Informal science educator professional identity

Perceptions of NGSS, work with teachers, and the centrality of place

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Abstract

There have been calls for meeting the goals of the Next Generation Science Standards (NGSS) through instruction and experiences in out-of-school, informal science education contexts. To maximize the effectiveness of such experiences, teachers and informal science educators must collaborate to create meaningful science learning experiences. However, in contrast to teachers, there has been little work done with informal science educators (ISErs), and their professional identity and motivations are not well understood. This paper presents the results of a survey and interview study with informal science educators in a state in the U.S. Midwest. Using a sociocultural framing of identity, we examined the values and positioning of ISErs through two avenues: their work with teachers, and the role of place/content in their work. We found that ISErs see their work as complementary to that of teachers. In addition, the place of their work or the content they teach were valued in different ways. We conclude with a discussion of how informal science educator identity can influence collaboration with teachers to the benefit of students.

Keywords: Informal science education, identity, place, teachers, NGSS

Introduction

Science learning takes place in many forms outside of classroom walls. A robust science learning ecology is life wide, life deep, and lifelong (Banks, et al., 2007; Bell, et al., 2009). An estimated 120 million people visit science centers globally each year (ASTC, 2016), and an estimated 11 million students visit environmental and outdoor education centers in the U.S. annually (Collins, et al., 2020). These informal science education (ISE) sites provide science learning opportunities to many children, families, and

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adults, which suggests that ISE is both impactful and worthy of investigation for deeper understanding. Though the balance is shifting as the importance of learning in multiple contexts has become apparent, much of the literature on science learning focuses on school settings. This is evident from a Google Scholar or EBSCO search for "science learning" or "science education" – the preponderance of results reference learning in schools and classrooms. What research has been done on informal science learning and education (ISE) focuses on students, largely rendering educators who work with them invisible (e.g. Bamberger & Tal, 2008; Davidson et al., 2009). This paper engages with informal science educators (ISErs) in a U.S. context to better understand their work and professional identity.

There have been several calls for bridging the gap between informal and formal science education and creating meaningful partnerships that promote coherent science learning across contexts (e.g. Hofstein & Rosenfeld, 1996; NRC, 2015; Stocklmayer, Rennie, & Gilbert, 2010). Work on the Next Generation Science Standards (NGSS) (NGSS; Lead States, 2013; NRC, 2015) suggests that ISE sites are a valuable part of the STEM learning ecosystem (Falk & Dierking, 2018), and provide K-12 students with rich science learning experiences that are not available in the classroom, such as direct experience of scientific phenomena and practical experience "doing science". An understanding of the NGSS can facilitate these kinds of work – extending classroom learning and work with teachers – while still maintaining the nature of informal learning experiences. In addition, we propose that ISErs have instructional and content expertise and resources that could support teachers in providing new types of classroom learning. The NGSS should not be used to guide learning in informal spaces, rather knowledge of these widespread science learning standards can help ISErs better leverage the power of informal learning to support science learning in the broader ecosystem. In order to understand the entire STEM learning ecosystem we must understand perspectives of ISErs and how they work with formal educators as audience members and collaborators, alongside what ISErs prioritize in their teaching (e.g. Plummer and Small, 2013; Tran, 2007). Ultimately, a deeper understanding of ISEr professional identity – how they see themselves and how they are seen by others in matters such as competency and agency, all constrained or supported by social structures within which they operate regularly – will help in leveraging their commitments and knowledge in supporting both teachers and their students in interacting with the scientific world in powerful ways. The goal of this study is to continue building on what is known about the factors shaping how ISErs approach their work (e.g., Ennes, Jones, & Chestnutt, 2020; Holliday & Lederman, 2014; Plummer, Crowl, & Tanis Ozcelik, 2021) by developing an understanding of how they work with teachers and what characterizes their professional identity.

Who is an informal science educator?

Though research on science learning beyond school walls has increased (e.g. Pinthong & Faikhamta, 2018; NRC, 2015; Coll & Coll, 2019), there remains relatively little research on the educators who work in these spaces (e.g. King and Tran, 2017; Tran & King, 2011). Even though millions of students go on field trips to

ISE sites each year (Collins, et al., 2020), research with and about ISErs falls short of that focused on K-12 teachers. This gap should be addressed for several reasons. First, using experiences in informal settings to support classroom science learning is a core feature of the NGSS (e.g., NRC, 2015). To make partnerships with professionals working in such settings productive, it is vital to understand more about ISErs and their work. Second, people learn a great deal about science outside of school settings (Falk & Dierking, 2018). This requires ISErs with diverse content and pedagogical knowledge and skills. ISErs have a great deal to offer in supporting reform-driven educational goals that center students and encourage students to figure out rather than learn about science in a variety of spaces (Blenkinsop, Telford & Morse, 2016).

For these goals to be achieved we must first identify who is an informal science educator.

Although ISErs work with audiences of all ages in a wide variety of settings, such as science centers and museums, nature centers, zoos, afterschool programs, youth development programs, and state parks, in this paper we focus on ISErs who work with K-12 students in out-of-school settings around science content. In addition, although this study focuses on and defines ISErs more broadly, we do have a large number of ISEr participants who teach science in outdoor education settings due to our sampling methods, which will be elaborated on below. Just as a science museum has affordances such as multimedia presentations that help visitors learn about science and their role in it (National Research Council, 2009), outdoor and environmental education sites are important ISE venues that can themselves be the topic of study for environmental science on field trips (Storksdiek, 2011) and allow for experience with doing science in authentic environments (Rios & Brewer, 2014). In a recent survey of environmental education providers (Collins, et al., 2020), 86% reported offering science, and 80% of programs were for grades 1-12 programming. Most of the programming was reported to be day-long or partial-day. ISE as a profession is evolving (Morrissey, Heimlich, & Schatz, 2020; Tran & King, 2007). While ISErs have a variety of backgrounds and training, ISE as a field certainly has sets of norms, professional associations, and various forms of certification (Morrissey, et al., 2020). However, *becoming and being* an ISEr – or any kind of professional, for that matter – is shaped by one's professional identity (e.g., Beijaard et al, 2004; Luehmann, 2007); we turn to that construct below.

Professional identity

Research has been done on children's identity work in informal spaces (e.g. Hull and Greeno, 2006; Todd & Kvoch, 2019), but despite some notable exceptions (e.g., Ash, Lombana, & Acala, 2012; McLain, 2017) there is little research on the identity of educators who work in such spaces. There are a variety of conceptions of professional identity; we use a sociocultural perspective (e.g. Author 3, 2016; Vagan, 2011) in which identity is considered to be dynamic, involves the processes of creating and refining, and is a result of the interaction of the individual with others and within particular physical, social and cultural contexts. It is influenced by the people, places, and systems where one works, as well as shaping one's work in return, and is thus of interest to those who are interested in groups and individuals

such as ISErs. We consider identity to be shaped by positioning and values – (See, for example, Author 3, 2018; Author 3, in press).

We consider positioning to be how the individual narrates themselves and their interactions in relation to others who inhabit the same community and the way others do the same with respect to the individual (e.g., Author 3, 2018; see also Arvaja, 2016; Hermans, 2003). Individuals can also position themselves in parallel with or in opposition to the sociocultural spaces they inhabit (Author 3, in press). So, for example, a beginning educator may position themselves in parallel with the teacher preparation program from which they graduated or they might position themselves in opposition to other members of the science department where they teach.

The second component of identity – values – refers to those ideas, goals, or priorities that drive an individual's or an entire community's actions (Author 3, 2011). An educator might prioritize students' developing deep understanding of scientific ideas and thus plan and respond to students with this in mind, or prioritize the experiential nature of their programming and respond to students differently. While every educator possesses a set of values, these values can change over time, with some being prioritized over others. Additionally, these values will not necessarily be prioritized if the context or the community does not support actions aligned with these values. This is where the constructs of self-efficacy and agency come into play.

Agency can be viewed as the result of the educator recognizing a challenge, developing a plan to address that challenge, and putting that plan into action (e.g., Bandura, 1986, 1989).

Additionally, when a particular action is aligned with an individual's values and yields some level of success, it is more likely that the individual will engage in that action in the future, and as a result of this process, agency develops (Author 3, in press). Similarly, the confidence that accrues as a result of a history of success contributes to a sense of control an individual feels with respect to their behavior and their social environment and thus to a greater sense of self- efficacy (e.g., Bandura, 1977). Our view is that this interpretation of identity applies as well to informal science educators as it does to classroom educators.

Collaborations between informal and formal science educators

Student learning occurs both in and outside the classroom, and informal spaces have benefits for students' science learning (e.g. Dunlop, Clarke, and McKelvey-Martin, 2019; National Research Council, 2009). Developing a productive science learning ecosystem calls for connecting multiple places, and this requires collaboration and communication between educators who know and work in those places, as well as family members. Here we focus on the work that occurs when teachers and ISErs come together, what types of collaborations are most common, and how more meaningful collaborations could be formed.

Beginning to understand how partnerships between formal and informal science institutions might yield more powerful learning requires identifying how it is that educators who work in these settings collaborate with each other. ISErs and teachers interact in many ways that support science teaching and learning both on the personal level and at a field level. Such conversations may for example address

how to make the most of field trip experiences by aligning field trip content with what students are learning in class, or providing suggestions for simple investigations that teachers could conduct with their class. We focus in this section on two common types of synchronous collaborations documented in the literature: school field trips and teacher professional development (PD). The literature on school field trips is focused primarily on youth cognitive or affective outcomes (e.g. Bamberger & Tal, 2008; Davidson et al., 2009; Dunlop, Clarke, and McKelvey-Martin, 2019; Lavie, Alon, & Tal, 2015). There is much less attention to how formal and informal educators collaborate with each other before, during, or after the field trip or how ISErs facilitate outcomes for youth, though research suggests that informal science learning experiences can be more powerful if they are connected to classroom learning through activities before and/or after a field trip (e.g. Davidson, et al., 2009).

Another common time that formal teachers and informal science educators interact is during PD at an ISE site. Studies on this type of teacher PD often focus on particular outcomes for teachers such as science content knowledge (e.g. Goodale and Sakas, 2019; Melber & Cox- Peterson, 2005; Miele et al., 2010; Pecore et al., 2013) or attitudes about teaching science (e.g. Melber & Cox-Peterson, 2005; Pecore et al., 2013). These studies do not typically focus on the interactions between ISErs and teachers or on the goals they each bring to the PD experience. Again, the ISErs are most often missing from the analysis altogether, despite facilitating outcomes that researchers are measuring.

Though science content knowledge is a common goal of PD led by ISErs for teachers, a focus on content alone is insufficient for fostering effective classroom science teaching. The NGSS (NGSS Lead States, 2013) have changed the landscape of science education in the United States since they were introduced. The NGSS called for the interweaving of science and engineering practices, disciplinary core ideas, and cross-cutting concepts to re-shape teaching, learning, curriculum, and assessment in the classroom. While the NGSS have had smaller reach to ISE contexts, the National Resource Council (NRC, 2015) has recommended organizations that provide ISE be used as resources to expand classroom science learning. ISErs may have goals that are not always centered on NGSS implementation for K-12 students, such as family and public education, conservation, attendance, or historical preservation (Reid, 2013), yet the NGSS are relevant if providing professional development to teachers.

As a first step in articulating the understanding necessary to support deeper and more meaningful science learning, we investigated two research questions in this paper:

1. How do ISErs position themselves and their professional work and how does that contribute to their professional identity?
2. What experiences do ISErs have in working with teachers and how do they interpret these interactions?

Methods

Researcher Positionality

It is important to consider our own positionality with regard to the people we work with and seek to learn about. We are three white women at varying stages of our careers. [Author 1] was an informal science and environmental educator for over twenty years and a researcher working with formal and informal educators before moving to the state where this study took place. [Author 2] was a naturalist and outdoor educator before becoming a PhD student studying science education, but is also new to the state. [Author 3], originally a bench scientist, is an experienced researcher and faculty member with a long history of scholarship focused on professional identity and deep knowledge of the formal education system. Together, we have an interest in understanding the informal science educator perspective in order to better inform our own work with both educators.

Instruments

We developed a two-part explanatory sequential study (Ivankova, Creswell, & Stick, 2006) in which initial data collection is primarily quantitative to develop a baseline understanding of a phenomenon, and followed this with interviews to provide richer data to build out initial understandings. In the first phase, we distributed an online exploratory questionnaire to ISErs across the state. The pilot questionnaire, developed, piloted, and revised in the spring of 2020, consisted of 57 items representing a mix of closed-response, open-response, five-point Likert- type scales (strongly agree to strongly disagree, with an open-response item "Would you like to tell us anything else" at the end of each item set), and item ranking (Appendix A). Items were developed based on literature on ISEr practice, teacher-ISEr partnerships, and the lived experience of the two authors with ISEr backgrounds. The questionnaire was distributed to a small number of educators who provided feedback on item clarity, and then items and scales were revised. Due to the limited scope of the questionnaire, and its chief role in eliciting patterns to follow up on in the interviews, it was not validated, and psychometrics were not calculated.

The questionnaire provided insight into two aspects of ISEr identity:

1. What ISErs value about their jobs and their goals for working with learners (e.g. an open response item "What do you love about your job?"; ranking items about the challenges of their job).
2. How ISErs position themselves in relation to their organization, the field, and teachers (e.g. Likert-type items on informal science and formal science techniques, whether they feel respected by teachers, and interactions with teachers).
3. How they relate to the NGSS and their relationships with teachers, in which 1 and 2 are enacted.

While questions on agency were included in the survey the responses did not yield fruitful insight, and are not included in the analysis.

At the end of the survey, participants could express interest in participating in a semi- structured interview of 30 – 45 minutes. The goal of the interviews was to expand upon questions included in the survey. The interview questions (Appendix B) addressed their motivations and goals as informal educators and how they perceived their work with teachers. Because of the pandemic, the interviews were conducted via Zoom or phone and were recorded and transcribed.

Participants

Survey invitations were sent to two environmental and outdoor education professional organization listservs, and to professional contacts and science museum contacts across the state. There were 153 responses. Due to the distribution method (listservs), the number of people who encountered the invitation is not known, therefore a response rate was not able to be calculated. Seventy-three responses were removed due to incomplete responses. Responses by K-12 teachers (n=7) were also removed. In the end, 73 responses were analyzed. Of those participants

who expressed interest in being interviewed, 12 were chosen using purposive sampling (Battaglia, 2008), "to produce a sample that can be logically assumed to be representative of the population" (Lavrakas, 2008). Interview participants were chosen to reflect as many of the work contexts represented in the surveys as possible (see Table 1). Teaching context and ability to participate in an interview were the only variables considered in participant selection. All participants and their places of work were anonymized to the greatest possible extent.

Survey participants represented 25% of the state's counties and were chiefly concentrated in metropolitan areas. Asked to describe their place of work, 37% of participants selected environmental education centers or nature centers, 11% museums and science centers, 11% government (state parks, conservation districts, municipal recycling, etc.), and 10% in zoos and aquaria. The remainder worked various other settings. The mean time employed in the field of ISE was 14.4 years, with a mean time at their current site of 9.0 years.

Data collection was impacted by our sampling methods (using listservs and emails) and pandemic conditions. We speculate that the overrepresentation of outdoor and environmental educators resulted from sending the survey to a large environmental and outdoor education professional listserv and the fact that outdoor education centers were more likely to be open during the COVID-19 pandemic than indoor education sites. In addition, when emailing museum, zoo, and aquaria sites, we received many automated responses that staff were furloughed due to the pandemic or the sites were closed. A large number of our survey and interview respondents were long-time ISErs, possibly because early-career educators were more likely to have been laid off or furloughed during the pandemic.

Table 1. Interview participant profiles

Name	Work setting	Self-identify as	Years in ISE
Susan	Garden	Naturalist	16-20
Matt	Museum	Educator	0-5
Kristen	Nature center	Environmental educator	6-10
Peter	Lake boating facility	Informal science educator	0-5
Sarah	Corporate community relations	Informal environmental educator	>25
Kayla	Nature center	Interpreter	6-10
Chris	State park	Interpreter	>25
Hannah	Afterschool	Volunteer Informal science educator	11-15
Sean	University research lab	Informal science educator	11-15
Ann	Farm	Educator	0-5
Lily	Education consultant	Environmental educator	11-15
Jill	Non-profit environmental organization	Informal science educator	11-15

Data Analysis

Data analysis took place in two stages. We first performed both quantitative and qualitative analysis of survey responses. Quantitative analysis took two forms: frequency of responses to Likert-type and multiple-choice items and analyzing ranked items. Additionally, open response items were open coded to look for patterns following the procedure described below.

Interview transcripts were then collaboratively hierarchically coded (Saldana, 2016) by the first two authors in two stages. In the first stage, categorical coding was based on a priori categories of questions from the interview protocol (e.g. NGSS, collaboration, work with teachers). After applying these categories, we

co-developed subordinate codes for those parent codes. Interviews were open coded by the first two authors for other codes relevant to the study. Through discussion, these smaller codes were collapsed into larger categories such as place and content (Saldana, 2016). After the importance of *place* and *content* categories (these terms will be expanded upon later) to educators became apparent, an additional round of collaborative coding was completed to look for further examples. Themes were established through discussion among the three authors of codes and categories in relation to our research questions. Codes and excerpts are available in Appendix A. Results

Here we present the results from this study framed by two critical components of identity. In each of these sections, we will address survey and interview responses which centered on work with teachers and learners in ways that reflect participants' values and positioning. The survey provided a baseline of information and broader patterns, while the interview data allowed for deeper discussion and exploration of those patterns. This allowed us to develop a fuller appreciation for the ways in which ISErs saw their work, the people with whom they interact, and the places they work, and thus their professional identity. We also address the significant ways in which place and content shape values expressed by study participants.

Values

Survey participants were asked to rank goals for their work with learners from one to six (Table 3), and were given the opportunity to elaborate on them. These goals reflect some of the values they hold with respect to the work they do – what is important for them to provide to learners.

Table 2. Percent of survey participants (n=73) who ranked each goal as 1st or 2nd in importance.

Goal "Learners will …"	*% ranked 1st or 2nd*
learn new things through fun and hands-on experiences.	80.82
have new hands-on experiences.	46.58
have fun	27.40
learn from someone that is knowledgeable about the topic.	19.18
develop new science practices.	16.44
meet one or more state standards.	9.59

Table 3. Percent of survey participants (n=73) who ranked each challenge of the job as 1st or 2nd most challenging.

Challenge	*% ranked 1st or 2nd*
Diversity and inclusion	50.68
The pay	42.47
Program enrollment or visitor levels	23.29
Supporting school curricula	21.92
Working conditions	17.81
Benefits	17.81
Other	15.07
Understanding how people learn science	10.96

The majority of respondents ranked "learn new things through fun and hands-on experiences" as their first goal. From these rankings, it was clear that the experiential nature of their work– including hands-on experiences – was important. A typical response was from a survey respondent who is an environmental educator at a watershed organization. They described what they value most about their job:

> I love working face-to-face with youth and families to help them have memorable hands- on experiences that we hope will help them feel closer and more connected to the watershed. I get the most joy out of my face-to-face work leading programming with groups.

Learners having fun was also an important goal for ISErs. Their perception of fun focused on engagement and motivation over entertainment. One interview participant, Lily, who identified as an environmental educator, expressed:

> By fun, I guess I don't mean like it's Chuck E Cheese partying, you know, I'm thinking about, did they create a memory? Did they make a memory that was different and will it stand out? So fun, I guess to me means like, is it a standout experience?

Values may also be represented in what is perceived as a challenge. In a question similar to the goals question described above, survey respondents were asked to rank the challenges of their work (Table 4). Diversity and inclusion was ranked first or second 50.69% of the time suggesting it is something they value. Diversity and inclusion was not defined in the instrument, but open responses focused mostly on urban-rural, racial, and socio-economic divides. Most saw it as a matter of representation, as expressed in this response:

Well, I work with a lot of inner-city kids. And still, when I'm going into their classroom, I'm a white woman, right? I'm trying to show them people who look like them. And it is hard, it is so hard to show them people that look like them. And

that is so important.

While another saw the issue of diversity and inclusion from a more structural perspective:

I think just having a voice at the table representing multiple types of people and that's race, inability, and socioeconomic status, I've found that in working nonprofits my entire life, the people that tend to hold these roles for any length of time without moving to another sector, tend to be people who are better off at home, have a spouse that makes a higher income to complement that work. And so the socioeconomic status of those people, and then those people making the majority of the decisions, they tend to kind of go hand in hand. We tend to, I've seen very few and I live and work within [City] and [City] and those are pretty diverse regions within this region. And there's just no people of color at the table. Our board, we try so hard to do community engagement, but we only have a few individuals who are people of color or anybody with any sort of disabilities, everybody's pretty affluent. It just doesn't seem like that voice is there at the table that needs to be. And when it is, it's almost like tokenism, and it's not intended to be, it just kind of rolls out that way, Thank and appears that way to the outside world, I would say as well.

Work with teachers

ISErs work with many groups and in many different formats (e.g., family programs, school field trips, professional development workshops). ISErs' work with teachers can be multifaceted, including informal interactions. The survey results showed that ISErs worked with teachers in a variety of ways (Table 5). When asked in a multiple response question how they have worked with teachers, the most common responses were informal interactions during visits, interacting with teachers during day-long workshops, and long-standing relationships with teachers. More in-depth, collaborative interactions such as co-developing curriculum, co-teaching and multi-day workshops were less common. However, ISErs were quick to note that they value many aspects

Table 4. Survey respondents' work with teachers (n=73)

Type of interaction	*% of participants*
Informal interactions during visits	94.52
Day-long workshops	60.27
Long-standing relationships	60.27
Short conference presentations	56.16

Co-developing curriculum	46.58
Co-teaching	39.73
Multi-day workshops	36.99
Other *	6.85
I don't interact with teachers	1.37

of their work with teachers. Many survey respondents said such work was important and leverage their own specialized knowledge, connecting it to the classroom. One interpreter at a nature center wrote:

> We always work to connect our program learning objectives to state standards and classroom goals while prioritizing the importance of place-based, outdoor and STEM- focused activities. It's my preference to work WITH formal teachers every step of the way and be the best resource for them and their students.

