Scales to Tails: Reimagining Relationships in Learning Ecosystems

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University of Pittsburgh, 2023

The Scales to Tails (S2T) learning series was designed to function like the biological ecosystems it explores. This learning series aimed to bridge the gap between formal science curriculum and the natural world for underserved youth in western Pennsylvania. The community partners that contributed to S2T include the University of Pittsburgh (Pitt), Carnegie Museum of Natural History (CMNH), Pymatuning Lab of Ecology (PLE), West Liberty University (WLU), and Allegheny College (AC). Each partner offers outreach programs and extends differing areas of expertise that fulfill a niche in the learning ecosystem of western Pennsylvania. During the 2021-2022 school year, four co-developed lessons were taught at three high schools across sixteen sections of ninth grade biology students in the Linesville, Pennsylvania region. Qualitative and quantitative data was collected to gain a more holistic understanding of learning outcomes. In addition to responding to open ended journal prompts, pre- and post- series assessments were completed by students. Findings suggest collaboration between formal and informal science educators led to the development of programming that engaged students and connected with nature. Teachers suggested this project helped students to see that the learning does not end beyond the classroom door.

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Preface

This project was made possible through the funding provided by The Year of Engagement Grant at the University of Pittsburgh. I would like to thank Chris David (PLE), Erin Allison (WLU), Dr. Nicole Garrison (WLU), and Wendy Kedzierski (ACCC) for their shared expertise and assistance in the field. I would also like to thank Dr. Becky Gonda and Dr. Kevin Crowley for their encouragement from Scales to Tails' inception to the program's reality. Dr. Lori Delale O'Connor for reminding me of the joy of writing. Finally, I would like to thank the pilot instructors and their students for their seemingly endless enthusiasm and willingness to learn and grow.

Rita Mukherjee Hoffstadt, Denise Esposto, Curt LaFond, and Cat Scharon are one of the greatest gifts from the EdD experience. Together we represent the crayfish of the learning ecosystem. Out of school learning encompasses a vast scope that contributes to each human experience. The diverse range of backgrounds, countless words of encouragement, and desire to see one another bloom connected us across space and time zones. Zoom calls, text threads, and in-person meetings allowed us to find our community. The strength of that foundation helped me to reach where I am today, and I will forever be grateful for them.

There are not enough words to express how much gratitude I have for my parents, Doug and Tammy Sykes. Every step of my journey through this life, they've encouraged me to chase my dreams. When I'd invariably hit a roadblock along the way, my mom would often remind me, "There's always a way if you're willing to find it." Throughout my educational experience, they were eager to let me share all that I'd learned, even when it challenged the culture we grew up in. It meant the world to me that my dad asked for almost daily writing updated because he wanted to

hear the changes or if I was particularly excited about a section. He let me practice Zoom presentations, talk through awkward sentences, and make sense of the work I was doing.

I'd also like to acknowledge to of my best friends. Near the conclusion of my master's program, I was grappling with what came next. I, like many others, was struggling with imposter syndrome in the face of a doctorate program, but Erin Allison and Cate Hamel, encouraged me to take the leap. They were both working towards their own master's degrees while I was in the EdD program. We spend countless hours on that green couch in Pittsburgh talking through assignments, our research, and reminding each that we could persist despite the challenges of a global pandemic, work, and school. I love them dearly, and I am so proud of all that they have and will continue to accomplish.

Finally, I'd like to acknowledge my best friend and fiancé, Dan Meyer, and our precious Corgi Vida. He has been as patient as he has been encouraging throughout this writing experience. From helping me set up a writing space at home, to adjusting our lives so that I could remain as productive as I've needed to get to the finish line, Dan has been unwaveringly supportive. He's been willing to let me test improvement projects at home, find enough cell service for me to take accountability Zoom calls on vacation, and made sure that fun and selfcare weren't forgotten along the way. Vida was a Covid puppy, part of every Zoom call in the last three years, and my emotional support each and every day. When I'd feel overwhelmed, her sweet smiling face encouraged me to remember the importance of taking time to play.

1.0 Naming and Framing the Problem of Practice

1.1 Problem Statement

Students' experiences in formal science classes may not be sufficient to encourage the development of environmental stewardship. Without connections between classroom materials and the natural world, Biology, or the study of life, may only be experienced through the pages of textbooks.

1.2 Change Idea

Providing experiential outdoor learning opportunities for students is an area where community members of a given learning ecosystem must work together. Supplementary curriculum development and instruction provided by informal science centers (e.g., museums, zoos, etc.), after school programs, and local higher learning institutions can provide meaningful outdoor experiences that support state and Next Generation Science standards. While each of the aforementioned components extend beneficial services as autonomous units, they may be capable of offering a greater overall contribution by working together. This required open communication, passion, stakeholder buy in, and pooling of available resources. In nature, mutualism is a type of symbiosis in which both parties' benefit. This biological concept can be applied in learning ecosystems as well. First, the opportunity must be recognized. Then, a strategic plan can be developed for implementation.

