deficit mindset is harmful because it focuses the blame on those who have been excluded instead of asking for environmental and agricultural conversations to be more inclusive.

New research from North Carolina State University challenges deficit thinking, as it shows that demographic factors like race, gender, and household income are not good predictors of youth agricultural literacy. Agricultural literacy is the knowledge, attitudes, and behaviors of an individual as it relates to systems of food and fiber production. Young people of color, from low-income families, or from urban areas were just as interested and knowledgeable about agriculture as those we typically associate with agriculture - white youth, those with affluent parents, and those in rural areas. From this, educators should remember never to assume that people who are generally less visible in educational programming don't care. Instead, we need to ensure our curricula, programming, and communication are relevant and engaging to communities who are currently underrepresented in mainstream environmental and agricultural education. We know this is an area in which we can do better. It may also be an opportunity for environmental and agricultural educators to join forces and collectively work towards avoiding deficit thinking and ensuring public engagement among diverse audiences.

Another interesting finding from this study was that kids who know farmers and share what they learn with their parents are more likely to care about and support agriculture. In fact, personally knowing a farmer was one of the most important things that predicted how much kids cared about agriculture. Interestingly, it didn't matter how parents themselves thought and felt about agriculture, but just that they interacted regularly with their kids about a range of topics including schoolwork and extracurricular activities. Educators should take note – if we want students more engaged with agriculture, we should give kids more opportunities to interact directly with farmers and encourage them to share what they learn with their parents.

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