An environmental educator put it this way: "One of the main things I strive for as an informal science educator is to connect and extend what kids are learning in the classroom. I believe a strong relationship with teachers is integral to what I do." An informal science educator in a research lab offered that "I believe supporting teachers is one of the most important jobs I can do." A naturalist in a nature center wrote "I feel modeling teaching outdoors is very important to show classroom teachers. We need to get down on the ground or into the water to "really" show effective teaching. We need to get dirty, be passionate, excited."

Place and content

Across the interviews and analysis, two factors appeared which seemed to reflect ISErs' values regarding their work with K12 students and teachers – place and content. Place was treated as where they engaged in their work. Content referred to what their work was about and was considered broadly to include disciplines [e.g. physics], concepts [e.g. nature], and curriculum [e.g. STEM workforce, teacher learning], independent of where learning took place. Each of these influenced how ISErs saw themselves, their jobs, and what they see as uniquely important about what they do. These two factors were not mutually exclusive, but some educators privileged one over the other, while others emphasized both equally. These are represented on the axes of Figure 1.

Some educators (Group 1) identified the place they work as one of the most important factors contributing to their work. Significantly, place was not restricted to the physical environment, but was inclusive of the social environment, including co-workers. Individuals in this group mentioned content that they teach as important, but place appeared to be the primary driver of that content and what

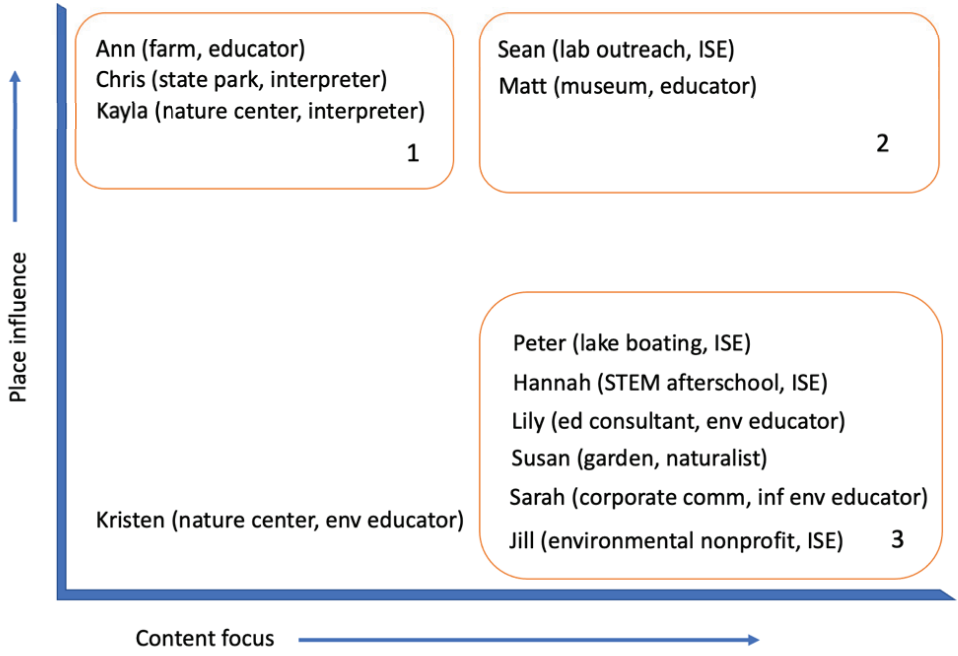

Figure 1. The extent to which participants prioritized place or content as a focus of their work illustrates professional values.

> Having the farm as a place that they can come and test out and learn about things that they're learning in the classroom that they can't see in real life, where they are in their community, makes it really strong. I mean, just the working farm aspect. They can explore a lot of scientific concepts and ideas there. So I think our place is amazing.

Other educators (Group 2) focused on the content of their teaching when discussing their work. This could be a topic such as physics, water quality, or waste management, or a concept such as nature, teacher learning, or the importance of a particular pedagogy. These educators described cognitive aspects of their work much more frequently than affective elements, and regularly noted that this work could be (and often was) done in many different spaces such as lakes, classrooms, outdoor spaces. This is how Peter, an ISEr who helped found a boat-based water quality monitoring program, spoke of how he addressed his goal to feed the STEM

pipeline with his work:

> Even though I think meteorology and probably groundwater and geology and a few other fields are even more critical than limnology, it's still one of the things that I hoped would be accomplished in doing this, is to introduce students to the idea that there are people who do real science outdoors in the environment, and that they're important.

A third group seemed to be driven equally by place and content. One educator did not provide enough detail in her interview to place her in any of the three groups and so was placed in the lower left quadrant of the graph. In the following paragraphs, we will highlight one educator from each of the three groups. These groups are not distinguished by having strict boundaries, but rather, by the extent of the foregrounding of the importance of place and content. Given the dynamic nature of identity and the role that values play in shaping it (e.g., Author 3, 2018), this lack of strict boundaries is not surprising; additionally, these influences can and do often shift with time and experience.

Group 1 - Focus on place

As can be seen in Figure 2, three interview participants were in this group. We focus on Chris in this section in order to give a detailed example of one specific participant who is an exemplar for a focus on place. Chris is a senior state park interpreter who has been in the ISE field for 30 years. He knew from a young age that he wanted a job in the outdoors and went to school to get a bachelor's degree in parks and recreation with an emphasis on interpretation. He worked at a county park and two other state parks before moving to his current park. This is the final state park he plans on working at "because there's nothing better than here." He mentioned frequently how important it is for the participants in his programming, both school and public, to get out to the park and experience the local ecosystem. Chris was particularly concerned with how the COVID-19 pandemic was affecting his ability to have people see the park's ecosystem in person and discussed how virtual programming was not the same because the participants were not there.

> You know, if I'm talking about the sand dunes here at Rolling Hills State Park, by golly, I want them to be here and see the sand dunes. Yeah, I can do a virtual – I can have video and show you the sand dunes. But it's not the same as actually being here, feeling, touching, seeing the real thing.

Chris has a strong connection to the park he works in and recognizes its unique affordances for the work that he does, using its assets to engage his participants in his programming. Chris is also aware of structural and societal problems both in his local community as well as at the park that he would like to be able to change. He mentions that schools have less funding for field trips than they used to, which in turn leads to fewer school groups coming to the park. He is also aware that the park does not have a very diverse visitor population or staff. To Chris, this is a problem because he knows the assets for learning that his particular place holds and wants them to be accessible to everyone.

Group 2 - Focus on content

Six interview participants seemed to prioritize content in their work (Figure 2). We highlight Jill here because of her focus on content and teacher relationships and lack of discussion of place.

Jill is an education director at a local environmental non-profit. She identifies as an ISE, having begun her career working directly with students at the same organization. As she moved up in the organization, her work shifted to a focus on teacher professional development. She works primarily with grade 6-12 teachers in offsite locations – local universities, county parks, and the school districts themselves. When asked about her goals and motivation, she said students should learn new things through fun and hands-on experiences because "....If it's not fun and engaging they won't retain the information," and that "...building environmental stewardship within our community and region and globally" is very important to her. Jill reports that a highlight of her work is "… becoming an expert in the material and helping to train others. That's been a huge highlight of it all, is helping bring others into this world and, and help them to understand the field and curriculum and the importance of environmental education in general."

The focus of Jill's work is working with and supporting teachers so they can teach about watersheds meaningfully. She reports that she is in touch with multiple teachers daily, and recognizes that they have a demanding job. She prides herself on the support she provides:

> I think a lot of people underestimate them and the work that they do. And I think it's important to understand where they're coming from and what their needs are. The biggest thing… I want to give them what they need without overwhelming admin and let them blossom.

Jill clearly values working with teachers and building relationships to support them in developing knowledge and teaching skills related to such issues as water quality:

> We really let them know that we understand how pressed for time they are, and we try to make ourselves as available as possible and tools for them as available as possible so that they don't have to put forth the effort of digging for specific activities or ideas.

Jill mentions the importance of working closely with teachers multiple times, yet she only mentions place twice – in terms of the watershed she works in and in contrasting the diversity in the major urban areas and its absence among the organization's board members. Her emphasis on teacher engagement is detached from place, perhaps due to the fact that she teaches in many places, none of which are tied directly to her organization.

Group 3 -Focus on both place and content

Two interview participants seemed to focus equally on place and content without prioritizing one over the other (Figure 2). Here we focus on Sean, an outreach specialist for a university physics facility, because he had a clear connection to the place that he worked as well as the content that workplace focused on. He

believed visitors would benefit from the unique affordances of the place as well as the interesting content that they would engage with. He has worked at the facility for fourteen years, after completing a PhD in physics and "catching the bug" for teaching while serving as an instructor at the college level.

Sean's identity is tightly tied to the facility in which he works – what he calls "world- class", that will soon be "the best in the world". He talks about all the ways the facility and campus afford his work – hosting tours, doing assessment with the university's College of Education, working with students to create a show at the adjacent planetarium, working with someone in Communications to create an app about his field of science, access to the public during the science festival. "I started, you know, seeking out experts on campus who could do something that I could not."

Yet he also expresses clear goals related to the content of the facility. When he talks about working with teachers, he mentions that he wants "… them to be evangelists for nuclear science, especially at [this] university." He talks about physics again when expressing frustration with NGSS, that physics is mostly covered in high school:

> … by the time they get to high school there, they have a pretty good idea of what they like and what they don't like, what they're probably going to get into. And so if I want to essentially convert some students into STEM and physics, then I need to be aiming younger. So that's for like middle school students, you can make it apply.

When asked about his goals for teaching, he talks about the limits of the one-off tours of the facility he provides and how he focuses on attitudes about science:

I can't expect to actually teach them anything. So, essentially my goal in outreach is changing attitudes. And so attitudes, you know, a lot of things can stem from that afterwards. Right? If I can bring them in and say, here's what nuclear science or science in general looks like, and they can come out and say, 'Oh, that's something I'm really interested in.' … it starts with, can I show them something they care about and that they get excited about? Thus, both place and content play strong roles in how Sean sees himself and his work. While Sean seems similar to Jill in their discussion of engagement, the focus on social and material resources of the facility in which he works is absent from Jill's discussion which focuses on the importance of "fun" as a vehicle for engagement with the content. Sean's access to the resources of his workplace and campus are integrated into his daily work that it is clear he values it highly, but this is absent from Jill's conversation.

Positioning

Positioning refers to how an educator narrates themselves and their interactions in relation to others in the same community as well as how others do the same with respect to the individual. This can be in alignment with the sociocultural system or in opposition to it. We looked at positioning in several ways. In the survey, participants were asked how they describe themselves professionally (Table 5). Participants worked in a variety of contexts, with the greatest percentage at nature or environmental education centers. We also analyzed survey data for shared perspectives on teacher collaboration, understanding of the nature and importance of

Table 5. Survey responses to "I identify as…" (n=73)

Identity	*% of participants*
Environmental Educator	27.40
Educator	19.18
ISE	19.18
Naturalist	16.44
Interpreter	6.85
Other*	4.11
Director	4.11
Teacher	2.74

* Depends on audience, non-formal educator, and conservation education program coordinator

NGSS, their views of the importance of the place they work and the content they address in that work. Items that illustrated their positioning are shared below (Table 6). Overall, ISErs viewed their work as just as important as school learning; however, they also viewed this work as distinct from that of classroom teachers. As one respondent, a naturalist who has worked at an environmental education center, wrote in the survey:

> Science-oriented, outdoor learning is the emphasis of all the programs I develop and lead at my facility. This offers program participants a way to directly observe and experience nature in a way that augments what they learn in their indoor classrooms at school. I regularly and very intentionally tie in science concepts/terms to the outdoor program experience for school groups.

An ISEr who works at a science center wrote:

> Nothing of what I do can completely replace formal education; however, informal education has its own way of engaging learners that is sometimes lost in the formal education setting. Informal education almost looks at learning from a completely different lens. Our goals and assessment are measured in different ways and allows forlearners to achieve success in ways that aren't done in the classroom.

Work with teachers

ISEr responses to questions about how they position themselves in relation to teachers were also analyzed (Table 6). When considering the statement "my skills and teachers' skills complement each other," and ranking from strongly agree (1) to strongly disagree (5), 97.26% chose strongly agree or agree. In an interview, Hannah, an ISEr who runs an after-school STEM program said:

> Well, the teachers have the know-it-all about how to get the information into the kids and that classroom management. Classroom management is a huge, huge part of anything dealing with kids, right. And that part they hold for me, I cannot do classroom management, I just don't have that skill.

Table 6. Responses to identity-related survey items. (n=73) (1 = Strongly Agree, 3 = Neither Agree nor Disagree, 5 = Strongly Disagree)

In relation to teachers	Mode	Median
My skills and teachers' skills complement each other.	1	1
I feel respected for my professional knowledge when working with teachers.	1	1
What I teach in my role is unconnected to what students learn in school.	5	5
What I teach in my role is more important than what is taught in school.	3	3
I have a strong understanding of how people learn.	1	1
I have a strong understanding of pedagogy.	1	1
The same methods are effective in classroom settings and at my site.	3	3
My skills and teachers' skills complement each other.	1	1
Organization related		
I choose what I teach in my programs.	2	2

Educator is part of how I see myself professionally.	1	1
I intend to stay in this career long-term.	1	1
I feel respected for my skills by the upper management of my organization.	1	2
I have opportunities to better my professional education skills.	2	2
There are opportunities to advance professionally in my organization.	2	2

In addition, 93.15% of ISErs chose strongly agree or agree when considering the statement "I feel respected for my professional knowledge when working with teachers". On the other hand, when considering the statement "teachers lack knowledge of informal science education," the responses were spread more evenly between agree to disagree, with the most common answer being agree (46.58%). In open responses at the end of this question, a common thread emerged – "it depends." Some teachers participated in field trips, some did not, some respected ISErs, and some did not. One educator at an interpretive center described the lack of respect they sometimes encounter thus:

> Some respect what knowledge our staff and I have to offer while others don't think we know how children learn outside a formal classroom. Even our own university education students don't quite believe what we do requires training and skill. After nearly 30 years in this profession, I can tell you it isn't just something anyone can do well and there are a variety of strategies and techniques that are effective for a variety of audiences.

In interviews, we asked participants what their ideal collaboration with teachers would look like. There was a sense that they had much to offer to teachers as learners, narrating themselves as educators for other professionals and in doing so, positioning themselves in a particular way.

Many ISErs noted specific teacher outcomes in their work. Initially, we assigned different outcomes distinct codes, then noticed a pattern of particular content-related outcomes when we looked across participants and so created a new parent code for outcomes. For example, some of the distinct codes included that ISErs wanted teachers to come away with more knowledge of how to teach in the outdoors, to develop science communication skills, develop more environmental awareness, or develop science content knowledge more generally. However, when looking across ISErs who focused on teacher outcomes in general, we saw a pattern of ISErs positioning themselves as educators with the expertise to support teachers in achieving such outcomes. When asked about teacher knowledge in the survey, many respondents saw teachers as lacking knowledge in some areas. However, they also viewed classroom educators as having specialized knowledge they

did not have, and sometimes complementary to the specialized knowledge they did possess. An additional thread that emerged was a desire for building longer-term relationships with teachers. For example, Jill expressed that relationship building was extremely important in her work with teachers and that building long-term relationships took a lot of work. She stated that relationship building required

Constant contact, even if it's just checking in or we're doing like right now, we're doing virtual coffee hours and things like that, so that they can meet with teachers from other schools and air their grievances and collaborate with one another and just giving them some open space, but not requiring it in any way.

Similarly, when talking about a specific program that they were developing along with a school district, Matt, a museum educator, said that he was "hoping to have that expand to be at least a multi-day program, if not a week-long program."

When asked what constraints prevent these ideal collaborations, ISErs identified lack of time both in their own and teachers' schedules. Many participants noted the large workloads that teachers have and that informal science experiences are often not a priority. Other ISErs had the perspective that informal science experiences were not a priority because teachers did not see the value in those experiences. For example, as Peter noted:

> You have lots of teachers and administrators in schools who themselves did not have these kinds of experiences and because they never had that experience, they don't recognize the value of it or how they could leverage such an experience to really do more and better education. And they think of, they tend to think of it therefore as being, you know, a fun outing, you know, or a fluff or something insignificant. And that would cause them to not want to do it.

Discussion

The results from this study provide insight into two components of professional identity: values and positioning. Here we will discuss each of these through the lenses of participant reflections about working with teachers, and alignment with place and content – before turning to possible avenues for investigating agency, the third shaping influence of identity.

ISErs' Perceptions of Working with Teachers

Because of the importance and potential of ISErs working with teachers to build a stronger science learning ecosystem, it is key that we understand their current relationships with teachers. Most of the ISErs responding to the survey worked with teachers, reflecting national trends (Collins, et al., 2020). Generally, ISErs felt that their skills and teachers' skills complemented each other. They also expressed the desire to have longer-term collaborations. However, these more meaningful collaborations also require more time, which was the primary constraint that ISErs noted for teachers and for themselves. Many of our interview participants also felt that such collaboration was not a priority for teachers, either because they have too much on their plate already or because they don't value informal learning. Many also felt that teachers were lacking in some specific skills or knowledge that ISErs

could provide. It is clear that working with teachers is something that many of the ISErs in the study value, and that providing learning experiences aligns with their organizations' values as well, which implies that they may also experience more agency as a result of engaging in that work. This desire for long-term collaboration with teachers has implications for building the types of partnerships called for in the literature (e.g. Hofstein & Rosenfeld, 1996; NRC, 2015; Stocklmayer, Rennie, & Gilbert, 2010).

Survey comments point to ISEr acknowledgement of the ways that teachers are different from themselves and reference ISErs' own lack of understanding of the life of a teacher. When asked about collaboration with teachers, interview participants often phrased it as what they could provide for teachers, as opposed to what they might learn from such partnerships. This may stem from a lack of prior collaborative experiences or a view of teachers as only one of the many audiences for whom they provide programming. They clearly valued the types of experiences they provide for students, and considered their role as equally important as that of teachers, but also distinct. ISErs positioned themselves as providers of complementary knowledge and experiences. This has implications for how ISErs might view their role and teachers' role in building partnerships that could leverage different kinds of students learning across the science education ecosystem. Avraamidou (2015) has shown that ISE experiences for pre-service teachers have a positive effect on their understanding of science and, learning related to inquiry-based science, and connecting it to their students' lives, all of which are afforded by ISE settings and educators.

Despite the generally positive feelings about collaborating with teachers, ISErs also were aware that they sometimes have different professional priorities. ISErs noted that many of the constraints they observed also depended on the districts, schools, or individual teachers they were working with and could also be found in their own organizations. Further work that focuses on relationships between teachers and ISErs, as well as on organizational affordances/constraints may help in building mutually beneficial partnerships among ISErs, teachers and the systems in which they work to better serve students throughout the science learning ecosystem.

The Role of Place and Content in the Formation of ISEr Professional Identity

During our analyses, we found that among interview participants there were two forces at work in shaping views of the nature of work and motivation to work in the informal education field: the physical and social context (place) and, in a broad sense, the science content. In our study, the extent to which each of these two elements played a central role in participants' perspectives yielded a three-part typology: place-focused, content-focused, and a third group guided by both. Walker (2007) discussed the influence of physical place on identity formation, but place goes beyond physical parameters and involves culture, history, and social interaction (e.g., Lin & Lockwood, 2014; Tuan, 1979). Much like identity, then, place is constantly "under development".

What is it about place and content that contribute to identity? As we noted

previously, this sample was largely made up of environmental educators, and for many of these individuals, aspects of their work site fundamentally shape their daily work, which requires that they have a strong sense of place, both cognitively and affectively (e.g., Ardoin, 2006). Additionally, ISE contexts provide unique opportunities for an embodied sense-making that uses learners' physicality as well as interactions with both the physical and social components of the place (Shaby & Vedder-Weiss, 2021). This resonates with work on teacher identity which has illustrated the importance of physical, social, and cultural context or place in shaping the way these professionals see themselves in relation to others and how they move and interact within their professional spaces.

In contrast, ISErs in the content-focused group worked across multiple sites (such as visiting various classrooms), and either did not require making strong connections between a place and the learners they work with, or expressed high value for work that was not place- centered (e.g., helping students enter and navigate the STEM pipeline). ISErs' emphasis on the value of place or content present different opportunities for what they choose to do in their work with students and teachers. An ISEr may reinforce this value by choosing teaching activities that reflect that value, and successful engagement with such activities can contribute to a sense of agency. A farm educator who values the place that they teach and its affordances for unique experiences may ensure that the students they work with have a chance to hold chicks or to harvest carrots. A content-oriented ISEr may ensure that their students learn about water quality or STEM careers in any setting. Those educators in the third group, which balanced content and place, may negotiate the two constantly and choose activities that reflect the connection between the content they teach and the place they teach it. Both ISErs emphasized the social aspects of place in their interviews, so they may bring in content experts from their organization as part of their instruction.

Millions of children visit a variety of ISE sites in the U.S. each year yet little has been done to understand the ISErs who work with them. By identifying the strong influence of place and content on professional identity, the research reported here begins to build that knowledge base. Increased understanding of how ISErs see themselves in relation to their lives and intent, their work contexts, and the learners they interact with can help us understand the work they do with children, families, adults and, of most interest here, teachers. This can then lead to more effective professional learning design, and facilitate strong and sustainable collaborations with other educators in or out of school.

Limitations

While the research described here provides initial insights into the professional identity of ISErs, and how they work with teachers there also are limitations that should be addressed in further work. As described in the Methods section, study participants were not necessarily representative of the larger ISEr population. In addition, the study was conducted during a pandemic, so responses may have been influenced by the stress and conditions of insecure employment that resulted. Finally, the recruitment materials invited "informal science educators" which may not enroll people doing ISE work who do not think of themselves as educators.