The design of the Scales to Tails (S2T) learning series aims to mirror the function of biological ecosystems students are learning about. Each community partner offers outreach programs and extends differing areas of proficiency that fulfill a niche in the learning ecosystem of western Pennsylvania. The community partners that contributed to S2T include the University of Pittsburgh (Pitt), Carnegie Museum of Natural History (CMNH), Pymatuning Lab of Ecology (PLE), West Liberty University (WLU), and Allegheny College (AC). Each collaborator offers outreach programs and extends differing areas of expertise that fulfill a niche in the learning ecosystem. Additional partners on this project included three high school biology teachers and sixteen sections of ninth grade biology students in the Linesville, Pennsylvania region. The goal of this program is to connect high school biology students and their teachers with the natural world through place-based programming.

In addition to connecting classroom lessons to the outdoors, this program aims to encourage the development of students' environmental identity. Throughout the program series students gained a sense of belonging in the ecosystem and greater community. Through experiences with nature based-professionals, additional educational and career pathways were discussed with the goal of expanding known opportunities in life after high school. In the Spring of 2022, I met with S2T partners via Zoom to discuss the successes and areas of the S2T program that should be adjusted prior to allowing the module to be available to all interested high school biology teachers and students across western Pennsylvania. This was accomplished through surveys and focus groups. Qualitative and quantitative data for students and partners collected to date was synthesized.

Students in rural communities have no shortage of green spaces. However, due to their geographical location, both rural students and educators have limited access to informal science

learning opportunities. Without intentional time to safely explore nature, we can hardly expect students to form a relationship with the natural world let alone care about the ecosystems that ultimately depend on humans to preserve. Additionally, with a place-based program series led by a diverse range of Natural History professionals, students will not only see the connections between the science textbook and green spaces, but also have a wider range of potential career paths to pursue.

1.3 Broader problem area

Engaged scholarship is derived from a need to better understand how to serve a community. My dual roles as a student in the Doctor of Education program (EdD) and Outreach Coordinator for the Biology Department at the University of Pittsburgh have provided an opportunity to serve as an agent of change. The focus of this dissertation in practice explored how students' experiences in formal science classes may not be sufficient for the development of environmental stewardship (Figure 1). One of the goals of the S2T program was to provide professional development opportunities and access to science-based programming to rural high schools. Pymatuning Lab of Ecology is in Linesville, Pennsylvania and is home to a well-established research station and outreach program. Its location and role in the area offers a unique opportunity to expand the available educational resources to the community. In an effort to better serve rural communities, my goal was to strengthen relationships between the community and higher learning institutions by removing distance from the equation.