Future Research

Now that we have a greater understanding of ISErs' values and positioning, we can better investigate how they see work-related challenges, decisions they make to address these and the outcome of these decisions, i.e., agency, as well as the nature of the relationship of these decisions to existing values and positioning. If an ISEr works in organizations whose values do not align with their own, might they have less agency, and be more likely to leave the organization or the profession? This has been documented for teachers (Dunn, 2018; Heikonen, et al., 2017; Author 3, 2022) and we might expect to see parallels among ISErs. Which types of decisions that ISErs make (Tran, 2007) can lead to greater agency? We hope to investigate these questions more deeply in the next study. In support of our finding regarding ISErs' perceived challenges of the field, Ennes, et al. (2020) also found that ISErs had low self-efficacy with regards to diversity and inclusion. As this issue gains momentum in ISE, it bears study to better understand ISEr agency with regards to diversity and inclusion.

This work has revealed several aspects of ISEr work and perspectives which shape their professional identity. It also has led us to several more questions that warrant further study. First, given the dynamic nature of both place and of identity, does an orientation towards place or content persist across a career or in different settings? If an ISEr shifts working context from one that emphasizes place to one that privileges content, does their understanding of their work with students, teachers, and partners shift as well? Additionally, it would be useful to investigate whether these ISEr groups hold different epistemologies, that is, whether there is a fundamental difference in how the three groups view knowledge and learning. For example, do they see learning as situated or as a linear process separated from context? Lastly, a fruitful area of related inquiry might be to explore whether these influences are present in non-K12 work done by ISErs. All of these areas of inquiry are likely to yield a greater understanding of both how ISErs teach and learn; knowledge of these practices and processes might also inform the development of effective partnerships with classroom educators.

Conclusion

Just as ISErs saw their knowledge and skills as complementary to that of teachers, we see their values, goals, and experiences also as complementary. This complementarity can be leveraged to improve both PD and practice across the STEM learning ecosystem (Allen, Brown, & Noam, 2020; Hecht & Crowley, 2020). For example, when providing PD opportunities to informal audiences, of which educators in this study reported a dearth, it would be wise to take into account the values (such as the importance of place or content or engaging hands-on instruction) of the ISErs and aligning instruction with them. The values that ISErs place on "doing science" which are so prominent in the context in which they work can be leveraged so that connections to not only the science and engineering practices of the NGSS (NRC, 2015) but to the cross- cutting concepts and disciplinary core ideas can help them move towards 3-D instruction that is congruent with their identity.

Establishing long-term partnerships between schools/districts and ISE providers can be informed by the research presented here. Well-constructed partnerships

which take into account the values and positioning of both sets of stakeholders would benefit ISErs, teachers, and learners. Such partnerships can open up other possibilities for more meaningful engagement with the NGSS, and create opportunities for thoughtful connections between conceptual learning in the classroom and the field and community. Joint sustained PD that engages the positioning and values of both groups of educators in a community of practice (Lave & Wenger, 1991) can lead to a well-integrated learning ecosystem for students and their families. ISErs' expertise fostering affective and motivational goals for a wide range of learners can provide mentoring for teachers who struggle with those matters.

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Appendix A. Sample codes with excerpts

Content Educators emphasize what they teach as important to their work		
Place-based ed	Educator emphasizes that their work is about place-based education, referring to it as a concept	I realized that place-based education, outdoor environmental education is really my passion. And it's two-fold. One is teachers are not taught to teach this way in pre-service teaching anymore - you're not taught to take students outside and those skills are not taught.
Science discipline	Educator emphasizes that their work is about a specific science discipline	I want them to be evangelists for nuclear science, especially at [University].
Career possibilities	Educator emphasizes that their work is about exposing students to career possibilities	it's still one of the things that I hoped would be accomplished in doing this is to introduce students to the idea that there are people who do real science outdoors in the environment, um, and that they have that they're important
Place Educators emphasize the place they work as key to their work		
Place - social	Educators mention social components of place as unique or meaningful	I started, you know, seeking out, uh, experts on campus who could do something that, that I could not… And I said, Hey, you make games. I got nuclear science, let's make a game. And now it exists… anybody can download it for free.
Place - Physical	Educators mention physical components of place as unique or meaningful	So I think the kids is like the main thing is just getting to see them learning, and see them so excited about being at the farm. And I think that's what, a place like the [Farm] itself is … there's so much there that they don't get to see in their regular lives, but it's like so profound for them.
Value – Goals Their goals for student learning		
experience	Goal for student learning is for them to have a meaningful experience	Just having that that great introduction, where you have the gigantic elephant toothpastes experiment going off, or you see a butterfly emerging from the chrysalis for the first time. And knowing that you're doing science and that it's something cool, but just really having that really fun, kind of gateway experience into learning about all the different facets of it.

fun	Goal for student learning is for them to have fun	Okay, how do I view my program with students and the teachers, okay. Number one, they have to have fun. they'll remember more if they have fun… But this is an educational fun, this isn't recess fun. This isn't just time to run around and do whatever you want to do. This is a fun time for education.
fun and hands-on	Goal for student learning is for them to have fun and experience hands-on	if it's not fun and engaging, they won't retain the information. It's really the long and, the short of it is it, you know, it has to be exciting or they don't want to do it if it's too much like your typical classroom schoolwork
to connect to classroom	Goal for student learning is to connect ISE earning to classroom	Our dream is to be able to know what they're doing in the classroom, so we can really extend what they're doing in the classroom and not just make it like a tour of the farm, but like extend what they're doing.
Positioning –Work with teachers* What they do in their work with teachers and how they regard them		
developing relationships	In their work with teachers, they focus on building relationships with teachers	There are several [teachers] that I've had sort of long-term relationship, over the years, they've come to my program. They brought their students, we've done a variety of things with them and they have been really great evangelists for us.
disengaged	In their work with teachers, they have noticed some teachers are disengaged	the teachers aren't really paying attention to what I'm doing. So, so since they're not paying attention to what I'm doing, um, I just feel neutral about it. For the most part, those examples I gave of like the teacher, you know, talking about vocabulary in the classroom, bringing it back. That's, that's a very rare happening.
training	In their work with teachers, they do mostly teacher trainings	I train teachers on how to implement cross-curricular, um, watershed quality monitoring sixth grade through 12th grade format. So a lot of my stuff has to do with teacher training.

Gatekeepers to Science and Engineering

Informal Science and Engineering Educator Roles in Positioning and Recognizing Girls' Identity Performances

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Abstract

Girls and women are underrepresented in many science and engineering fields. The gender stereotypes associated with who belongs in science and engineering (SE) disciplines are one of the reasons for this underrepresentation. Research on formal SE classrooms has shown how these stereotypes negatively affect educators' positioning and recognition of girls as science and engineering learners. Informal SE education (ISEE) programs have shown promise for confronting stereotypes and creating environments for girls to develop SE identities based on improved interest and sense of belonging in SE. Yet, few studies have focused on the role of educators in these ISEE spaces both in terms of how they recognize girls but also the ways they position girls to perform their SE identities. To address this gap, we examine how ISE educators in two summer camps enact and implement activities that engage girls in the "doing of science" and the "doing of engineering". Educators built on the inherent social contexts of the respective camps and gave girls the opportunity to negotiate their roles as scientists and engineers. We observed the girls engaging in collective sensemaking, initially modeled by the educators and eventually led by the girls, which mirrors the collaborative work of scientists and engineers. We also highlight a continuous feedback loop wherein educator positioning and recognition elicited SE performances and resulted in more opportunities for girls to engage in the practices of science and engineering and build their SE identity development.

Key Words: Science and Engineering Identity, Educator Positioning, Girls, Informal Science and Engineering Education

Introduction

In the United States, calls to reform science, technology, engineering, and mathematics (STEM) education have focused on building the STEM workforce through science education (National Research Council [NRC], 2011; 2012; 2015). K-12

science education reforms call for the preparation of all students to become proficient in science (i.e., sensemaking to construct and refine explanations about phenomena; Hutchinson & Hammer, 2010) and engineering (i.e., iteratively designing and refining solutions to problems; Cunningham & Kelly, 2017; NGSS Lead States, 2013; NRC, 2012). To address the needs of our society, there have also been calls to attend to marginalized populations that have historically been underrepresented in STEM, including girls, women, and people of color (Bell et al., 2017; National Science Foundation [NSF], 2021).

Women hold less than one-third of STEM jobs despite representing 50% of the US population (NSF, 2021; US Census Bureau, 2019). The underrepresentation of women has multiple causes, but one of these is the decline in science and engineering (SE) interest due to perceptions that these fields do not relate to their lives and because they do not see a place to succeed in these male dominated fields (Authors, XXXX; Joseph et al., 2017; King & Pringle, 2018). The stereotypes that portray SE as unwelcoming and irrelevant begin as early as elementary school (Archer et al., 2017; Carlone et al., 2014; Tan et al., 2013). In order for girls and women to become and stay interested in SE and see themselves as potential scientists and engineers, they need to develop SE identities during their formative years (Allen & Eisenhart, 2017; Kang et al., 2019).

We define SE identity as one's interest and sense of belonging in SE based on their growing sense of competence developed through opportunities to perform and to be recognized for doing the work of scientists and engineers (Calabrese Barton et al., 2013; Carlone & Johnson, 2007; Carlone et al., 2014). This definition is a combination of Carlone and Johnson's conception of science identity as a continuous cycle of performance and recognition of science competences spurred on by interest, along with the resulting sense of belonging that has been highlighted by Calabrese Barton et al. (2013). Recognition has been found to be a valuable piece to SE identity formation and has traditionally been studied as coming from formal classroom teachers and family members (Authors, XXXX; Carlone et al., 2014). But for many girls, stereotypes associated with gender and race affect their perceptions of who belongs in SE. These same stereotypes lead teachers to position girls differently or not at all and/or recognize the SE competence of boys in more supportive ways than girls (Archer et al., 2015; Collins, 2018). This in turn makes it more difficult for girls to develop SE identities.

Literature Review

Both formal and informal educators are often the first gatekeepers to SE for youth because they are the adults who introduce youth to science and engineering and what constitutes the *doing of science* and/or the *doing of engineering*. Research has indicated that participation in informal science and engineering education (ISEE) programs in elementary and middle school, can positively influence girls' and women's SE identity development (Chan et al., 2020; Ferguson & Martin-Dunlop, 2021). ISEE spaces can offer participating youth opportunities to see the relevance of SE to their lives and to engage in authentic SE practices, increase their interest in SE, and make them feel like they belong (Calabrese Barton et al., 2013; Carlone et al., 2015; Kim et al., 2018; Pattison et al., 2020). Consequently, educators have the power to strengthen or diminish girls' SE identities through their position-

ing and recognition of these performances, consequently, shaping how they are viewed by others and how they view themselves (Calabrese Barton et al., 2013; Carlone et al., 2015; Davies & Harré, 1999; Tan et al., 2013).

Research that has focused on girls' SE identity work in ISEE spaces has typically referenced positioning from the perspective of the girls – i.e., how girls are positioned by the norms and structures of the space and how they position themselves within these spaces (for science see, Calabrese Barton et al., 2013; Carlone et al., 2015; for engineering see, Pattison et al., 2020). When these authors reference the role of the educator in girls' identity work, they usually do so in the context of recognition. These studies help us to understand girls' SE identity development but call for a stronger understanding of how ISE educators' positioning and recognition influence girls' performances (i.e., their identity work). Our study addresses this gap.

Conceptual Framework: Positioning and Recognition in the Ways of Doing Science and Doing Engineering

SE identity development is both a reflection of how one perceives, positions, and aligns oneself within a discipline, and how one is perceived and recognized by meaningful others (Calabrese Barton et al., 2013; Carlone & Johnson, 2007; Collins, 2018). In order for girls to identify as science and/or engineering people, they must have opportunities to do the work of scientists and engineers (Calabrese Barton et al., 2013). Consequently, it is important define educator positioning and recognition. Both positioning and recognition occur within social contexts like ISEE spaces where educators and youth are negotiating roles (van Langenhove & Harre, 1999). During these negotiations, educators can position youth as scientists through opportunities wherein youth are producing and assessing knowledge (Berland et al., 2015; NGSS Lead States, 2013; NRC, 2012) and as engineers through opportunities to design, build, and test prototypes to assess the success of their design solution (Cunningham & Kelly, 2017; NGSS Lead States, 2013; NRC, 2012). Inherent in positioning are dynamics of power in which those doing the positioning – educators as gatekeepers – can have a stronger influence than others based on their perceived authority. Educators can position certain youth and ways of knowing as more important based on the types of activities they choose to implement in their class/programs, the design of the activity, the framing of the activities, and how and who they acknowledge during the activity (Archer et al., 2015; Bell et al., 2017; Berland et al., 2016; Collins, 2018).

Recognition is intricately linked to positioning (Calabrese Barton et al., 2013; Carlone et al., 2015; Tan et al., 2013). How one is recognized and by whom for their SE performance in a positioning event can support or constrain one's views of themselves as a scientist or engineer, how they choose to act in future SE events, and how they interact with others during those SE events. The purpose of our study is to understand how ISE educators' positioning and recognition during moments of doing science and engineering create opportunities for girls' SE identity work in a science summer camp and an engineering summer camp. This study was guided by the following research questions:

1. How do educators position girls during tasks to engage them in the work

of scientists and engineers?
2. What are the types of recognition that occur during these moments?

Methods

To answer our research questions, we chose a case study approach (Creswell & Poth, 2018). Initially, the two cases were two all-girls middle school summer camps held the summer of 2018: (1) the Marine Science Camp (MSC) which had a science focus and (2) the Explorations in Engineering (EiE) camp which had an engineering focus. (The names of programs and all people have been changed to pseudonyms, and the study has been approved by our institution's Human Subjects Board). Both camps were free to participants and advertised to students living in the nearby area. The programs both had the term "girls" in the title of the camp. On the application, individuals could self-select their gender category among options of male, female, and would prefer to specify. All participants in both of these camps selected "female". The purpose of both camps was to support girls, as underrepresented groups in STEM: (1) to engage in science and engineering activities; (2) to expose participants to female role models in science and engineering; and (3) to develop their confidence and competence in science and engineering. The participating girls were asked to complete video diaries on the first and last day of the program that lasted between 15 and 55 seconds. On the first day they were asked why they signed up for the camp and what career they were most interested in. On the last day, they were asked what their favorite part of the camp was and if the camp had changed their career interest. For the MSC camp, the pre and post video diaries show that of the 20 campers, 14 (70%) said that the camp increased their interest in SE careers and the remaining six (30%) said that the camp maintained their interest in marine science. For the EiE camp, the pre and post video diaries show that of the eight campers, three (38%) said that the camp increased their interest in SE careers, five (64%) said the camp maintained their interest in engineering or STEM. This improved interest and maintenance of interest were indicators of improved science identity or at least maintained interest during the camp.

To better understand what was occurring to create these changes and/or maintain interest in the girls we examined 40 hours of video footage from both camps. The cameras were placed at locations on the edges of the rooms to capture the entire space and to avoid being in the way of camp activities. The first author was a participant observer at the MSC and the second author was a participant observer at the EiE camp. As participant observers, we jotted down notes related to the physical structure of the room, educator positioning, girls' performances, and the recognition these performances received.

To better describe the positioning and recognition of educators we chose to select a science and an engineering activity (from launch to debrief) from each camp wherein the girls were engaged in the doing of science and the doing of engineering respectively. To define activities as doing of science and doing of engineering, we were guided by Tekkumru-Kisa and her colleagues (2015; 2020) concept of "tasks", ambiguous activities that ask students to use disciplinary knowledge while engaging in disciplinary practices (Tekkumru-Kisa et al., 2020). The implementation of rigorous science or engineering activities (i.e., tasks), positions girls

to take on the role of scientists and engineers and engage in disciplinary ways of doing, which is crucial for identity development (Calabrese Barton et al., 2013). In their work, Tekkumru-Kisa and her colleagues defined tasks – which we refer to as activities - as meaningful chunks of classroom activities (from introduction to debrief) that focus the researcher on the structure of the task and the quality of teaching and learning enacted during the task. Examining these activities from introduction to debrief helped us to identify and focus on educators' positioning and recognition during moments wherein students were engaging in cognitively demanding work that promoted learning and identity development, which we define as the disciplinary ways of doing science and/or engineering (Nasir, 2002; Tekkumru-Kisa et al., 2015; 2020). We selected one activity from each camp that served as an exemplary case because it was an example of doing science or engineering and because of the amount of dialogue present within the activity that provided the discourse between the girls and the educator(s) allowing us to answer our research questions.

Identifying Activities Aligned with the Doing of Science and Engineering

There were three stages to our analysis that led to our final case selection. During Stage 1, we used our notes from the observations, and the video recordings to select activities where we observed girls "doing the work" of scientists (Berland et al., 2016) or engineers (Cunningham & Kelly, 2017). Activities that did not fall into this category were those in which students were engaged in getting to know each other, mentor presentations, and field trips/tours. The final list and description of the identified science/engineering activities can be found in Table 1.

Table 1: Description of Doing Science/Engineering Activities

Marine Science Camp		
Name of Activity	Description	IQA Scores (Rigor of Design/ Launch/Implementation/Discussion)
1. Core Sampling	Day 1. Girls were given a "core sample" (e.g., sand and clay) made by the educator and asked to identify layers.	(4/4/4/5)
2. Who Messed with the Nest	Day 1. Girls were asked to solve the mystery of who messed with the sea turtle nest by collecting data from the site.	(4/4/4/4)

3. Floating Rainbow	Day 2. Girls used the density to create a "rainbow" in a glass (distinct layers of water using heat, cold, salt, and food coloring).	(4/4/4/4)
4. Snook Water Needs	Day 2. Girls tested three water samples for various parameters to determine which area would be the best nursery for baby snook.	(4/4/4/4)
5. Animal Stranding	Day 3. Girls were given data (e.g., lab results, pictures) about a dolphin or manatee stranding and asked to determine cause.	(5/5/5/5)
6. Calculating Wave Speed	Day 4. Girls solved for speed, given the frequency and wavelength. The compared their answer to the computer simulation.	(2/2/2/NA)
7. Dough Creatures	Day 4. Girls were asked to use circuits to design a marine animal (real or imagined) that had multiple LED bulbs that lit up.	(2/2/1/NA)
8. Shark Movement	Day 4. Girls were given accelerometer shark data movements and asked to infer/present what their shark was doing.	(5/5/5/4)
9. Communicating a Prototype	Day 5. In pairs, girls designed a written prototype and then worked to create prototypes based on other pairs' descriptions.	(5/5/5/4)
Explorations in Engineering Camp		
1. Grab-n-Go	Day 1. Girls built a mechanical arm that could be operated by one person to pick up and return a weighted paper cup that was one foot away without damaging the arm.	(5/5/5/4)

2. Deep Sea Diver	Day 1. Girls engaged in the engineering process by designing, building and testing a "diver" that was neutrally buoyant in a column of water.	(5/5/5/4)
3. Wetlands Band	Day 1. Girls created an instrument from everyday materials (e.g., sticks, balloons, and rubber bands) that sounded like a wetland animal of their choosing.	(5/4/3/0)
4. Dough Creatures	Day 2. Girls created simple circuit creatures that would light up using dough, wires, lights and batteries.	(5/5/4/2)
5. Locker Lights	Day 2. Girls created a locker decoration that used a simple circuit using common materials such as tape and paper.	(5/5/5/NA)
6. Twirling in the Breeze	Day 2.Girls created a device that would act as an anemometer and to come up with a way to use that device to measure wind speed.	(5/4/4/3)

During Stage 2, we examined the activities in more detail using the Instructional Quality Assessment – Science Observation Rubric (IQA-SOR; Tekkumru-Kisa et al., 2020) to determine how each educator positioned youth in the doing of science/engineering. According to the IQA-SOR, activities are divided into four phases: Phase 1: design, the potential of the activity for intellectual work; Phase 2: launch, the educator's launch of the intellectual work; Phase 3: implementation of students' actual intellectual work that occurs during the enactment of the activity; and Phase 4: debrief, the discussion in the whole group debrief wherein students' explanations of their sensemaking are grounded in their work and evident through their arguments. We assessed the rigor of design for each activity based on our position as participant observers. For Phases 2 through 4, we assessed the rigor by examining the launch and debrief phases in our videos focusing on the educators' positioning of doing science and/or engineering identity work and the youths' related performances along with the educators' recognition of these identity work performances. The enactment of activities in both camps began with an introduction (or launch), which was followed by the implementation in small groups and then a whole group debrief facilitated by the educator.

Using the IQA-SOR we analyzed videos and assigned numbers to each phase based on the cognitive rigor, ranging from 0 to 5. Higher IQA-SOR scores or more

rigorous tasks (4 and 5) align with the ways of doing science and engineering and lower scores (0 to 3) align with more traditional ways of learning that are not considered the doing of SE (i.e., rote memorization, following steps to an expected outcome) (Berland et al., 2016). We rated the four phases of each camp activity separately and then met to watch the video segments together to determine if our rationale and observations made sense to the other author. We reached consensus on these ratings after discussion and we used the consensus IQA-SOR scores to determine which activities to examine more thoroughly in our Stage 3 analysis. These activities and their IQA-SOR scores (nine activities in the MSC and the six activities in the EiE camp) can be found in Table 1.

Analysis of Positioning, Performance, and Recognition

During Stage 3 of our analysis, we focused on the launch and debrief sections of the activities. These sections provided rich opportunities to explore the educators' positioning of the girls as SE people and the resulting performances and recognition events that occurred therein. Due to the locations of our cameras, we were not able to capture conversations at individual tables (in small groups) during the implementation phase but the whole group debrief could be captured giving us a reliable source of data to derive conclusions on recognition. We admit that recognition does occur and influence SE identity work in small groups, however, we were not able to capture those conversations. To guide our analysis, we developed codes based on each iteration of analysis. Initially, we started with three broad parent codes: educator's positioning for the doing of SE; SE performance by youth, and SE recognition by educators. We used the NGSS' and others' definitions (Berland et al., 2016; Cunningham & Kelly, 2017) of doing science and engineering (e.g., clarifying what counts as data, sensemaking, communicating your explanation). Our code book can be found in Table 2.

Table 2: Code book

Codes	Descriptions
Positioning for	**Science fact inside content knowledge:** factual content learned in the camp **Science fact outside content knowledge:** factual content outside of camp **Epistemological knowledge inside camp:** describing how scientists and engineers do their work learned inside camp **Epistemological knowledge outside camp:** describing how scientists and engineers do their work learned outside camp **Inclusive positioning:** when the educator gives girls the opportunity to respond as a group (thumbs up/thumbs down) or gives a wait time for more girls to raise their hands and intentionally calls on girls who have not been vocal **Clarifying what counts as data:** youth are positioned to plan and carry out (collecting data) an investigation

Performance as	**Factual response** (single word answers or answers without discussion of how or why) **Epistemological knowledge response** (youth explain their reasoning) **Sensemaking:** youth analyze and interpret data, active engagement in the uncertainty as they are figuring out a problem, making connections, brainstorming, using data to improve on a design **Communicating your explanation:** youth verbally make sense of the phenomenon by explaining how and why something works and demonstrating prototypes **Application to the real world:** youth give recommendations based on their understanding of the problem at hand (extrapolate out from the immediate scenario)
Recognition forms	**Positive affirmation (e.g., '**great job') **Repeating of answers** **Building on the ideas** (following up by asking girls to sensemake about their idea/answer) **Inclusive recognition** (when the educator refers to girls as engineers or scientists, which tells them they are valued and recognized as STEM people)

Throughout the analysis process we met to discuss our interpretations and ideas. We challenged each other's interpretations and suggested alternatives by providing evidence from our data sources. To highlight the educator positioning and recognition we have chosen to present our results as two comparative cases. The cases consist of an exemplary activity from launch to debrief from each camp. By using this format, we are able to present an in-depth examination of educator positioning and recognition that illustrates the complex issues bounded by the disciplinary context of each camp (Creswell & Poth, 2018; Miles et al., 2014).

Setting and Participants

Marine Science Camp (MSC) Learning Environment. The MSC met daily from 9 am to 4 pm across five days at a marine research facility. There were two main educators, but our chosen case only includes one, Miss Angstrom. She is a white woman with experience working in museums and other ISEE programs. Twenty girls participated in the program, all of whom were from the local area. Table 3 includes the demographics of this camp

Table 3: Marine Science Camp

	Percent	N (20)
Race and Ethnicity		
American Indian or Alaska Native	5.0%	1

Asian	5.0%	1
Black or African American	5.0%	1
White	70.0%	14
Hispanic or Latino/a	20.0%	4
Other	0.0%	0
Gender		
Female	100%	20
Academic Information		
Currently Enrolled in Honors Classes	60.0%	12
6th Grade	42.1%	8
7th Grade	36.8%	7
8th Grade	15.8%	3
9th Grade	5.3%	1

Explorations in Engineering (EiE) Camp Learning Environment. EiE was a two-day camp that met from 9 am to 6 pm. The two educators were Miss Litre, a white undergraduate woman, and Miss Bohr, a Latina educator. Twenty-three girls participated from the local area. The demographics for the participating girls can be found in Table 4.

Table 4: Explorations in Engineering

	Percent	N (23)
Race and Ethnicity		
American Indian or Alaska Native	4.3%	1
Asian	21.7%	5
Black or African American	8.7%	2
White	30.4%	7
Hispanic or Latino/a	34.8%	8
Other	8.7%	2
Gender		
Female	100.0%	23
Academic Information		
Currently Enrolled in Honors Classes	73.9%	17
6th Grade	30.4%	7
7th Grade	52.2%	12
8th Grade	17.4%	4

Results

The goal of our study was to determine how educators' position and recognize girls during activities that are meant to engage them in the work of scientists and engineers. The girls in both camps either increased or maintained their interest in SE which is one metric for SE identity development. The educators played a crucial role in both camps because they positioned the girls for identity work through the design phase of each SE activity, their launch of the activity, and their facilitation of the discourse during the debrief. This section presents an exemplary activity from the MSC, followed by an exemplary activity from the EiE camp so that the reader can see the structure and educator positioning along with our coding analysis.

Marine Science Camp Animal Stranding Activity

For the MSC, we chose to focus on the Animal Stranding activity. This activity occurred on the third day of the camp. It tied together a number of experiences and skills from the previous days. For example, on the first day, the girls visited the bone room at the Marine Lab where they met, Dr. Gwen, a marine biologist who investigates strandings on the nearby beaches – dead marine animals that wash up on shore. She is often asked to visit the site of a death to determine its cause in case there are steps that the local law enforcement or community can do to reduce further incidents. The Animal Stranding activity was framed as figuring out an uncertain phenomenon (Tekkumru-Kisa et al., 2020) because the girls were asked to determine what data they needed and then analyze that data to come up with a possible explanation of how their animal died. They did not know nor could they be exactly certain of the cause.

Miss Angstrom was the lead teacher for the activity. During the activity, the girls worked in small groups to determine the cause of death for their animal using evidence from case files and then presented their findings to the group in a mock interview by the local newscaster (Miss Angstrom). Miss Angstrom began the activity by showing the girls a PowerPoint highlighting marine biologists, since biology was the theme for this day. She asked the girls if they knew what type of career each woman pictured had. This positioned the girls for outside science foundational knowledge at first. She then positioned them for outside camp epistemological knowledge by broadening the concept of what counts as science when she asked:

> Miss Angstrom: Does anyone have any fish tanks at home? [hands go up indicating yes] So you have to be really aware of the water quality and the health and the nutrition of your animals within that tank. So, you're being a Marine biologist. Anyone in here like to fish? [hands go up] So you are learning about the environment, you're being a Marine biologist. If anyone's interested in filmography or photography underwater, you have to know some of the behaviors of these animals to know when you're gonna get the best shot. So, you have to have a little Marine biology background. Environmental law. I know a couple of you want to be lawyers, right? If you want to do environmental law, you need to have that science background too.

In this statement, Miss Angstrom was connecting the girls outside interests to science while also calling them scientists. She broke down stereotypes associated

with what counts as science. We identified these moments as inclusive recognition because Miss Angstrom positioned all the girls to feel like they belonged and could be part of the work of scientists. In this example, she demonstrated the value that each girl's interest had, even those that might not be considered science by traditional Western standards.

Then Miss Angstrom launched (introduced) the activity by asking them about strandings, a concept that they had learned about on the first day of camp:

> Miss Angstrom: What program at the Marine Lab is Dr. Gwen responsible for? Do you remember?
>
> Peggy: The strandings program.
>
> Miss Angstrom: Absolutely. Strandings investigation. And can you remind me what exactly that means? What is a stranding?
>
> Joan: It's basically the same thing as beaching. So when a shark or a whale gets too close to the shore, they wash up on the beach.

Here Miss Angstrom positioned them for inside foundational knowledge, again broadening the opportunity for girls to perform (answer questions) because they all had the shared experience of meeting the role model and learning about her work on the first day of camp. Miss Angstrom called on different girls each time to bring more girls into the conversation (inclusive positioning). She also inclusively positioned the girls to participate because they had all met Dr. Gwen.

Next, she guided the girls through a conversation about how to tell the difference between dolphins and manatees.

> Miss Angstrom: [picks up manatee skull and a small container with teeth in it], so this is a manatee skull. All right, I'm gonna bring it around. And here are some dolphin teeth in here. I want you to see the differences? All right. [walks to each table] What do manatees eat?
>
> Sara: They mostly eat vegetation
>
> Miss Angstrom: Yeah, they eat sea grass, right. And what do dolphins eat? we mentioned earlier [someone yells out fish] and yeah, so they do eat fish. Um, so animals that are carnivorous and eat other animals, have what kind of teeth? [someone yells out, very sharp]
>
> Miss Angstrom: Right, sharp or pointed right? And animals that eat vegetation and plant life, they have what kind of teeth? Flat, Right? We have kind of a mix of those two in our mouths because we are omnivores, we can eat whatever, we can choose to not eat certain things, but we're designed to eat whatever. So yes, we can tell a lot about the difference between them.

Here Miss Angstrom positioned the girls for sensemaking. Rather than simply asking how the shape of the animals' teeth were different, she asked them what food they eat. This allowed them to connect the form and function. As the girls answered, she built on these answers and connected them to the sensemaking form

and function conversation. Although the girls' performances here were mainly science factual responses, later in this conversation, we saw how Miss Angstrom modeled sensemaking for them.

Miss Angstrom: And what else does a dolphin have that a manatee doesn't?

Joan: echolocation

Miss Angstrom: Okay. Can we see that?

Joan: no

Miss Angstrom: That's true, but you can't see that. So if we were just looking at a dolphin and a Manatee, one has a dorsal fin, and one other thing?

Here Miss Angstrom positioned the girls for clarifying what counts as data, when one girl says "echolocation" she asked if that trait was observable for them with the tools on hand. Although Miss Angstrom was doing much of the sensemaking and clarifying what counts as data for the girls (recognizing building on idea), her cognitive work served as a model of the doing science (e.g., clarifying what counts as data and sensemaking) that she wanted the girls to engage in during their small group work.

After engaging the girls in observational differences between manatees and dolphins, she moved the girls on to a discussion of animal behavior so they could better interpret the evidence they would be given in their evidence packets.

Miss Angstrom: Now these tails look a little bit strange. Can someone tell me what they think has happened or why these tails look so weird?

Fely: maybe a boat

Miss Angstrom: Yeah. Okay, so maybe a boat strike. Both these animals have big chunks out of their tail missing what else is going on?

Rayna: maybe they got tangled in fishing net

Miss Angstrom: Okay, so maybe they got tangled in a piece of fishing net and a piece of their tail might have come off. what's a natural predator of dolphins?

Joan: sharks

Miss Angstrom: So sometimes they get into a little bit of a fight. So all these things could have happened. Now with all that in mind, would you send someone out to assess the situation and see if these animals are okay? Thumbs up if you think yes [girls vote], thumbs down, if you think no [girls vote]. [Majority vote yes]. Okay. I want you to take a closer look at these tails. Do you see anything oozing blood? [multiple no's]. So, we might, if they were displaying a behavior that wasn't normal, you might send someone, but if they're just going about their day and doing their normal thing. They're all good. This is an old injury. And if they're still acting fine,

then they're good.

Dr. Gwen had referenced these types of injuries on Day 1. So, all of the girls had access to inside foundational knowledge related to injuries and therefore had an opportunity to answer. We again saw Miss Angstrom use inclusive positioning when she asked the girls to vote with a thumbs up or down. Here she was giving girls, who might not feel comfortable sharing or confidant in their answer, an opportunity to engage in the work of science - making claims based on evidence. Then she clarified what counted as data for them.

As she moved to the implementation of the activity, she gave each small group a puzzle for them to put together the bones of their animal (i.e., a dolphin or a manatee). The girls began the implementation by completing their puzzle, identifying their animal, and then obtaining a folder with more evidence related to their specific case (e.g., pictures, description of the animal when it was found). Some of these descriptions included information on whether a necroscopy was completed or whether evidence was kept by the state. The girls then had to go to the various locations in the classroom to collect documents that represented lab results and analyze them at their tables. The authors observed the girls working together to solve their mammal mystery. Girls congregated at the evidence table, discussed questions and ideas with each other and Miss Angstrom. As Miss Angstrom went to each group she could be heard asking if they had a theory about what happened to their animal. She could also be heard asking them to explain the evidence they had that supported their theory. After 30 minutes, Miss Angstrom reminded the girls that the final step of the activity was to present their information to the group.

The debrief of this task was each group's presentation of the stranding investigations they participated in, which was designed to allow them to perform and engage in the work of scientists. Each small group presentation began with a mock interview with Miss Angstrom introducing herself as a newscaster and referring to the girls as the "Marine Lab stranding investigations team", and then asking them to explain what happened. Thereby positioning each group as scientists by asking them to communicate their explanation and recognizing each group for doing the work of scientists. And then positioning them as scientists again by asking them to explain what happened. During these group presentations we saw the girls performing sensemaking and the communication of their explanation. We provide one group presentation as an example below.

> Miss Angstrom: This is Miss Angstrom with the evening news on channel six. I have with me the strandings investigation program from the Marine laboratory and they're going to clue us in to what happened recently in our neighborhood. Take it away.
>
> Mary: Breaking news on case number four, one two, one with the dolphin that has been found dead on our beach. We have some information on that beach. Take it away, Peggy.

Miss Angstrom was inclusively recognizing them as doing the work of scientists by calling them members of the investigation program. The girls recognized each other as doing the work of scientists by turning to each other to explain.

> Peggy: So the dolphin was found in the evening with a minor cut on his forehead. Um, or that we think might have been the results of a burn from a ship coming through where the oil got caught on fire.

Tricia: The dolphin had lung damage which is a result of the fire from the oil spill.

Joan: We think the cause of death was because of it breathing in too much smoke and ingesting too much oil. Here are the pictures of the dolphin stranding. [Lana is holding up pictures]

Initially, the girls were performing science facts by telling us that the dolphin had a scratch. Then they move into performing explanation by telling us how they thought the scratch occurred. Tricia performed the sensemaking for us by making the connection between lung damage and death. Miss Angstrom probed them for further sensemaking with her next question.

Miss Angstrom: And team, how can we avoid this in the future? What can we do to prevent a death like this?

Joan: So I've heard there's a solution and it was to put like a giant bag around the oil rigs. So the oil, when it leaks, it doesn't get out into the ocean.

Miss Angstrom: So better designed ships.

Peggy: and also, um, there could be, um, a substitute for oil. So something more eco-friendly,

Miss Angstrom: So clean energy. Well thank you very much. Give them a round of applause.

Here we saw Miss Angstrom asking them to apply what they had learned (positioning for application to the real world). Both Joan and Peggy provided outside foundational knowledge. And then Miss Angstrom recognized them by making the connection between the stranding and the application. She concluded the presentation by having the entire camp recognize the girls (positive affirmation).

The Animal Stranding activity was an exemplary case of the type of positioning, performance, and recognition that occurred during the MSC. Miss Angstrom designed an activity with a high degree of uncertainty where girls had to collect evidence to explain a scientific phenomenon thereby engaging in the work of doing science (Tekkumru-Kisa et al., 2019). During the launch phase Miss Angstrom positioned the girls so that they all could feel included by asking them about information they learned in the camp, thereby giving more girls an opportunity to perform their science knowledge. Then Miss Angstrom modeled the cognitive work of sensemaking and clarifying what counts as data as a way to model scientific behavior for the girls. Through her positioning, Miss Angstrom was also recognizing the girls by building on their ideas. Sometimes this included more talk from her but by the debrief phase the girls were doing the explanations and Miss Angstrom was recognizing them as doing science by calling them members of the Marine Investigation Team and by asking them shorter questions to elicit their performance of sensemaking. Miss Angstrom's use of inclusive positioning (giving more girls an opportunity to perform) and inclusive recognition (calling them scientists) gave girls multiple opportunities to engage in the doing of science and to be recognized for this work.

Explorations in Engineering Grab-n-Go Activity

For the EiE camp, we chose to focus on the Grab-n-Go task, which occurred on the first day of the camp. The Grab-n-Go activity was led by Miss Bohr and supported by Miss Litre. During the activity, the girls were challenged to create a mechanical arm from a set of materials (e.g., rubber bands, tape, straws, and popsicle sticks) that could lift a weighted cup across a given distance and back. The challenge began with Miss Bohr introducing various concepts inherent to engineering, such as building and testing prototypes (NGSS Lead States, 2013). The girls then worked in groups to build, test, and revise a prototype of a mechanical arm that they had designed. They then shared this design by demonstrating their prototype in front of the whole group, picking up different weighted cups and moving them a predetermined distance with their constructed arm. Miss Bohr launched the activity by opening up a discussion about mechanical arms:

Miss Bohr: How many of you have seen a mechanical arm anywhere. Like, on tv, at a museum. What stands out about those arms that you see?

Allie: They don't have skin.

Miss Bohr: They don't have skin. What are they used for?

Student: To grab.

Miss Bohr: To grab. Maddy?

Maddy: Prosthetics

Miss Bohr: Prosthetics.

Jamine: Work purposes.

Miss Bohr: Work purposes. Yes.

Miss Bohr positioned the girls for outside foundational content knowledge, by asking them if they had seen a mechanical arm, what stood out about mechanical arms, and what mechanical arms were used for. We saw evidence of inclusive positioning in this excerpt because Miss Bohr was providing opportunities for multiple girls to respond, calling on a different girl each time. This positioning and recognition helped the girls to see that they all possessed a common base of understanding and expertise that they could draw upon during the activity. However, unlike the Animal Stranding, Miss Bohr was relying on outside knowledge, privileging girls who might have more experience with engineering.

During the launch phase, Miss Bohr inclusively positioned the girls by highlighting the collaborative nature of engineering and soliciting multiple girls' ideas.

Miss Bohr: Okay. What are some of the ways to go about this if you're working as a team?

Allie: Communicate.

Miss Bohr: Communicate. What does communication look like when you're brainstorming?

Harini: Actually speak to each other.

Miss Bohr: Actually speak to each other. Make sure everybody is listening. What are other really good things to do as a team?

Sierra: Brainstorm. Hear everybody's ideas. Like, not just one person.

Miss Bohr: Yes. Share everybody's ideas. All of us are at different levels so make sure if somebody is a little bit more, ah, quiet. Create space to really hear all their ideas. Our teams tend to be stronger when we hear all of the inputs. Right?

During this back and forth, we saw evidence of inclusive recognition because Miss Bohr recognized and built upon the girls' ideas of the collaborative nature of engineering.

After unpacking and discussing the importance of collaboration, Miss Bohr explained: "We [the educators] are not going to be able to tell you the answer because that's like no fun. But, we're able to be a sound board. If you have questions or something, we can try to help." This statement inclusively positioned the girls as the "engineers" during the activity and positioned the educators as "helpers" who could provide support but not "the answer". This changed the power dynamic in the space and empowered the girls to see themselves as the engineers. After this introduction, the girls engaged in the implementation phase of the activity. During this time, the authors observed the girls working together in small groups (2 to 3 girls per group), exploring and tinkering with the materials they were provided, negotiating their ideas for how they would use those materials to build their mechanical arm, building prototypes based on these ideas, testing out those prototypes, and making alterations to them based on those tests. Both Miss Bohr and Miss Litre moved around the room to see what each group was doing and answer their logistical questions about the requirements of the challenge; however, the groups were largely left alone to engage in the design process. Then Miss Bohr brought everyone together to demonstrate their prototypes during the debrief.

During the debrief, each group demonstrated their mechanical arm for the rest of the girls. Miss Bohr ensured that all girls had access (inclusive positioning) to these demonstrations saying: "Alright. So make sure all of your team members are around you. I'll move this chair so everyone can stand around. I want everybody from the rest of the teams to be able to see. That's the most important." This inclusive positioning continued throughout the debrief as the educators made sure that all groups showcased their device (performance). During these demonstrations, the girls were positioned by Miss Bohr in the ways of doing engineering including communicating explanations and sensemaking. Her positive affirmations during demonstrations and suggestions could be seen when she encouraged the girls who had successfully moved the cup across the finish line to "make their cup heavier or try to move it further down the table". Her encouragement to try something harder

represents her recognition of the girls as doing the work of engineering and then positioning them to strengthen their skills by giving them a more challenging task.

We also saw examples of sensemaking and communicating explanations in the girls' mechanical arm demonstrations. In the following example, Miss Litre positioned a group by pressing them to explain (i.e., sensemake) how their devices work:

> Miss Litre: So what did all do to strengthen your design?
>
> Cailyn: So, at first we had string in it but then the string wasn't strong enough. So, instead, we just cut the string off and put it on a tooth brush thing.
>
> Miss Litre: Did you make it stronger with the toothbrush thing?
>
> Cailyn: [Shakes her head yes].
>
> Miss Litre: Good job.

In this excerpt, Miss Litre positioned the group to explain their sensemaking. Cailyn provided some explanation but Miss Litre finished the sensemaking for her. This was typical for the EiE camp, where sensemaking episodes were brief and mainly led by the educators rather than the girls.

The Grab-n-Go activity was an exemplar of the types of positioning, performance, and recognition that occurred during the EiE camp. Miss Bohr designed an activity with a high degree of uncertainty wherein the girls were challenged to engage in prototype design and testing collaboratively (Tekkumru-Kisa et al., 2019). During the launch, Miss Bohr positioned girls to share their outside foundational knowledge about mechanical arms and recognized them with positive affirmations. During the debrief phase, Miss Bohr and Miss Litre inclusively positioned all the girls to demonstrate their mechanical arm prototypes (communicate explanations). This positioning provided opportunities and resulted in performances of doing engineering as the girls communicated their explanations which included some sensemaking. Through these opportunities for performance and recognition, the educators were supporting the girls in their identity work by building a common foundation for the girls to reference. The educators helped the girls to feel like they belonged through their use of inclusive recognition and positioning.

Discussion

Our presentation of these two cases: the Animal Stranding and Grab-n-Go activities, highlight the ways in which ISE educators position girls to engage in the work of scientists and engineers. The educators in both of these activities used similar strategies for positioning (e.g., positioning for content knowledge, epistemological knowledge, and the doing of SE) and recognition (e.g., positive affirmation, repeating answers, and building on ideas) which elicited doing science and engineering performances (e.g., factual knowledge, epistemological knowledge, clarifying what counts as data, sensemaking, and communicating an explanation). Despite research highlighting disciplinary differences between science and engineering instruction and engagement, we did not observe these differences in terms

of educator positioning in either of these middle school ISEE spaces (Cunningham & Kelly, 2017; Hutchinson & Hammer, 2010). Rather the educators used similar types of positioning for both disciplines.

Positioning Girls for Disciplinary Work

Although, the Grab-n-Go debrief had fewer examples of sensemaking by the girls, this is not necessarily an indication that one group of educators was better at positioning for sensemaking. The Animal Stranding activity occurred on the third day of camp, which gave the educators more time to create a space where girls were more comfortable sensemaking in front of the group. By focusing on positioning, we were able to see how educators built on the inherent social contexts of the respective camps (e.g., inclusive positioning, inside camp content, and epistemological knowledge) and gave girls the opportunity to negotiate their roles as women scientists and engineers (van Langenhove & Harre, 1999). These negotiations were evident in the launch and debriefs of the activities. During the launches, we saw the educators modeling the types of sensemaking that scientists and engineers do for the girls. The educators then provided space and asked questions that elicited more sensemaking from the girls during the debrief sections.

During the launches, we observed collective sensemaking that occurred in ways similar to the collaborative work of scientists and engineers (i.e., girls built upon and negotiated their roles and ideas together). This builds on previous research that has focused on the positioning of individual girls as they engage in science and/or engineering identity work– e.g., how individuals are positioned by the norms and structures of the space and how individuals position themselves within these spaces (Calabrese Barton et al., 2013; Carlone et al., 2015; Kim et al., 2018; Pattison et al., 2020). However, by focusing on educators' positioning and recognition within each case, we were able to see how these collective sensemaking norms and structures were demonstrated, fostered and taken up by the girls. Specifically, the girls met female role models who showed them that women could engage successfully in science and engineering identity work. Then the educators, reinforced these future selves through the positioning and recognition within the activities.

The Role of Positioning and Recognition on SE Identity

Science and engineering disciplines are infused with social, cultural, and historical power domains that privilege canonical knowledge and practices that stem from Western male thought (Caraballo, 2019; Ryu et al., 2019). ISEE spaces, like formal science learning spaces are not immune from these power structures (Dawson et al., 2019). Educators play the role of gatekeepers, because educators hold the authority in the space (Calabrese Barton et al., 2013; Carlone et al., 2015; Tan et al., 2013). In both of our cases, we saw how educators were able to change the power differential and empower the girls to be recognized (and recognize themselves) as experts, negating stereotypes related to who participates in science and engineering. We saw this more often in the MSC than the EiE. However, we still saw evidence of educators' supporting girls in both activities to see themselves as

scientists and engineers (Ryu et al., 2019).

Educators in these cases created space for foundational science and engineering content and epistemological knowledge. Although Miss Bohr relied more on outside content knowledge in the Grab-n-Go activity, this was because it was the first activity of the camp. She was creating an inside content foundation for the girls to reference. In the Animal Stranding activity, we see how Miss Angstrom built on camp experiences, rather than relying on the girls to bring their outside content and epistemological knowledge which would privilege those with more science capital (Archer et al., 2015). The educators' positioning for inside content knowledge created a space wherein the social norms of who belongs in science and engineering were challenged (Dawson et al., 2019). For instance, in the Animal Stranding activity, the girls had met a woman scientist who did the work that they engaged in. This introduction to Dr. Gwen provided a foundational experience for them to relate to and having a women talk to them, showed them it was possible for a woman to be successful doing the work. Miss Angstrom built on this foundation through her positioning and recognition, particularly in the inclusive positioning she utilized. Though we see evidence in both cases of this inclusive positioning by educators.

During the cases, the educators called on multiple girls, rather than privileging the same girls. The educators often had the girls voice their ideas in a group format (e.g., girls could vote on what they think the answer might be through thumbs up or thumbs down). This allowed girls who might not be as confident in their science and engineering skills (e.g., background knowledge) to pose an explanation. In addition, this positioning of all girls as scientists and engineers helped girls who might not see their salient identities as fitting with the social norms of the disciplines challenge these stereotypes and see themselves as scientists and engineers (Dawson et al., 2019). By engaging multiple girls and giving even those who are shy or less confident in their STEM skills opportunities to engage, the educators created a space for collective sensemaking where girls of multiple identities engaged in the disciplinary practices of science and engineering.

Recognition of Disciplinary Work is Connected to Positioning

We observed that recognition and positioning were interconnected. Throughout both the launches and debriefs, the educators recognized the girls collectively as doing the work of scientists and engineers by actually calling them scientists and engineers or simply by saying that the girls had the knowledge that they needed to solve the uncertain and ambiguous tasks they were given. This type of inclusive recognition, changed the power dynamic within the space because the educators were showing that they were not the sole authority in the room. In addition, when educators were building on ideas, they were recognizing girls by asking them questions while simultaneously positioning them for disciplinary engagement (Bell et al., 2017; Berland et al., 2016). The girls were supported by the educators and each other as collaborators and experts in their disciplinary engagement, which showed them how they could resist the social norms of who does science and engineering (Dawson et al., 2019).

Implications

Educators play an important role in helping girls develop stronger SE identities, however our understanding of this role has largely been focused on recognition (Calabrese Barton et al., 2013; Carlone et al., 2015; Kim et al., 2018; Pattison et al., 2020; Ryu et al., 2019). This study shows the connection between educators' positioning and recognition, demonstrating how educators can model the work of scientists and engineers (e.g., group sensemaking) and create opportunities for girls to engage in this work in ways that empower girls and challenge the stereotypes related to science and engineering. This study highlights that activities can be designed and facilitated in a way where girls can engage in relevant disciplinary identity work and see themselves as agents of scientific and engineering work in a relatively short time frame. The Grab-n-Go task occurred on the first day of the Engineering camp and yet within 45 minutes, the girls were engaging in the doing of engineering in a space where they were able to perform true disciplinary competences, like being willing to make mistakes and willingly sharing those mistakes in a group setting. Similarly, the Animal Stranding task built on shared knowledge and experiences from the camp to help the girls feel confident to engage in sensemaking and communicate their explanations like true scientists. The educators in both activities modeled the work of scientists and served as role models to the girls. Then the girls were given the opportunity to sensemake and construct disciplinary knowledge and be recognized as experts. Through these efforts, the educators supported the girls to create new and challenge existing social norms in science and engineering to see themselves as valuable members of these fields.

Although our study focused on ISE Educators, both formal and informal SE educators are often youth's first introduction to the disciplinary ways of doing science and engineering – gatekeepers to these disciplines and belongs within these disciplines. They translate SE practices and show girls what counts as SE performances and knowledge. Therefore, educators have an important influence on SE identity development. Their choices for and facilitation of activities and the ways they position girls for SE identity performance affect whether girls see themselves as scientists and engineers. In particular, girls may struggle to see themselves in male-dominated SE spaces. Our research provides evidence that educator positioning and recognition can create spaces for collective sensemaking where girls can share in the ownership of the production of knowledge. We must continue to critically examine the ways in which educators serve as allies to girls if we want SE disciplines to become diverse and inclusive and serve all members of society.

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Lessons learned in building a sustainable and meaningful cooperative outreach program

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Abstract

Introduction

In the United States there is a growing sentiment that scientists conducting primary research with public funding should also be directly engaged in science education through outreach to the community and public schools (NSF 1999, Leschner 2007; Whitmer et al. 2010, Alberts 2013). These perceptions fueled by public opinions that public school K–12 education has failed to adequately prepare students in science literacy (NRC 2007, Feinstein et al. 2013, Mervis 2013, NAC 2016, Sharon and Baram-Tsabari 2020). With little doubt these concerns have grown exponentially with the onset of remote and hybrid educational approaches launched nationwide with the COVID-19 pandemic (Bozkurt et al. 2020, Maqableh and Alia 2020, Toquero 2021).

Research faculty at colleges and universities tend to support the principles of the implementation of broader impact goals in grant funding (Sarewitz 2011), however, the requirements are ambiguous in criteria and the lack of guidance therein surely has left many researchers unprepared (Kamenetzky 2013; Halland, 2019). A now defunded program, the National Science Foundation's (NSF) own Graduate K–12 (GK–12) Program was highly successful in its original goals of enhancing graduate student professional development. At the time this program was the only NSF program that actually embedded scientists in local communities,

predominantly public K-12 schools, as such had allowed young graduate students in STEM fields to forge lasting partnerships within public school systems, informal science centers and across discipline with other GK-12 fellows (Boone and Marsteller 2011, Adams et al 2016; Adams 2020). Despite this program's successes, the announcement to terminate the program was made in 2011 (Mervis 2011). Ufnar et al. (2012) made a call to former participants in this program to disseminate their findings, propose sustainable models to be adopted by other universities and to determine whether there is a place for a program similar to the GK–12 on university campuses, and if so, what the model looks like and what the requirements are for sustainability.

Herein, the authors seek to share their experience, successes, and hurdles in building a sustainable, and meaningful outreach program at their current institution. One author is a former NSF GK-12 Fellow and Association of Science and Technology Center (ASTC) docent and informal educator, the other a professionally licensed and former fulltime middle school science teacher, both are active Clinical Assistant Professors and researchers in their disciplines. This piece is a commentary based on the recent experience of these uniquely qualified geoscience educators at The University of Buffalo across their interrelated departments in forging a collaborative outreach program. While this paper contains no formal studies, in it we discuss the background and the experience in the formation and implementation of the EarthEd Institute, a local outreach program aimed at reaching underserved children in the Buffalo-Niagara area. This piece is being shared with the hope that other such programs may be formed, possibly learning from and improving on the experiences shared here.

Overarching Outreach Goals, Struggles, & Solutions

Constructing the Main Goals, Aspects & Desired Outcomes

The departments of Geology (GLY) and Environment & Sustainability (EVS) at the University at Buffalo, both departments are closely related and several faculty members holding joint appointments in each, recognized a deficiency in the departments' ability to continuously engage and host outreach events. The groups felt that the departments could and should do more for our local education system. Thus, an ad-hoc committee that included both tenure-track and clinical faculty was formed to begin the journey of transforming the idea into reality. This committee quickly decided on the outreach program's basic overarching goals that included 'must haves' and 'must not include' to best suit the two departments' abilities and needs (Table 1). A general consensus was founded between the two departments and planning for implementation soon followed.

Table 1: Preliminary overarching goals for outreach program across departments.

Goals	Mode of Delivery

Create a program that has high impact Diversity, Equity, & Inclusion (DEI) components for urban and rural underserved public schools	Low to No cost participation for educators from underserved districts
Involve real research from our tenure-track faculty; demystify STEM	Enlist faculty present their research in the form of a lecture to this novice audience
Promote experiential learning components that align to state & federal standards	Create hands-on learning experiences for educators that can be scaled up or down in their classroom; supply materials as needed to the classrooms based on best current practice as presented by scientists earlier in the program.
Emphasize relevancy of science in our region	include local citizen science & research opportunities for educators & students
Establish & foster long-term relationships with local educators & their students; create opportunities & engagement in our communities	Establish a year-long outreach component to have scientists and/or graduate students available for support for participating educators in their classrooms

Conceptual Frameworks for University-led STEM Outreach

For developing the framework of a university-led outreach program, is it often stated that there are two opposing scenarios to be considered as framing the boundaries of outreach operations within universities (Eilam et al., 2016); top-down and bottom-up scenarios. The two extremes hypothetically embodying a continuum which allows for a range of operational modes within each. Top-down is a scenario in which the university governance develops a policy and management systems for performing STEM outreach programs. Top-down approaches are funded from their launch and are frequently longer-lived programs than bottom-up approaches (Eilam et al., 2016).

The bottom-up approach is developed spontaneously, and centralized initiatives and policies are absent as a guiding directive but evolve in place during outreach to direct these operations (Eilam et al., 2016) with limited links between the outreach programs and the central university management systems. These programs evolve spontaneously through the initiatives of individual academics or other staff. Once they are up and running the discrete faculties would attempt to support them within their limited capacity, as add-ons (Eilam et al., 2016). Often, the programs operate under the university governance's 'radar', unregistered, and known only to those who are directly involved with them. In this scenario, the main challenge that the programs face is obtaining legitimacy within the organization; supply of space, facilities, administration, and other services would be based

mostly on goodwill and availability of the individual and department-level support. Such constraints are a challenge for small departments or individuals wishing to start up an outreach program and often littered with start-stop issues (Eilam et al., 2016), at least until internal legitimacy is achieved and continuous support is granted from the institution.

Having little idea on how to initiate press, advertisement, and foundational funding, we originally sought out help from our college administration. While the university is an R1 institution the direction at which the administration was immediately taking the concepts and the costs at which they projected for running the outreach program well exceeded what we thought was ideal for our primary goal of creating a low to no cost and high impact program meant to serve underserved rural and urban communities. We abandoned our relationship with university administrators and as such the bottom-up approach was the basis in which our program began but knowing how difficult this route would be we began to reach out to other potential support systems as collaborators and first years' support systems. Thus, we inadvertently created a third approach, one that is collaborative and bridges the needs and goals of the community, the academics, and public informal education centers.

Informal Science Centers in Outreach Collaborations

The requirements set forth by funding agencies for outreach components are broad and deriving a sound and succinct program is often laborious for researchers. Primarily, establishing relationships with public schools and teachers can be time consuming. Thus, having had experience working in and with informal science centers, we were aware of the resources that they possessed and wanted to integrate our regions informal science centers into the EarthEd Institute. Forging relationships with informal science centers is a great starting point for those with little time or resources at hand. Science centers (ASTC centers, natural history museums, nature centers, etc.) often provide community education programs that welcome researchers to participate in and assist, however, many professional development series and paid programming are a source of income for non-profits. As such, the long-term impacts of researcher contributions may fall short of the broader impacts intended. Non-profit informal science centers' make great collaborators, many are ready and willing to assist with outreach program implementation but should not be considered the solution to the broader impact aspect of research funding but a starting point.

We wanted our participating educators to be familiarized with informal science centers in and around the Buffalo-Niagara Metro Area and understand that EarthEd Institute workshop activities (hands-on lesson plans) could augmented with field trips where possible. Many institutions have classroom-supportive activities on hand and could be utilized for instruction on these sites without additional work on the end of the teachers. Given the breadth of research the two departments are involved in academically, we already had a list of friends in the field ready and willing to help us out. We formed formal collaborations with several local institutions (e.g., nature preserves, Audubon societies, remediation non-profits, etc.) and incorporated visits to these facilities in our workshop planning. These collaborations go further than the week-long workshop, both the informal science centers'

now advocate for our outreach program and we for theirs. This creates a new source of well-respected advertisement for both the university outreach program and these non-profit science centers.

Funding Limitations & Pooling Resources

While research funding may supply generous funds to individuals and groups, combining resources within a whole department or across departments under an outreach program umbrella allows for each dollar to go further. We found that a type of united front approach to funding allowed for our desired broader impact goals to go further, while minimizing researcher time and maximizing effort. In addition, pooled resources make a better, more cohesive program, and the established reputation of an annual program ensures more participation from the community and less time advertising. Further, early career researchers collaborating with outreach coordinators were able to participate with little to no funding given the pooling of resources from senior faculty. This allowed each faculty participant to form their own meaningful approach to outreach within their immediate community.

At the launch of the EarthEd Institute workshop series in July of 2021, we had not yet received direct funding for our outreach program. Research grants listing our institute as a route for their broader impact and outreach were in review. Thus, we were set to launch without funds. Through the generosity of an emeritus faculty member of the Department of Geology at UB, were we granted $2000USD to cover the costs of the program in its inaugural year. As veteran educators of both rural and urban underserved communities, we were able to truly test our "science on a shoe-string" skill in this launch year. In example, where a lesson plan called for 10 sediment corers, we knew that purchasing 10 corers at a minimum of $250USD each was not going to happen. In lieu of such a purchase, we were able to construct nearly identical devices through raw materials purchasing at local hardware and plumbing stores and constructing the units ourselves, producing 10 sediment corers for $120USD total ($12.00/unit). These same sediment corers are now available to be loaned out to EarthEd participating teachers. We also supplied the sediment corer designs and a list of purchase locations and costs of the materials to EarthEd participants.

Resources for outreach extend far beyond cash flow from grants and research funds, people power and creative thinking are some of the biggest assets a coordinator can tap into for planning. Further, keeping in mind that public schools are often cash strapped, particularly for urban and rural communities, let "science on a shoe-string" become a mantra when delving into workshop planning. Financial accessibility to educators should be central to lesson plans.

Federal & State Education Standards & Outreach Applicability

To understand all the federal, state, and advanced diploma standards and outcomes is a full-time job. Expecting a STEM researcher to know, understand, and be able to implement the standards as they pertain to their research to a novice audience is daunting. Further, as research scientists, we often forget where we started in our

educational journey; foundations and structuring of content is necessary to achieve desired final learning outcomes. While we can navigate training on a scanning electron microscope or population statistics with ease, teaching a novice to read begins with phonics, and without pedogeological training of STEM researchers, much is lost in translation. This coupled with the dynamic and perpetually evolving standards often causes frustration for those truly wishing to make an impact in their community's public education system.

As former k-12 educators we wanted to ensure that our workshop and all of its components were applicable to federal and state learning standards. Serendipitous to our collaborative departments, the authors were well versed in formal and informal education systems and pedagogy prior to their work at the university. Through this experience were able to guide research faculty in their lectures and lessons for K12 educators. While this is not true for most departments in STEM, we strongly suggest forging relationships with any departments of education at your home institution if resources and experience of outreach falls short of your needs.

Drawing an Audience

Many higher educational institutions have resources in-house to connect researchers to local public educators. Some are obvious, such as an Office of Community Relations or an Office of Academic Outreach, other resources are more discreetly available, such as tenured colleagues having established relationships and lists of names through their own outreach programming having built-up over the course of a multi-decade career. These resources are priceless, containing anywhere from 12 to 100 names and contact information. In consideration of diversity, equity, and inclusion (DEI), it was a goal of both participating departments to expand our outreach to underserved communities in the Buffalo-Niagara Metro Area, and >90% of the contacts readily available through prior programing involve individual from predominantly white-affluent schools. Hence, we chose to abandon these resources and lists and seek out schools and educators who had not engaged in outreach with our institution. The sheer number of those schools and educators, particularly within urban centers of Buffalo and Niagara Falls were seemingly endless.

The process of recruitment began in 2018. Gathering contact information on public and charter schools is relatively easy, however, getting in contact with individuals interested in participating in outreach programing or an individual responsible for disseminating opportunities is another story. We tried several approaches: 1) physically printing out and mailing out flyers and letters, 2) attempting to coordinate meetings with heads of schools or showing up with flyers, and 3) email blasts to anyone and everyone who may need or advocate for professional development in STEM (e.g., principals, educational coordinators, teachers).

With direct emails and telephone messages direct to high school principals in 2018, only one responded to the opportunity and took time to meet and discuss our program. Following failed emails and telephone messaging in early 2018, we attempted to make contacts through visiting targeted schools with information in hand, in mid-2018. On most occasions (6 of 10 visits) seemingly well received and spoke with someone in-house about our outreach program, in some rare cases we were all but ignored (2 of 10), or disregarded by front of the house staffing (2 of 10). Ultimately, no administrators, principals, or educators responded to physical

materials left at these schools. In 2019, one of the authors was relocated temporarily, and the outreach program was shelved, no recruiting occurred in this year. In January of 2020, flyers and letters we produced and mailed directly to science educators, this was costly, and rendered 4 responses to 75 packages mailed by early March of 2020. Continued recruitment was abandoned in 2020 due to the global covid-19 pandemic. Our final test to recruit educators began in March of 2021. This was done through email blasts, directly to STEM educators in nearby district high schools, we bypassed all school administrators and principals; of 235 emails sent, 22 educators registered for our inaugural outreach workshop. In consideration of the stresses of the pandemic on educators, we felt that this was a very healthy response for the time. The launch of EarthEd Institute was set for July of 2021.

EarthEd Institute Workshop Overview

The development of lesson plans for workshop themed days centered around the primary goals stated in Table 1. What the themes were and the order that they were executed was largely dictated by the participating faculty availability. Summer is field season for geoscientists and as such many researchers were not in the Buffalo-Niagara Region due to the conflict. Where faculty commitments fell short, the authors committed to lectures and lessons centered around their research and successful K-12 lesson plans (Fig. 1).

ECOLOGY					
	Monday July 12	**Tuesday July 13**	**Wednesday July 14**	**Thursday July 15**	**Friday July 16**
	ECOLOGY	RESTORATION	HYDROLOGY	EVOLUTION	SUSTAINABILITY
9:00	Registration, Pre-Workshop Survey & Ice Breaker: Henshue	Gray to Green: Restoratioin of WNY Communities Henshue	Current Research & Tech	Current Research & Tech	Sustainability projects in schools
10:00	USING ECOLOGY IN THE CLASSROOM Henshue	NYS resources for brownfields and restoration: Radon	Chris Lowry	James Boyle	
10:40	Break	Break	Break	Break	Break
11:00	USING ECOLOGY IN THE CLASSROOM Henshue	Community gardens and outreach:	Citizen Science in the classroom: Lowry	Caminicules/Lizzards	Integration & debriefing
12:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:00	NATURE JOURNALING for ELA: Henshue	Silo City field trip: Grundy VANS	Analytical Data Science in the classroom, AKA: "Don't panic!"	Natural History and morphology for Evolution Education: Geffner VANS	Environmental history in the US: Rome
14:00					
14:40	Break	Break	Break	Break	Break
15:00	Lesson development for Ecology and journaling	Creating a restoration project on your campus	Leaf Packs measuring soil and water biodiversity	Natural History and morphology for Evolution Education: Geffner VANS	
16:00					
16:30	Integration & debriefing	Integration & debriefing	Integration & debriefing	Integration & debriefing	Integration & debriefing

GEOLOGY					
	Monday July 12	Tuesday July 13	Wednesday July 14	Thursday July 15	Friday July 16
	Climate Change & Glaciers	Remote Sensing	Ancient & Modern Geo WNY	Volcanology?	Venus? Mars?
9:00	Registration, Pre-Workshop Survey & Ice Breaker: Meehan	Integrating math/geospacial awareness into curriculum: LINK	Community Scale Earth Science Projects to enhance current curriculum	Current Research & Tech	Current Research Mars & Venus
10:00	Climate Day: Briner and Thomas	'low tech' mapping (SED CORE LOCS): Meehan	Microfossils of WNY & basinal History Implications: Meehan	Experimental Volcanology & GeoHazards: Kolzenburg	NASA Remote Sensing Resources: Gregg
10:40	Break	Break	Break	Break	Break
11:00	Flex Time: LINK	Flex Time: LINK	Flex Time: LINK	Flex Time: LINK	Flex Time: LINK
12:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:00	Ping Pong Isotope activity	Higher Tech Mapping approaches: Csatho and Ivan	Schrieber or Stokes history of Devonian Trilobite beds???	Sonder	Integration of real time STEM resource data into Curriculum
14:00	Construction & Implementation of Shoe-string sediment corer		Penn Dixie Fossil Collection	Springville GeoHazards Field Station	Challenges within Curriculum Discussion
14:40	BREAK	BREAK			BREAK
15:00	Data collection best practices: In the field at UB	Creating a mapping project in your classroom: building on basics throughout the year			Interclassroom & Inter-school Collaborations
16:00					Opportunities in real research for your students
16:30	Integration & debriefing	Integration & debriefing	Integration & debriefing	Integration & debriefing	Debriefing & Post-Workshop Survey

Figure 1: EarthEd Institute workshops series' schedule, Ecology and Geology, as established for summer 2021 launch.


RIVERSIDE
class of
2021
#FIRSTCLASSEVER


Zircon -
sometimes

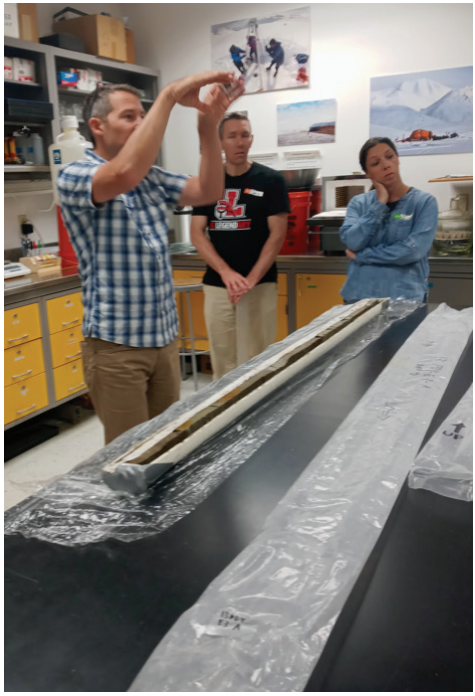

Figure 2: Compilations of images taken during the 2021 EarthEd Institute.

Evaluation & Assessment of Workshops

While the success or failure of an outreach program may be considered to fall upon the coordinator, our endeavor is not exclusive to a single individual, nor is it binary. Organization of the day or week falls upon management of the program, perhaps the primary role of a coordinator, however, some ideas developed and then executed in a workshop are outside of a coordinator's control. The success of a lecture from a research faculty member, the execution of a lesson plan by themselves or supporting graduate students is rooted in several foundational concepts; relevancy for the K12 students, applicability to standards and curriculum, feasibility in the classroom, and more. To better understand, assess, and grow from successes and failures of workshop programming, we developed our own version of a standard informal workshop evaluation used at the New York Hall of Science (Sylvia Perez NYSCI credit somehow).

UNIVERSITY AT BUFFALO
EARTHED GEOLOGY WORKSHOP SERIES
2021

Please take the time to complete both pages of this evaluation. We will use your responses to improve and modify our presentation and to develop future projects.

Name: (optional): _____ Date: _____

1. What grade levels and subject areas do you teach?

_____

2. Before this course, how would you classify your knowledge of the topics covered in the Geology EarthEd workshop?
_____Extensive _____Good _____Average _____Little _____Very Little

3. Were the workshop series objectives clearly explained today?
_____Extensive _____Good _____Average _____Little _____Very Little

4. Were the workshop objectives met?
_____Extensive _____Good _____Average _____Little _____Very Little

5. Did you consider the level of difficulty of the series to be…?
_____Just Right _____Too Easy _____Too Hard

6. Did the workshops stimulate or maintain your interest in the topics covered?
_____YES! _____Yes _____OK _____No _____NO!

7. Were the instructors informative and helpful in answering questions?
_____YES! _____Yes _____OK _____No _____NO!

8. Were the instructors appropriately prepared for the workshop?
_____YES! _____Yes _____OK _____No _____NO!

9. Please provide an overall rating for the instructors.
_____Very Good _____Good _____OK _____Poor _____ BAD!

10. Do you now know enough on the topics covered to teach a good lesson or implement some of the ideas shared this week?
_____YES! _____Yes _____OK _____No _____NO!

11. Do you feel comfortable with your ability to conduct hands-on science activities in the classroom?
_____YES! _____Yes _____OK _____No _____NO!

14. Were the readings and handouts helpful?
_____YES! _____ Yes _____OK _____No _____NO!

15. Would you like to participate in additional courses, workshops, conferences, lectures, etc. through the EarthEd at the University at Buffalo's Departments of Geology and Environment & Sustainability?
_____YES _____ Yes _____ OK _____No _____NO!

16. Did for today's workshop meet your expectations?
_____ YES! _____ Yes _____ OK _____ No _____ NO!

17. Please provide an overall rating for the workshop series.
_____ Very Good _____ Good _____ OK _____ Poor _____ BAD

Please write an explanation for the following questions.

A. Please describe what you like best about the Earth Ed Workshop Series. What was most valuable for you?

_____

B. Please describe which session was most valuable to you and why.

_____

C. What was least valuable to you and why?

_____

D. Please rate the following sessions on their value to you (one being the least valuable and five being the most valuable).

Session 1: Climate Change and Coring Day with Dr. Elizabeth Thomas, Dr. Jason Briner and graduate students?
1 2 3 4 5
Field trip to Letchworth Woods at UB to collect sediment cores?
1 2 3 4 5
Session 2: Geospatial Concepts and Remote Sensing with simple common technologies with Dr. Beata Csatho and Dr. Ivan Parmuzin?
1 2 3 4 5
Session 3: Microfossils of WNY and regional Basin history with Dr. Kim Meehan?
1 2 3 4 5
Field trip to Penn Dixie with Dr. Holly Schreiber?
1 2 3 4 5

Session 4: Hands-on fluid flow (as related to lava flows) activities with Dr. Stephan Kolzenburg?
1 2 3 4 5
Field trip to the Geohazards Field Station, Springville, with Dr. Ingo Sonder?
1 2 3 4 5
Session 5: Current research and integrating planetary|remote sensing data into the classroom with Tracy Gregg?
1 2 3 4 5

E. How would you rate this comprehensive model of a professional development in an educator series? (One being the least valuable and five being the most valuable)
1 2 3 4 5

F. Please add any comments, observations, or suggestions here.

_____

F. Please add any comments, observations, or suggestions here.

_____

_____

_____

_____

G. What from the Forensic Science Educator Series do you think you will use most in your clas (pedagogy, lessons, materials, etc.)?

_____

_____

_____

_____

_____

H. What topics would you recommend for future educator series?

_____

_____

_____

_____

I. Will you recommend the EarthEd Workshop Series to your colleagues?
_____ YES! _____ Yes _____ Maybe _____No _____ NO!

J. Would you take another workshop series as a professional development with EarthEd and th departments?
_____YES! _____Yes _____Maybe _____No _____NO!

Table 2: Results from whole workshops questions from the 2021 EathEd Institute Evaluations. Scores are displayed in both number of educators (N) who voluntarily participated in the evaluations and the corresponding percentages to N.

Evaluation Question	Excellent (N)	%	Good (N)	%	Average (N)	%	<Average (N)	%	Poor (N)	%	Total N

Before this course, how would you classify your knowledge of the topics covered in the Geology EarthEd workshop?	2	16.7	4	33.3	5	41.7	1	8.3			12
Were the workshop series objectives clearly explained today?	4	33.3	6	50.0	1	8.3	1	8.3			12
Were the workshop objectives met?	5	45.5	5	45.5	1	9.1					11
Did you consider the level of difficulty of the series to be…?	12	100.0									12
Did the workshops stimulate or maintain your interest in the topics covered?	10	83.3	2	16.7							12
Were the instructors informative and helpful in answering questions?	11	91.7	1	8.3							12
Were the instructors appropriately prepared for the workshop?	8	66.7	4	33.3							12
Please provide an overall rating for the instructors.	11	91.7	1	8.3							12
Do you now know enough on the topics covered to teach a good lesson or implement some of the ideas shared this week?	5	41.7	7	58.3							12
Do you feel comfortable with your ability to conduct hands-on science activities in the classroom?	5	41.7	7	58.3							12
Were the readings and handouts helpful?	6	50.0	5	41.7	1	8.3					12
Would you like to participate in additional courses, workshops, conferences, lectures, etc. through the EarthEd at the University at Buffalo's Departments of Geology and Environment & Sustainability?	11	91.7	1	8.3							12
Did for today's workshop meet your expectations?	7	63.6	4	36.4							11

Please provide an overall rating for the workshop series	12	100.0									12
How would you rate this compared to other professional development?	8	72.7	3	27.3							11
Will you recommend the EarthEd Workshop Series to your colleagues?	11	91.7	1	8.3							12
Would you consider taking another PD with EarthEd/UB?	12	100.0									12

Table 3: Workshop centered question comments.

Liked best about UBEE/most valuable?

- I loved the hands-on workshops. Most valuable is applications for my classroom (and LAVA!)
- Good variety of presentations and info. Good mix of sitting & exploring
- Seeing science taught in context was extremely valuable to me. I find I can learn things better when I see them happening. I really liked seeing the current research from the faculty and getting ideas on how to incorporate it into my classroom
- After challenges and frustrations of the last academic year, it was refreshing and inspiring to work and learn alongside such dedicated professionals. This workshop has excited me to reconnect with my students
- In-depth and highly practical. Staff knowledge and research is very impressive. Informal structure led to more efficiency
- I enjoyed the different topics and how we thought about/figured out how we would use things in our classrooms
- Collaborating with motivated, knowledgeable teachers and professors on novel lessons and topics. Networking with teachers in similar subjects for ideas and perspectives.
- Collaboration. Fantastic group!
- To collaborate with colleagues on topics. Practice practical classroom strategies that I can use in my classroom on topics

Please describe the session that was most valuable and why?

- Hydrology. Testing water flow. I can easily apply this to my curriculum. I am also able to incorporate citizen science into it.

- I learned an entirely new way to demonstrate/conceptualize grain and H2O flow. I also appreciated a new way to conceptualize greenhouse gases.
- The lava flows, hydrology session, and the sediment core samples were all valuable because that is something I teach. This will definitely be included with my lessons next year.
- The planetary geology session. I teach both earth science and astronomy so it has application in both. I will use google earth mar map when discussing what properties make a planet habitable.
- Restoration ecology - loved the field trips and websites. I plan on using them in my class. - LOVED THE GOATS!
- Hands-on fluid flow - I can do this in my classroom
- I enjoyed all of the sessions and can/will directly apply the resources shared in my science classroom. I am very excited to have my students create their own sediment cores from Cayuga Creek.
- Sediment coring can be used to illustrate abstract earth science concepts.
- I thought the 'food web' activity was great as well as thinking about everything Earth Pope (*sic* Sandy Geffner) shared.
- Helping make connections and future planning

Table 4: Teacher-centered question comments.

Additional comments, observations or suggestions?

- It would be nice to have ongoing support in my classroom after the workshop
- Thank you for being so flexible. I feel like a lot of classes (*sic* professional development classes) are scheduled to the minute. This was so great!
- This workshop was amazing! I loved how flexible it was and how helpful everyone was. I would definitely be interested in attending next year and helping out if needed.
- Liked the Good/Bad/Good at the beginning of the day. Liked the flexible atmosphere
- I appreciate the hard work and planning that went into making this an informative and enjoyable week for us. Thanks so much!
- Overall, it was really great and gave me tons of good ideas! :)
- Thank you for this tremendous opportunity to improve my pedagogy and enthusiasm for teaching. Your work is deeply appreciated!

- These were all great and most applied to the current ES (Earth Science) high school curriculum, Change the topics so I can attend next year.
- I experienced more Ah-has. A positive, nice and relaxed setting compared to the chaos this year. Positive seeing how ideas and activities work with groups.
- Thank you for hosting this workshop! Not only did I learn a ton that I can bring back to my classroom, but this has been by far the best workshop I have taken in my time as a teacher. This is exactly the type of thing I enjoy doing for professional development. This has been such a valuable experience for me. Thank you again!!

Topics for the future?

- Atmospheric science (climate and weather) air pollution, etc.
- Anything rocks related (I <3 rocks) meteorology would be great too!
- it would be great to have a workshop in meteorology of the great lakes and how they (the lakes) influence the weather in WNY
- Mineralogy and meteorology
- Stream ecology (stream macroecology)
- Air, H2O. Soil and land pollution, climate change, global warming, deforestation and logging, increase carbon footprint, genetic modification, oceanography, meteorology, astronomy, minerals and rocks.

Future Plans & Pivoting

Financing

While in 2022 our workshop format will remain unchanged, our desire to expand and include a third workshop series centered around sustainability themes and a greater commitment to in-class outreach and support remains. Though a generous financial contribution from a grant award winner in the Geology Department we are able to float a second and third year for free to all attendees, however, to have a higher enrollment closer to our desired capacity, we must shift gears in funding of consumables and/or seek out additional financial resources. We are currently seeking funds through private and public education grants and given our initial successes have been offered financial assistance through an affiliated group at the university (RENEW program). Corporate charitable giving requests is a resource that is potentially available through university offices and sponsorship commitments through materials donation are being considered.

Growing Collaborations

Throughout the subsequent school year, the authors maintained regular contact with several 2021 EarthEd attendees through invitations to local lectures and field trips, supplied information and contacts to STEM resources and opportunities for the educators and their students. Since the announcement for EarthEd 2022 was given, six veteran teachers have reached out seeking to attend the alternate workshop and 3 of these individuals wish to assist and/or run a workshops lesson. Further, these educators have created a buzz within their communities and new relationships with community activists are being forged. In addition, graduate students who participated with one research group in 2021 have sought out commitments to participate again in 2022 and through their conversations with peers, several additional graduate students within both departments are becoming involved in 2022.

Conclusions

The creation of an outreach program, whether top-down, bottom-up, or collaborative, is a daunting endeavor. While a top-down approach ensures financial support and longevity of an outreach program, college or university level management styles may affect the flow and creativity of individual workshops and freedoms in approaches. The bottom-up and collaborative approach does allow for more workshop creativity and freedom in decision making, however, the upfront workload may be overwhelming for smaller groups or individuals seeking to launch an outreach program. The creation, organizing, and implementation requires a diverse set of skills that need to be addressed prior to jumping into such a project no matter what frame-work style is chosen. We strongly suggest a single individual to spearhead communications and organization such as a project manager or coordinator. The success of our program is largely based in the fact that our two departments' faculty and staff are almost always 'on the same page', in that we rarely have division among our colleagues regarding department goals, policies, and desired outcomes, as such, faculty and staff flexibility and assistance was just as important as coordination and organization.

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Environmental Impact, Successes, and Challenges of a Statewide Green Schools Program

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Abstract

This paper evaluates the affect that Green School programs have on their local environment. The design of this study includes the assumption that Green School programs not only benefit students and teachers—while developing their environmental literacy and environmental stewardship—but that the program also provides essential ecological improvements. To perform this assessment, data excel sheets submitted by Maryland Green Schools (MDGS) from 2014-2019 were assessed to quantify environmental parameters and to demonstrate environmental advantages produced by this Green School program. Additionally, representatives from exemplar Greens Schools and random Green Schools across the state of Maryland were interviewed in order to identify factors contributing to the success of the Green Schools program as well as any challenges or barriers green schools are facing.

Key words: Green Schools programs, environmental literacy, environmental stewardship,

Introduction and Literature Review

This paper evaluates the affect that Maryland Green Schools have on Maryland's environment. A Green School is defined as a school consisting of a healthy, safe environment conducive to learning, while simultaneously conserving energy, money, and environmental resources (Boston Public Schools, 2013). Green Schools are designed with the future in mind—providing a scholastic environment for students while teaching them sustainable practices and preparing them to be supporters and leaders towards a healthier, cleaner, more eco-conscious future (Heming, 2017).

Green School programs offer an array of benefits to the individuals involved. Students exposed to Green School programs demonstrate increased confidence, development of problem-solving skills, improved test scores, and improved attention spans when compared to pre-green school program exposure (Heming, 2017). Research indicates that academic performance increases when students are

given outdoor learning opportunities (Bartosh et al., 209; Coyle, 2010; Khan et al., 2019; Kuo et al., 2018; Richmond et al., 2017)). Several studies have documented increased standardized test scores (Ghent et al., 2014; Kweon et al., 2017; Lieberman et al., 2000; Lieberman et al., 2005; Lopez et al., 2008), enhanced attitudes towards school (Arikan, 2021; Fagerstam & Blom, 2013;Shay-Margalit & Rubin, 2016; Waliczek et. al., 2001), improved in-school behavior (Lieberman & Hoody, 1998; Shay-Margalit & Rubin, 2016), and attendance (Price, 2013) in schools that integrate outdoor learning experiences into their curricula versus those that do not. Many researchers believe that these observed performance increases can be attributed to the immersive experience of outdoor learning (Benefield et al., 2006; Gill, 2014; Kuo et al., 2019; Lloyd, et al, 2018; Waite, et al., 2017; Wells et al., 2015; Wells, 2000). One study evaluating the influence of Green School certification found that educational gains and improved environmental performance are exhibited by students in schools accredited as ongoing green (Goldman et al., 2018). An evaluative review on Green School programs involving school gardens assessed 12 different studies and found that 9 of the 12 studies displayed a positive difference in test scores between gardening students and non-gardening students. The review reported that in all the studies, school gardening increased science scores (Blair, 2009).

Similarly, teachers also benefit from training, experience, and exposure to these green programs. Teachers reported that becoming acclimated to Green School programs by leading environmental education programs or by incorporating environmental literacy into their curriculum increased their self-confidence and self-efficacy (Ayaz & Sarikaya, 2021; Haines et al., 2019; Smll et al., 2012).

Natural environments emulate restorative qualities that stimulate children's adaptive developmental processes such as motor fitness, self-confidence, creativity, and learning (Blair, 2009). Students and teachers alike have reported decreases in stress levels after exposure to nature and outdoor learning (Alvarsson et al., 2010; Bratman et al., 2012; Vella-Brodrick & Gilowska, 2022). Outdoor learning offers students an outlet to be active while increasing their physical, social, and mental health. In 2010, the National Wildlife Federation surveyed 1,878 educators on their professional opinions on outdoor learning—75% of the educators interviewed agreed that students who are exposed to regularly scheduled time outdoors exhibit a higher level of creativity and problem-solving skills (Coyle, 2010). As a direct result of outdoor learning exposure, Green School students suffering from ADHD have displayed decreased symptoms (Kuo & Taylor, 2004). The majority of parents with children experiencing ADHD reported a greater reduction in ADHD symptoms exhibited by their children after green outdoor activities when compared to activities involving other settings (Kuo & Taylor, 2004). Aside from promoting independence, confidence, decision-making, and problem-solving skills, outdoor learning also develops students' empathy towards others and develops their self-discipline and initiative. Immersive experiences in nature incite a student's desire to comprehend and cognitively digest ecological concepts and processes (Blair, 2009).

Many researchers support the claim that childhood experiences in green, outdoor environments cultivate lifelong positive attitudes toward nature and sustainability (Louv, 2008). One study conducted by Duerden & Witt (2010) synthesized that environmental programs involving direct ecological experiences catalyzed

environmental knowledge into a stronger motivating force for pro-sustainability, eco-responsibility, and positive environmental attitudes. When students are given the opportunity to participate in environmental projects, they can see the direct progressive effects of their efforts toward sustainability and environmental betterment (Duerden & Witt, 2010). Researchers evaluating environmental education in Turkey observed that these programs contributed to students' gaining an understanding of ecological processes and concepts, developed students' perception of nature, and increased students' eco-responsible tendencies and behaviors (Erdogan et al., 2013). These opportunities provided by Green School programs allow students to feel a part of something larger than themselves. As a result of involvement in environmental projects and programs, students exhibit improved eco-attitudes (Bergman, 2015; Robina-Ramirez & Medina-Merodio, 2019). The demonstrated increase in eco-attitudes epitomizes the significance and value of Green Schools and Green School programs (MacLeod, 2012).

Maryland Green School Program

The Maryland Green Schools Award Program (MDGS) is the primary Green School program for the state of Maryland. MDGS is designed as an opportunity for schools and their surrounding communities to investigate the positive and negative ecological impacts their school is having on the surrounding environment (Maryland Association for Environmental and Outdoor Education (MAEOE, 2019). By implementing the MDGS program, students are empowered to make real changes by advocating and employing sustainable practices thereby fostering environmental literacy while also reducing the school's environmental impact (MAEOE, 2019). The MAEOE designed this program to provide eco-educational opportunities for students ranging from pre-K through 12th grade in hopes of increasing environmental awareness and stewardship across all age groups. The MDGS program is aligned with the Chesapeake Bay Watershed Agreement goals (Chesapeake Bay Program, 2022) while also supporting the Maryland State Department of Education environmental literacy standards and environmental literacy graduation requirement (State of Maryland, 2020).

In order to become a certified MDGS, a school must meet the Green School objectives set by MAEOE; these objectives include environmental issue instruction, professional development, altered environmental behavior, celebration of sustainable practices, responsible transportation and reduced emissions/carbon footprint, pollution reduction, water and energy conservation, structures for environmental learning, habitat restoration, solid waste reduction, and community partnerships (MAEOE Green Schools application, 2018). Upon completion of the listed objectives, a school has earned its certification as a Maryland Green School (MDGS).

Currently, there are approximately 681 registered Maryland Green Schools. Maryland Green Schools receive instructional aid from their partnerships with either a Green Center or Green Leader—or from both for some Maryland Green Schools (MAEOE Green Centers Program, 2022; MAEOE Green Leaders, 2022). A Green Center is assigned to a school becoming "green" and is a useful resource even after achieving certification. Green Centers provide valuable information

about the Maryland Green School Program. Green Center staff and volunteers assist schools working towards certification. Green Leaders are the individuals representing the assigned Green Center. They act as MAEOE's navigators for the MDGS program by guiding uncertified schools through the certification process and helping these schools devise green projects to meet the requirements of certification. Again, they are a valuable resource even after receiving this award.

One study evaluating the influence of Maryland Green Schools on student achievement concluded that students enrolled in Green Schools display higher performance levels across all assessed criteria (Ghent et al., 2014). These conclusions were based on a 3-year assessment of pre- and post-Green School designation from exam pass rates in reading and math for 5th and 8th graders and exam pass rates in math, biology, English, and language arts for secondary students. The data showed that the 5th and 8th-grade students' Martland School Assessment performances in reading and math increased significantly from pre- to post-MDGS program instillation. Additionally, 10th-grade students also demonstrated a significant increase in algebra and English from pre- to post-MDGS designation (Ghent et al., 2014).

As previously stated, research confirms that the MDGS program provides various benefits for students, teachers, and leaders involved; however, the environmental impacts of the programs have not yet been thoroughly evaluated. The primary assumption for this research is that Maryland Green Schools not only positively affect all individuals involved but that they also provide positive benefits to the environment. Therefore, the objective of this study is to evaluate all Maryland Green Schools and their impact on the local environment by quantifying several different environmental parameters. The research question is "What are the environmental impacts of Maryland Green Schools?"

Methods & Materials

Quantifying Environmental Impact

This study is an analysis of the environmental impact of Maryland Green Schools (MDGS). Environmental impact was measured by quantifying numerous environmental parameters based on green school project data submitted to the MAEOE by certified MDGS. The environmental parameters quantified include pounds of recycled material; footage of stream bank cleaned; number of trees or shrubs planted; square footage of rain gardens installed; percentage of schools with no idling zones; percentage of schools that compost; volume of rain barrels installed; square footage of gardens installed; number of bird boxes created; square footage of habitat installed; and square footage of invasive species removed. The exact values for all listed environmental parameters for MDGS were determined using data provided by the MAEOE (MAEOE Green Schools Program, 2019) from 2014-2019.

The data supplied by MAEOE was utilized to provide a general statement of how MDGS are performing in all seven categories of the MDGS application which include Water Conservation/Water Pollution Prevention, Energy, Solid Waste Reduction, Habitat Restoration, Structures for Environmental Learning, Responsible Transportation, and Healthy School Environment (MAEOE Green Schools Program, 2019). This study evaluates 635 MDGS that were certified at the time of the

study and analyzes quantitative environmental action project data of these schools.

Environmental Interviews

The second portion of the study consisted of a series of interviews including four exemplar green schools, four random green schools and three non-green schools; one of each was chosen from Southern, Central, Western, and Eastern Maryland. The interview portion was designed to identify perceived barriers as well as elements of the program that have contributed to the success of MDGS programs in these schools. These factors were identified with the goal of improving the MDGS program as well as making these elements known so that schools considering seeking MDGS status or states running similar programs may consider how these barriers and positive attributes may affect them.

An exemplar green school was defined as a certified MDGS that is continuously expanding on its environmental action projects, incorporating environmental literacy into all subjects, and is effectively inspiring the local community to contribute to the school's environmental projects. Non-green Schools were interviewed to measure statewide awareness of the program as well as to determine whether or not Non-green Schools are implementing their own green initiatives outside of the MDGS program. Interviewing Non-green Schools was necessary in order to determine whether these Non-green Schools find the MDGS certification process motivating or meaningful. This helped us to understand why there are still Non-green Schools across the state that have not yet partaken in the MDGS certification process.

In each region, one county was chosen from which one of each type of school (exemplar, green, non-green) was selected. The county chosen in Southern Maryland consisted only of Green Schools, explaining why non-green schools were interviewed in three of the four counties rather than four as initially planned. When reaching out to these schools to ask for their participation in the project, the non-responsiveness of most schools was surprising. This made the process of finding representatives from four schools in each county a bit difficult and rather time-consuming as many schools never replied or declined to participate. As many schools as possible were contacted in each county—in some counties, all schools were contacted. Schools included in the interview portion of the study were those that were willing to participate and offer insight and information. Thus, the sample was based on convenience.

Administrators/teachers from each of these schools were interviewed to determine what facets of the Maryland Green Schools program are most challenging and what facets are most beneficial. Interviewing non-green schools provides insight regarding statewide awareness of the program and provides reasoning as to why some schools have not yet begun the Green School certification process. Determination of these potential barriers revealed what needs are and are not being met and thus, will enable MAEOE to better serve future green school applicants.

The interview questions for exemplar and random Maryland Green Schools included:

- ☐ What kind of relationship does the school have with Green Centers or Green Leaders?

- ☐ What is the community involvement?
- ☐ What green school implementations have worked best? What implementations have not worked?
- ☐ Has administrative consistency made a difference in your success as a Green School?
- ☐ Is there a correlation between administrative consistency and how many grades the school expanded on since first application?
- ☐ What is the overall impact of the Green Schools program on the entire school? Are there more students involved in clubs that are environmentally based since the school achieved Green School status? Are there more teachers involved?
- ☐ How many established partnerships does the school have?
- ☐ What are some barriers your school is facing that have prevented it from expanding since certification?
- ☐ If you had unlimited funding, what would you do next?
- ☐ How can MAEOE help your school further its expansion?

Interview questions for Non-green Schools included:

- ☐ Have you heard of the Maryland Green Schools (MDGS) program?
- ☐ Are you interested in learning about the MDGS program?
- ☐ Does your school have a green initiative?
- ☐ Do you know if your principal is supportive of Green School programs?
- ☐ Does Green School recognition motivate you to become certified?
- ☐ Does your school possess a "green grant"?
- ☐ Does your school have an eco-club, Future Farmers of America, 4H, or participate in a BioBlitz?

These questions were asked with the intention of determining and addressing barriers that Green Schools face after certification which prevent them from further developing sustainable practices.

Quantitative Results

After evaluating the data excel sheets provided by MAEOE, the following quantifications were determined (See table 1; table 2). The MDGS program began in 1999, however, green initiative data was not recorded until 2011. In the early years of data collection and recording, the data was recorded inconsistently. Beginning in 2014, a data record template was created and used consistently; however, there were still a few key differences in documentation style between 2014 and 2015, hence we are presenting the parameters in two separate tables.

Table 1: Table demonstrating quantified environmental parameters from 2014 to 2019.

Environmental Parameters	Number of trees/shrubs planted	Square footage of plants implemented (ft^2)	Square footage of habitat implemented (ft^2)	Square footage of raingardens implemented (ft^2)	Volume of rain barrels implemented (gallons)
2014-2019: Totals	36,674	24,135,066.1	21,722,090.77	600,268.1	65,399

Table 2: Table depicting quantified environmental parameters during 2015 to 2019.

Environmental Parameters	Square footage of garden area implemented (ft^2)	Square footage of Invasive species removal (ft^2)	Number of bird houses created	Stream bank cleaned (feet)	Recycled Material (lbs.)
2015-2019: Totals	71,262.05	1,128,678.13	2,955	202,411.5	14,642,231.79

To generate the percentages in Figure 1 and 2, Excel sheets provided by MAEOE for each year (2015-2019) were utilized to determine, of the Green Schools recorded, how many indicated that they are currently incorporating composting (Figure 1) or a no idle zone at their schools (Figure 2).

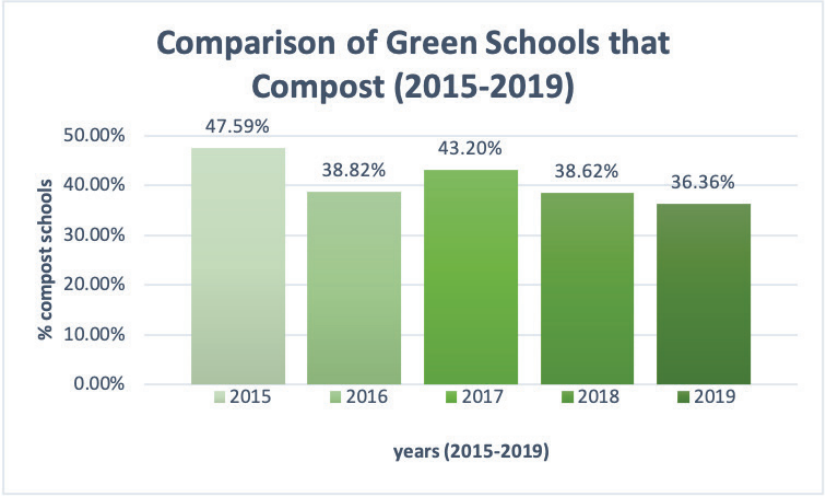

Figure 1: Graph demonstrating the annual percentage of Green Schools that compost from 2015 to 2019

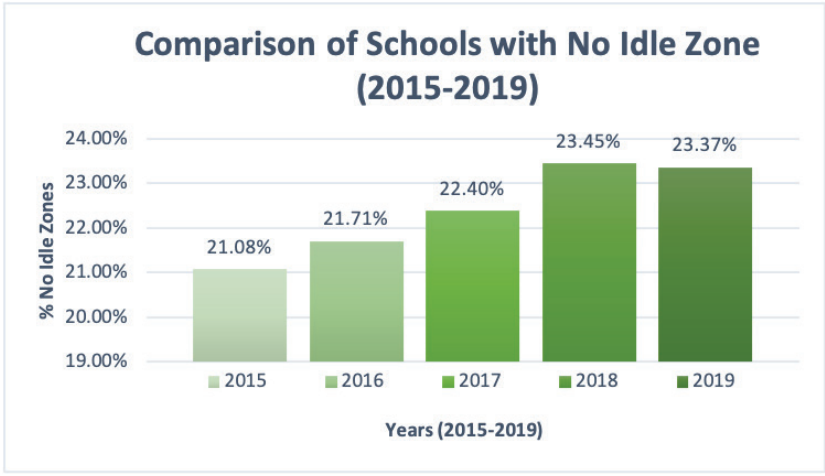

Figure 2: Graph demonstrating the annual percentage of Maryland Green Schools that enforce a no idle zone during student drop-off and pick-up from 2015 to 2019.

Discussion Quantitative Implications

These quantified environmental parameters provide insight as to how well MDGS are performing in all seven categories of the MDGS application. They also indicate the numerous benefits that these implemented initiatives are providing for Maryland's environment. Maryland Green Schools accounted for over 36,000 trees planted within the state. This is a vast environmental achievement. A sapling absorbs about thirteen pounds of carbon dioxide each year (Bordelon, 2019). Being that MDGS planted approximately 36,674 trees (from 2014-2019), that translates to 476,672 pounds of carbon sequestered each year. A mature tree absorbs forty-eight pounds of carbon each year (Keystone 10 Million Trees Partnership, 2022). Once these planted trees reach maturity, they will sequester nearly 1,760,352 pounds of carbon each year, resulting in a positive environmental impact.

Aside from carbon sequestration, these trees can also serve as a tool for flood mitigation and Best Management Practices (BMPs). In both suburban and urban settings, a single deciduous tree has the capacity to capture between 500-760 gallons of rainwater/runoff per year (Keystone 10 Million Trees, 2022). Each year, the 36,674 trees planted intercept 18,337,000 to 27,872,240 gallons—depending on the maturity of the tree.

Additionally, the planted trees provide energy savings via their strategic placement around school buildings. These strategically placed trees can reduce air conditioning by 30% and can save 20-50% in energy used for heating. These trees create a net cooling effect making it so that each tree serves as ten room-size air conditioners operating about twenty hours a day (Keystone 10 Million Trees, 2022). Not only do these strategically placed trees provide energy savings but they also reduce annual heating and cooling cost by eight to twelve percent (Keystone

10 Million Trees, 2022).

Based on the quantified environmental parameters, it was determined that MDGS are performing spectacularly regarding the following categories of the MDGS application: Water Conservation/ Water Pollution Prevention through implementing raingardens and stream bank cleanups; Energy by not only providing energy savings through strategic tree placement but also by implementing energy efficient light bulbs and motion sensing light switches; Habitat Restoration via plant, shrub, habitat, and bird house installation; Structures for Environmental Learning by employing garden and habitat areas, pollinator gardens, and outdoor classrooms; and Healthy School Environment as all of these implemented initiatives grant students access to new and beneficial experiences.

Analysis of the quantified values indicated that the two categories in which MDGS are performing very well but could still stand to improve are Solid Waste Reduction and Responsible Transportation (Figure 1 and 2). As demonstrated by Figure 1, each year (from 2015-2019), less than fifty percent of Maryland Green Schools compost. Although Maryland Green Schools have significantly contributed to Maryland's Solid Waste Reduction by recycling over fourteen million pounds of materials since 2015, increasing the percentage of Green Schools that compost is the key to improving MDGS performance in Solid Waste Reduction. By encouraging more MDGS to compost, we can reduce materials deposited at landfills and can reduce greenhouse gas (GHG) emissions (Environmental Protection Agency, 2022). In addition, composting provides various benefits including soil enrichment by increasing moisture retention and suppressing plant pests and diseases. Composting reduces the need for chemical fertilizers that can be harmful to students and the environment. Food and yard waste composition promotes production of beneficial bacteria and fungi that aid in degrading organic matter into humus which provides rich nutrients for local plants (Environmental Protection Agency, 2022). Several teachers and administrators at different Green Schools across the state were interviewed to provide insight as to why so few MDGS implement composting.

From these interviews, it was determined that the most common reasons contributing to the lack of composting at MDGS include lack of administrative support, spatial limitations and restrictions, and safety concerns. Many teachers expressed that their school was unable to implement composting due to administrative pushback out of concern that composting bins and barrels might attract wildlife and become a safety hazard for their students. Across the state, many counties require schools to have their composting bins a specific distance from the school building, numerous MDGS are incapable of meeting this requirement due to school grounds' spatial limitations. If we can find a way to address these composting concerns and limitations, not only will MDGS improve their Solid Waste Reduction performance, but the state of Maryland will benefit as a whole by reducing its carbon footprint.

Regarding Responsible Transportation, from 2015 to 2019, less than twenty-five percent of MDGS enforced a "no idle zone" during student drop-off and pick-up (Figure 2). Responsible Transportation is the most complicated category to record and to implement. The primary methods that schools employ for Responsible Transportation are carpooling, no idle zone, school bus system, public transportation, and walk/bike to school days. Other methods to implement Re-

sponsible Transportation include showing students biking safety videos, installing bike racks, carpool training, etc. This category proves challenging for MAEOE to record being that schools have to try to report their estimated percentages of students and teachers that carpool, take public transportation, utilize school transportation, and students/teachers that participate in walk/bike to school events. This data can be difficult to gauge and even more difficult to implement based on location and responsiveness of student, parent, and teacher body. All of these implemented methods can only be suggestions, they are not designated projects, thus, there is no obligatory participation or guarantee that they will make an impact. Additionally, location significantly contributes to the success of these Responsible Transportation implementations. In submitted MDGS applications, teachers expressed that location affected the effectiveness of implemented transportation efforts. Several stated that because the community was near the school, the majority of students utilized the school bus system and the remaining student body either walked or rode their bikes to school or carpooled. Some schools even employed a "walking school bus" which was led by a group of teachers that would safely walk a group of students to school each day.

There were several schools that expressed that public transport was too far from their school for students, making it so most students utilized the school bus system; only one family walked to school due to the area being too rural for students to safely walk there. Although these are challenging obstacles to address, they are crucial to the successful reduction of Maryland's carbon footprint. Not only would implementing a "no idling zone" at all Maryland Green Schools provide various benefits to the environment, but also to students, teachers, and parents. We must consider the detriment we are inflicting upon students walking to designated vehicles as well as the teachers guiding them as they are all subjected to dangerous fumes emitted by the idling vehicles they walk past (Minos, 2022). Inclusion of no idle zones is crucial to protecting students and teachers who can suffer stunted lung growth and can experience lung disorders such as asthma (Minos, 2022). Additionally, idling vehicles release harmful GHGs (greenhouse gases) and consume copious amounts of petroleum which negatively impacts the environment by contributing to carbon pollution and atmospheric (global) warming (ibid). If we can convince MDGS to enforce obligatory protocols that must be followed, such as an enforced "no idle zone" for bus drivers and parents/guardians, this would be a major step in the direction of carbon emission reduction.

Qualitative Results

From interviewing non-green schools, random Green schools and exemplar Green schools, the following observations were made:

- ☐ All non-green schools reported that they do not find green school certification to be a motivating or meaningful title
- ☐ All three non-green schools interviewed stated that they were aware of the Maryland Green School program
- ☐ Two of the non-green Schools specified that they were not interested in learning more about the MDGS program
- ☐ Two of the non-green schools have an environmental club/host ecological

seminars
- ☐ All non-green schools implemented green projects at their school despite not being certified
- ☐ All principals interviewed stated that they support the program although their school is not currently a MDGS
- ☐ Administrative support is completely crucial to success as a green school
- ☐ Having enough teachers involved in a school's Green School program determines the school's ability to maintain or expand green initiatives
- ☐ The more partnerships a school can generate, the more resources they have access to and ultimately the better they perform as a Green School
- ☐ Exemplar Green Schools incorporate green initiatives and projects into all scholastic subjects
- ☐ Exemplar Green Schools choose directly applicable projects that serve a purpose
- ☐ Exemplar Green Schools efficiently involve most of—if not all—staff members
- ☐ Teacher trainings are important for growth
- ☐ Some of the biggest barriers are that Green Schools face are pushback from grounds grew and administrators on outdoor projects and change of staff with no successor to continue the program

Discussion Qualitative Implications

It was reassuring that all non-green schools interviewed stated that they were aware of the Maryland Green School program as this indicates that the program is being properly advertised across the state. Two of the Non-green Schools articulated that they were not interested in receiving more information about the MDGS program, giving reason that certification was an undertaking that their school is not yet equipped for. One of the principals expressed that "as a small school and working as a Teaching Principal in a Title I School, the focus is on our students. Our staff work diligently to implement the Maryland State Curriculum in a way that engages our students in active hands-on learning." Although the school is focused on hands-on learning, it is not yet prepared to meet the requirements of Green School certification. The other principal that declined further information on the program explained that she had previously been employed at a MDGS and was aware of all that it entails and felt that her school was not yet ready for the work necessary to obtain certification. In comparison, the third school interviewed expressed interest in learning more about the program as they are in the midst of achieving certification and felt as though the more informed they are, the better implementations they can employ.

Although these non-green schools are not certified, they still delegate efforts toward including green practices such as outdoor classrooms and stream banks cleanups. A couple of the schools interviewed had several excellent projects in place including a trout raise and release program as well as allowing students to explore the local watershed and complete water quality testing to learn how water quality affects the local trout population. Additionally, this non-green school was engaging in a partnership with the Maryland Department of Natural Resources (DNR) by which the school monitored American Chestnut trees for DNR scien-

tists. The school also tapped trees in a maple grove located on school property, created a pollinator garden, and planted an apple orchard. These outdoor structures were utilized as tools to provide hands-on, outdoor learning experiences for their students. This year, the school plans to implement more initiatives including a greenhouse project and a rain garden that will collect run-off from the parking lot.

One of the most surprising discoveries made was that all the non-green Schools reported that they did not find the Maryland Green School title to be meaningful. This indicates that more work needs to be done marketing the program to show people the positive benefits that this program offers for its students and staff. These non-green schools need assurance that achieving certification is not about the award itself but is about incorporating practice that will strengthen the spirit of their school's community.

When asked if they found the MDGS award to be meaningful, one of the principals stated that "our focus is on providing quality education through the most motivating and engaging activities for our students. The banner is motivating to some schools but…the recognition we seek is through our students not the [MDGS] flag." Another principal plainly stated that that title does not prove to be meaningful. As mentioned, one of the schools interviewed is currently in the process of obtaining Green School certification—the green team leader at this school explained that after convening with her green team of high school students, they collectively decided that they wanted to become certified, not for the sake of having that title, but because they want to create a green community within their school and certification was the best method for holding themselves accountable in reaching this goal.

Practically all the interviewed non-green schools possess an environmental club or incorporate ecological seminars. One of the schools had both an environmental club and a climate action team that students could attend after school. An elementary school interviewed hosted voluntarily eco-seminars for each grade level where students from a neighboring high school would come and administer presentations to the elementary students.

Thorough interviewing of random and exemplar Green Schools across the state of Maryland allowed for the identification of key factors and differences regarding characteristics that comprise a successful Green School versus an exemplar green school. A successful Green School is a school that has met all objectives set by the MDGS application and is continuously working on progressing initiatives at their school. In comparison, an exemplar Green School is a school that has gone above and beyond the requirements of the MDGS application and is constantly employing new and innovative ways to incorporate sustainability. Becoming an exemplar green school requires time, patience, and effort—it is not something that is achieved during the initial certification process but rather is something that a school must work on achieving and perfecting.

Both successful and exemplar Green Schools demonstrate the value of administrative support. All schools reported that administrative support was essential to their growth as a Green School—many green team members articulated that it is impossible to accomplish anything without the support of your administrators. Several interviewees stated that oftentimes, projects flow more smoothly when your administrators back your projects or are involved in some way as, sometimes, there are necessary approvals that can only be obtained or are easier to obtain as

an administrator.

At these successful and exemplar Green Schools, the green team members were always established principals, teachers, or staff that had been at the school for several years—anywhere between five to twenty-two years. Having these long-standing employees and relationships allowed these schools to continuously progress and innovate new initiatives being that all members were aware of and endorsed the school's green projects. Successful Green Schools always have at least three green team members—when a school has one or two people responsible for all sustainable developments, it is overwhelming and difficult to maintain and advance initiatives.

Exemplar Green Schools discussed the importance of incorporating shared responsibility by having most, if not all staff, involved in green initiative implementation and development. They explained that having most or all staff involved makes sustainable incorporation much easier and more achievable. Although many schools struggle with getting most or all staff involved, shared responsibility is the best method for progressing your program within your school. Teachers have a lot on their plates, oftentimes making it challenging to convince teachers to participate in their school's green team; however, as explained by one the exemplar Green School principals, schools must focus on incorporating the Maryland Green School program into every subject before they can effectively get more teachers onboard. This principal mentioned that at her school, they utilize green projects and green project data to teach all subjects. For example, the school conducted a green project with students by which they recorded data, they used this data and incorporated it into math class to teach decimals. They created a school garden and had their elementary students plant the seeds, they used this as an opportunity for a math lesson on how to use a ruler to measure the distance between seeds as well as a reading and comprehension lesson by having the students read and comprehend the instructions on the back on the seed packets. This method of incorporation makes it feasible for teachers to participate without increasing their workload while simultaneously promoting sustainable practices and environmental literacy.

The story of Crellin elementary school

Crellin Elementary School (CES) is located in Oakland, Maryland within Garrett County. The town of Oakland is the west-central part of Garrett County. Crellin Elementary is a near perfect example of a successful Green School. CES is the true embodiment of MAEOE's intended purpose of the MDGS program. This school has worked diligently with its Green Centers such as Hickory Environmental Center to meet the needs of their Green School and to provide more opportunities for their students. Crellin has gone beyond working with their assigned Green Centers and has developed partnerships with key organizations such as the Chesapeake Bay Foundation and Smith Island to supply their students with new immersive eco-educational opportunities as well as to provide staff with inspiration for new environmental action projects.

CES has the complete support of their community; community members are the muscle behind many of their implemented projects. Their principal expressed that it took time to evoke communal involvement, but she began with asking parents and community organizations for help and was able to convince these members to volunteer.

In regard to initiative implementation, Crellin's principal stressed the importance of incorporating initiatives into what is a current need or problem at their school. This allows students to witness issues that are affecting their school and become actively engaged in solving these issues. Crellin's motto is to teach students to take care of their own space because they must first learn how to tend issues in their own backyards before they can solve issues in distant places.

Principal Dana McCauly also expressed the importance of learning from unsuccessful implementations. She stated that she did not see any unsuccessful initiatives as failures but rather used them as an opportunity to convene with staff, discuss why they did not work, and find a new approach. For example, students at Crellin Elementary planted different plants in an area on campus, but none of the plants grew. Rather than perceiving this as a failed attempt, they used this as an opportunity for students to study the soil area to determine exactly why the plants did not grow. As projects are incorporated—whether successful or not—the more everything builds off of each other and continues to expand.

Overall, the main attributes of Crellin that have contributed to its success as a Green School are reaching out for assistance from organizations and community members, actively engaging students, trying new things, and making the best out of any situation.

Several of the schools reported having involved Green Centers or Leaders as well as community members provided them with crucial resources. For example, a green team at one of the schools planned to attend a teacher training at their Green Center that would provide their teachers with information on how to incorporate environmental literacy; however, the training was going to cost twenty-five dollars per participant and the school was unable fund the training so their Green Center graciously waved the fee so all the teachers could attend. Green Centers also provided outstanding site visits such as animal shows for students, or even Green Center employees hosting educational discussions for teachers to attend. Exemplar and successful Green Schools expressed the criticality of their community partnerships. Examples include partnerships with a local nursery that was able to provide the school with discounted plant prices, with the community beekeeper that would come and speak to the students on the importance and purpose of pollinators, or simply parents within the school stepping up and assisting with green initiatives such as garden maintenance. Exemplar Green Schools always possess between five to ten or more partnership thereby exemplifying the influence and contribution that these partnerships have on the growth and development of a school's sustainable practices.

As previously mentioned, exemplar Green Schools emphasized the purpose of incorporating the program into every subject as well as picking projects with purpose. Picking a project with purpose involves integrating green initiatives that meet a need or address an issue on the school's campus or surrounding community. For instance, one exemplar school decided to plant a pumpkin patch because they wanted pumpkins; however, this project did not last being that it served no purpose. The school learned from this experience, decided to replant the pumpkin patch with the intent of using the pumpkin seeds to discuss plant growth and reproduction and used the harvested pumpkins to cook with during home economics class.

The exemplar Green Schools also emphasized the cruciality of reaching out and asking for assistance. Many expressed that if they had been apprehensive about contacting MAEOE, Green Centers, or community members for access to resources, their school would not have progressed as fluidly and exceptionally as it has.

Interviews of MDGS determined specific factors that have contributed to the success of these green schools including administrative support, partnerships, and incorporation of purposeful, applicable projects. Another factor that has contributed to Green School success is teacher trainings. These trainings expose teachers to information that better prepares them as environmental educators and equips them with knowledge of innovative sustainable practices. A primary contributing factor to Green School achievement is effectively involving your surrounding community. Successful Green Schools efficiently create a green culture at their school by engaging parents and community members. By engaging parents and giving the opportunity to participate in green projects, parents observe the positive impact that the program is having on their children and are encouraged to become involved themselves by assisting on projects and project maintenance.

Success can also be achieved via collaboration with neighboring schools. Several green team leaders conveyed that some of their most successful projects had been in collaboration with neighboring schools—some of the projects were long-standing and had been going on for more than two years. Even simple collaborative efforts such as having upperclassman at high schools teach lessons or administer readings to students at neighboring elementary or middle schools is a great opportunity for partnership extension as well as a meaningful experience for all students involved.

Lastly, a primary contributing factor to success can be staff and administrative consistency. Staff and administrative consistency allow for uninterrupted development and progression of projects. When staff is constantly changing, it is difficult to maintain an established green team, responsibility is always shifting, and incoming staff require training on current operations—these all prove to be hindrances to green growth. Staff and administrative consistency can be increasingly difficult, depending on the population density of the school's location. In western Maryland, the counties are generally more rural, and people tend to remain employed at the same school for an extended time, allowing these schools to maintain an established green team and projects. This issue highlights the importance of incorporating the program into all subjects as a means to get all teachers involved in some way. If a school is able to do this—involve most or all staff—then there is less concern when a staff member leaves as there will be staff remaining that

can continue established projects. Without this incorporation, schools run the risk of not recertifying being that once it is time to recertify, there may be no staff remaining to carry the projects or fill the application. There were Green Schools contacted to fill out the Green School survey; however, these schools were unable to do so as they no longer employed any staff that were involved in the initial certification process. This is a pertinent issue for the statewide expansion of the MDGS program, as well as achieving the goal of fifty percent of Maryland schools being Green Schools by 2024.

Conclusion

Common Barriers to Expansion

Interviewing Maryland Green Schools granted these schools the opportunity to voice obstacles they are facing, thus demonstrating common barriers to green expansion experienced by Green Schools. One of the most commonly reported issues was receiving pushback from grounds crew when trying to install outdoor projects such as gardens or habitat areas. Green team members reported that grounds crew were in opposition of outdoor project installations due to creating additional work for crew members that now have to mow around and avoid these designated project areas. Because of receiving continuous pushback, many green team leaders were unable to install their desired outdoor projects and were limited to only maintaining their current outdoor projects. A green team leader from an elementary school had been caring for her school's garden for over eight years—this past summer, the grounds crew mowed down the garden. This pushback is extremely demoralizing for those wanting to install or for those caring for installed garden and habitat areas. It is understandable that grounds crew feel frustrated and feel as though their workload is being increased; however, for the sake of green expansion amongst Green Schools, discussions between grounds crew and green teams must occur in order to find common ground and to move forward. Several teachers also mentioned receiving administrative backlash via constant emailing involving keeping gardens and other outdoor projects looking satisfactory, thereby, setting a precedence of continuous pressure on teachers.

County pushback is also a major hindrance that Green Schools across the state are facing. Numerous counties require special permission for projects such as raised beds or rain gardens. Although the county does not directly fund the project in any way, counties require submission of extensive paperwork fully describing project details and cost analysis. The additional effort required to obtain special permission for these simple projects deters teachers from pursing and installing these projects.

Practically all Green School staff mentioned time restricting them in some capacity. There are instances when projects take more time than anticipated, which can cause projects to never reach completion. For Green High Schools, where students often design their own projects, these projects can take a long time—if students, do not complete the project before graduating, the project dissipates when the student leaves. A green team leader from a school in Wicomico County

expressed that she feels the need to pursue freshman for student-led projects making it so she will have a full four years to work on projects since she has so many juniors and seniors that devise amazing projects that do not come to fruition due to time constraints.

Inadequate funding for environmental initiatives or for teachers and staff to attend more environmental education conferences and trainings can be extremely limiting. In order to progress sustainable development, Green Schools require sufficient funding for planned projects. Attending conferences and trainings are essential for equipping green teams with the necessary knowledge and inspiration to expand environmental literacy within their schools.

For various reasons, garden upkeep and maintenance were frequently described barriers. Some teachers reported having underestimated the effort required for garden installation and conservation and were not properly equipped to nurture their garden. Others reported that they were solely responsible for tending their school's garden—without assistance from students, parents, and other staff, this is often not sustainable long term. Those who were exclusively accountable for their school's garden and were able to maintain it reported struggling to preserve it during the summertime when their availability was much more limited. Additionally, teachers who were the sole caretakers of their school gardens expressed concern that once they leave their school, they have no staff that will take over garden maintenance. To ensure school garden success, schools must incorporate garden care into the school day, incorporate garden duties into environmental clubs, or ensure that several staff, parents, or students are involved in garden care.

As previously discussed, many teachers yearn to incorporate composting into their Green School program but are met with many obstacles including administrative pushback out of concern of composting bins attracting wildlife or spatial limitations making them unable to meet county requirements to have bins a specific distance from school building.

Additionally, county regulations prevent some schools from incorporating recycling programs at their schools. Certain counties refuse to pick up recycling at their local schools based on the school's location or other factors making it impossible for these schools to recycle; thus, hindering Maryland Green School recycling performance. Several teachers mentioned that for years, they have taken materials such as juice pouches, crayons, and glue sticks to be recycled at facilities that are now no longer accepting these materials, forcing these teachers to discontinue this specific recycling program.

Another primary barrier to green expansion is administrative pushback on implementation of more extensive environmental projects such as green wall or green house installation. Many schools are unable to execute such projects due to absence of funding. Green Schools that are able to financially afford these projects are often met with lack of support from their schools and are impeded by their administration.

It was repeatedly cited that many found maintaining enthusiasm and momentum to be challenging—inability to do so impedes advancement. After achieving initial certification through employed initiatives, schools face the possibility to entering a stagnant state in which they are complying enough to maintain certification but not expanding their program any further. It is vital to Green School development to continuously devise innovative means of captivating the attention

of all students, teachers, and staff, not only for the sake of ecological expansion across the school's campus, but also Maryland's local environment.

Failed Initiatives

Extensive interview analysis demonstrated frequently failed initiatives as well as why these initiatives were unsuccessful. Professional Development (PD) such as teacher trainings and conferences are crucial to providing inventive insight for environmental literacy and green initiative installment. Most schools do not have funding available to give their teachers these PD opportunities. Several schools struggled with ineffective student-led projects due to students' lack of interest to lead their own projects, students leaving their school, or students graduating before project completion. School gardens failed due to improper garden care or lack of support from other staff, parents, and students. As previously mentioned, school recycling programs failed due to their respective counties putting an end to recycled material pickup as well as many facilities that recycled materials such as crayons, juice pouches, and glue sticks no longer accepting those types of waste.

Successful Initiatives

Certain Maryland counties do not pick-up recycling at local schools; in response, many schools have launched their own recycling programs. Schools have introduced student-run recycling programs where their students are responsible for ensuring that the recycling is placed in the correct bins—teachers and parents then take these materials home to recycle themselves. One Green High School we interviewed has a completely student-run recycling program. These high school students were so dissatisfied that their county no longer offers recycling pick-up that, at the end of each week, students volunteer to take these materials home and recycle them.

Many teachers expressed that outdoor classroom installation has been an incredibly beneficial tool for outdoor education, learning, and exposure for students. Teachers reportedly enjoyed teaching their students in these outdoor settings and stated that students also enjoyed utilizing the outdoor classroom, making this initiative a great structure for captivating students' attention.

In relation to outdoor classroom installation, birdhouse installation and maintenance is another excellent tool for outdoor education and stimulating student's excitement and interest in nature. Many Green Schools with installed birdhouses had their students periodically clean out these birdhouses and perform any necessary maintenance. This hands-on experience grants student's direct exposure to nature, provides them with the opportunity to observe nest structure and nesting behavior, acts as a learning opportunity for bird reproduction and incubation, and ultimately teaches students eco-responsibility. Teachers stated that this direct exposure empowers students as they are able to first-hand witness the positive contribution they can make.

To fund environmental action projects, many schools hosted events to raise money for any materials needed for environmental action projects. To fund their initiatives, some schools hosted yard sales of unwanted clothing and items donated by students. One elementary school in Howard County sold T- shirts with turtles

on them to promote plastic use reduction and used the T-shirt sale revenue to fund installation of a refillable water station. Hosting funding events is not only a great tactic for raising project money but also for reaching out to the community to raise awareness of the program, educate the public on sustainable practice, and discuss what they can do to contribute to the betterment of their local environment.

Although there are schools that are unable to recycle due to extenuating circumstances, overall, MDGS have efficiently incorporated recycling into their programs including paper and ink cartridge recycling. In North America, approximately forty thousand tons of plastic and metal are spared from landfills annually as a direct result of recycling ink cartridges (Graphique Creative, 2021). By recycling ink cartridges, MDGS prevented these cartridges from being discraded at landfills where they would take more than one thousand years to decompose. Additionally, ink cartridge recycling reduces air and water pollution caused by landfilling and incineration; conserves natural resources such as timber, water, minerals, and petroleum; saves energy; and reduces GHG emissions (Graphique Creative, 2021). Paper recycling also reduces GHG emissions that contribute to climate change via methane emissions, extends supply of fiber, contributes to carbon sequestration, saves landfill space, saves energy and water, and decreases carbon dioxide emissions via reducing paper incineration (Environmental Protection Agency, 2016).

Maryland Green Schools have efficiently employed energy monitoring via installation of light switches that automatically turn off; installation of energy efficient bulbs; low-flush, dual-flush, or composting toilets that provide water savings; solar panel installation; as well as strategically planting trees along school buildings in order to provide shade and energy savings. A few schools interviewed shared that their school buildings were previously rebuilt or were being rebuilt; in these new buildings, eco-friendly architecture was incorporated such as pressed wood, high efficiency windows, and green roofs.

Pollinator gardens have proven to be a great resource for Green School teachers and students. Pollinator gardens serve as an excellent means for teaching students about pollinators and the importance of pollination. Students also help tend these gardens, providing additional first-hand experiences as well as teaching them environmental stewardship. Pollinator gardens also grant students with the opportunity to express creativity and to develop their critical thinking skills. An elementary school teacher assigned her fifth-grade students a research project by which the students were instructed to devise a product that assist pollinators in some way—she left this project open-ended so that students could employ their creative thinking skills. After completion of the research project, this teacher then had her fifth-grade students teach the second graders all about pollinators. The fifth-grade students thoroughly enjoyed this assignment; they became very invested, excited, and overall, proud of themselves and all their hard work.

Many schools hosted periodic seminars where students would voluntarily attend and learn about different environmental topics such as decomposers, the food chain, and the role of the food chain. Some schools have continued hosting seminars virtually during COVID-19 and students have still attended. This is incredibly impressive considering that students attend school virtually each day yet, they are interested enough in these seminars to attend them after an entire online school day.

Agency visits effectively capture students' attention and excitement by pro-

viding enthralling learning opportunities and immersive experiences. Such opportunities include animal show programs performed by the Nature Conservancy where Conservancy employees bring snakes, rabbits and other animals and teach students all about these creatures. These up-close encounters are extremely meaningful being that they may be the only first-hand exposure some students have ever had with wildlife. Another school partnered with the Chesapeake Bay Foundation (CBF) and would have CBF employees come and perform environmental education programs and would periodically take their students on trips to visit the CBF to participate in nature hikes or fish and crab seining. As the principal described the purpose of these agency visits, she said that these programs "'trick' the students into learning." When students are placed in hands-on, nontraditional educational settings, they are unknowingly gaining essential information and skills that will not only make them better students but better environmental stewards.

Habitat implementation is another great tool for teaching students the importance of caring for and protecting the environment as well as exhibiting to students the crucial role they play in contributing to a greener, more eco-friendly future. Several factors contributed to the success of these various implementations including legislation passed that altered Maryland's environmental literacy standards to ensure that students at each school level are subjected to a meaningful Watershed Educational Experience (MWEE). One high school teacher reported that this alteration in Maryland E-lit standards made it easier for her to incorporate new information and experiences into her curriculum being that every incoming freshman has already had an environmental education experience.

Collaboration with Green Center, Green Leaders, and community members and organizations tremendously improved the success of these implementations; one could argue that many of these initiatives would not have been possible without these partnerships and the associated resources that they provided. By fostering strong relationships with local agencies, Green Schools have been able to cultivate long lasting project partnerships to impact their school and the surrounding community. Community involvement is very important to effective environmental action project expansion. One exemplar Green School in Garrett County stated that community participation has been key to their own green expansion and achieving sustainable school status. By efficiently engaging their local community, the school has set a precedence so that when new families join their school, they immediately express their desire to become involved in program activities. It is equally as important to encourage parents to become involved in any way they can, not only to have more assistance in project maintenance, but also for parents to observe the benefits their children are receiving as a result of the MDGS program. Many schools expressed that having an engaged Parent Teacher Association (PTA) significantly contributed to successful eco-action projects being that PTA members were willing to contribute to project maintenance such as tending school gardens and habitat areas.

A primary contributing factor to initiative success is administrative support. All productive Green Schools have administrative support endorsing their projects. One aspect that many Green Schools struggle with is applying for and receiving grants. Although, many find this process intimidating, it is important to be unafraid to ask for assistance from MAEOE or Green Centers and Leaders. Grants contribute to green growth by funding environmental action projects; for example,

one school utilized their grant money fund a student-led research project aimed to solve agricultural issues on their school's campus.

Awarding students the freedom of choice encourages student project participation. As exhibited by the pollinator garden project where students were given the creative liberty of constructing a bee friendly garden product, these types of projects evoke interest, excitement, and confidence as students are empowered to make their own decisions regarding environmental application.

Perhaps the most significant feature of a successful initiative is defined purpose. A purposeful project is one that provides a solution or addresses a current issue that your school or community is facing. A principal at a Garrett County Green School epitomized the criticality of this project feature by posing the question, "how can we expect our students to solve bigger issues like saving the rainforest, etc. if they can't solve issues in their backyards' first?" She raises the point that we must first get students to care for and about the space around them before they are fully capable of addressing larger, more distant issues.

Concerns for the Future

MAEOE set the goal to achieve fifty percent Green Schools in the state of Maryland by 2025 (MAEOE, 2019). In order to attain this goal, current limitations and perceived barriers must be addressed. To ensure environmental action project expansion and MDGS recertification, current MDGS must ensure that they have sufficient staff, parents, and community involved in their programs so that when green team members leave, other green team members will maintain these projects and continue the recertification process.

MAEOE, as well as other organizations, has worked diligently to obtain funding to improve the MDGS program. During the 2019 Legislative session, Senate Bill 662 and House Bill 1366, which proposed that the MDGS program is allocated additional funding to strengthen the program and encourage the growth rate of the program across the state in order to meet the fifty percent Green School goal by 2025, were passed (MAEOE, 2019). Assurance of statewide Green School expansion is dependent on continuing evaluation of the program as well as persisting efforts to obtain more funding. Maryland Green Schools can contribute to MDGS program assessments by maintaining accurate green action project records and values. MAEOE can contribute to these assessments by recording and preserving Green School data in a consistent, unchanging manner. The success that MAEOE has had with passing these bills highlights the criticality of these assessments and efforts to obtaining funding, supporting Maryland's environment, and developing the MDGS program.

Regarding funding, many Green Schools desire to implement new projects or participate in conferences and trainings but do not have the funding to do so. To further environmental expansion and ecological benefits, we must devise ways by which Green Schools can bridge the gaps in their funding and make incorporation of these activities and events possible. To try and generate these opportunities, Green Schools can reach out to local organizations for funding purposes or apply to receive grant money.

One of the most vital factors to green project implementation and development is maintaining momentum. After obtaining certification, schools can become sta-

tionary with their current initiatives. Sustaining momentum is essential to Green School recertification and growth and development. Green Schools can work to preserve momentum by implementing new and exciting initiatives and activities for students. It is important to remember that momentum must also be maintained amongst staff—schools can accomplish this by attending free informational sessions hosted by MAEOE as a means to become informed and inspired.

As previously mentioned, there are still several counties across the state that do not offer recycling pick-up to their local schools. To increase Maryland's solid waste reduction, we must address and combat this issue. If Maryland is to reach its goal of increasing the number of Green Schools, our counties must endorse the program by picking up school recycling as means to integrate statewide sustainable practices.

Another conversation that must be had is between MDGS green teams, administration, and grounds crew about implementation of outdoor environmental action projects. Green team and grounds crew members must work to find common ground regarding outdoor implementations. Without coming to an agreement, Green Schools will continue to struggle with expanding their outdoor environmental action projects. Additionally, to remove the pressure that green team members receive from administrators requiring outstanding outdoor project appearance, it must be universally accepted that outdoor projects can look flawed and natural. Administrators must be reminded that these are projects that students help employ and maintain and we want these students to feel proud of their work, no matter what.

This study confirms and demonstrates that Maryland Green Schools do indeed have a positive effect on Maryland's environment. Without the MDGS program, many of these environmental action projects would never have been implemented. Additionally, students involved in this program are gaining knowledge and skills they will shape them into and better equip them as environmental stewards and environmentally responsible citizens. Therefore, it can be said that the Maryland Green Schools program provides both environmental and educational benefits that can be replicated in other states and school districts.

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