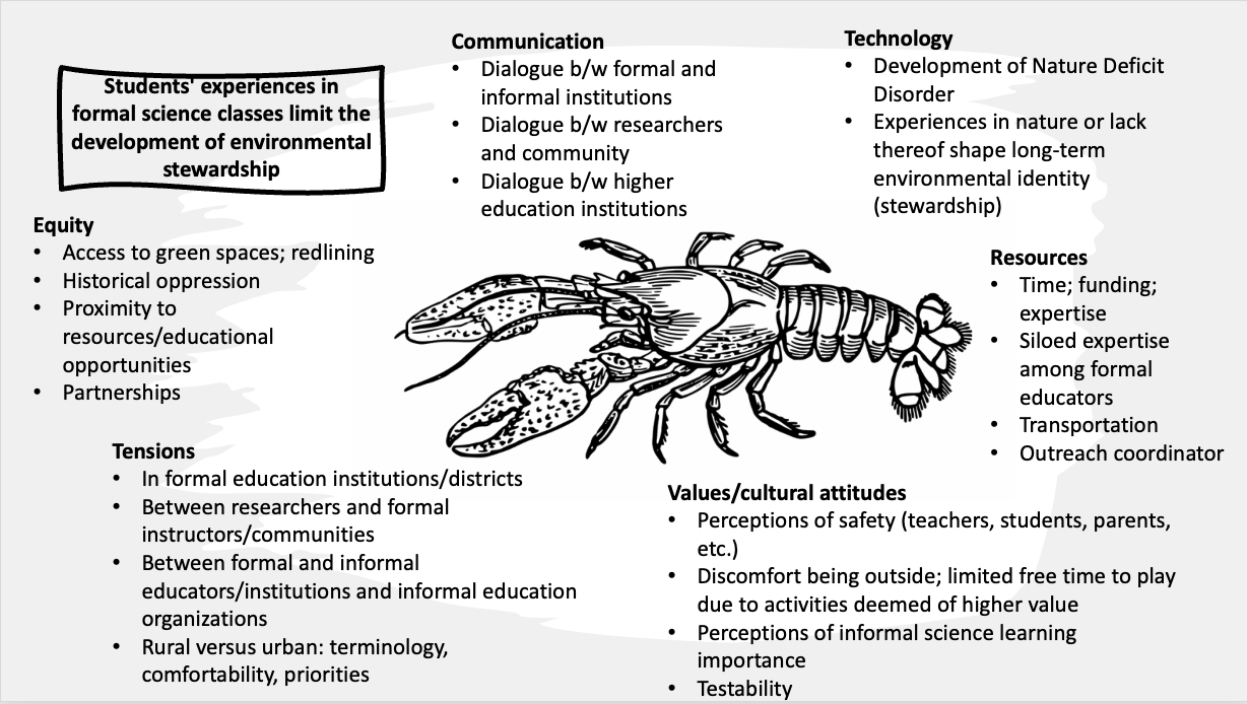


Figure 1 | Factors Contributing to the Development of Environmental Stewardship

Partnerships between informal science educators and regional schools can provide educational experiences that allow students to work through the scientific method by conducting experiments under the guidance of professionals. Using a combination of in-class and outdoor opportunities allows students to apply concepts covered in the classroom and experience research through hands-on, place-based learning activities. A primary aim of the program was to allow students to explore a local ecosystem, which created opportunities for youth to connect with nature and use deductive reasoning to determine ecosystem health. A secondary aim of the S2T model was to instill confidence in the students in a Natural History branch of science. Science is a subject that is sometimes considered intimidating, but through the S2T program students became more comfortable in their abilities as budding scientists and in approaching future science courses (Maison *et al.* 2020). Studies have shown allowing students to directly participate in scientific inquiry gave students a sense of responsibility and pride, and instilled confidence in their abilities

(Barthel *et al.* 2018; Schuttler *et al.* 2019). Symbiotic partnerships between scientists and members of the public-school system exemplify just how much can be achieved collectively. These experiences encourage environmental stewardship and a sense of place among students in their ecosystem.

1.4 Organizational system

The Pits Kits Outreach program aims to support K-12 students and instructors. One of the core values of the Pit Kits outreach program is that everyone should have access to knowledge and education and that is what led to the creation of an outreach program in 1993. Through grant funding, the Pit Kits lab is able to provide professional development workshops for instructors in a range of scientific disciplines, kits with hands-on programs that align with state standards for use during the school year, and summer research programs that partner students from underserved communities with scientists at the University of Pittsburgh. Since that time our program has expanded from Pittsburgh, Pennsylvania to serve throughout western Pennsylvania. Partnerships between the university, community, and the K-12 school system not only provides an opportunity to better support teacher and student development but also provides the tools and encouragement to develop youth scientists.

The Pitt Bio Outreach program is situated in the Department of Biological Sciences at the University of Pittsburgh. In addition to supporting K-12 teachers and students, our program also assists researchers in our department to achieve broader impact goals. In doing so, we collaborate with research labs on grants and outreach learning series. The Department of Biological Sciences diversity statement states that, “we are committed to attracting, mentoring, and promoting a diverse

community of scholars in an environment conducive to excellence for students, postdocs, and faculty from all backgrounds." Pitt Bio Outreach exemplifies the department's diversity mission statement through work in the greater Pittsburgh area and throughout western Pennsylvania.

1.5 Stakeholders

Inspiration for the S2T program came from the design and function of biological ecosystems. Community partners including Carnegie Museum of Natural History (CMNH), Pymatuning Lab of Ecology (PLE), West Liberty University (WLU), and Allegheny College (AC) collaborated on the S2T pilot. Each of the aforementioned groups offer outreach programs and extend differing areas of expertise that fulfill a niche in the learning ecosystem. I worked closely with community partners and high school instructors to develop and implement curriculum between fall of 2021 and spring of 2022. Through the lending collection at the Carnegie Museum of Natural History, the Outreach lab secured skins, skulls, and preserved specimens for educational use at little cost. Additionally, Pymatuning Lab of Ecology, Allegheny College Creek Connections, and West Liberty University's Crayfish Conservation lab assisted on the stream exploration day.

The community partnership relationships are unique to each organization we work with. Beginning with the University of Pittsburgh, my supervisor was very supportive in my interest to develop the module and my acquisition of funding for the pilot. Their management approach gave me the freedom and flexibility to explore the development of the series. Research labs that we regularly interact with have been enthusiastic in being involved in facilitating all the regional S2T programs to date. Pymatuning Lab of Ecology was the partnership that has grown the most. PLE

was actively engaged in lesson development, the field days at pilot high school, and provided housing for me every week I've traveled up to the study schools. Our work has transcended the pilot to include co-facilitation of training for high school students who are Envirothon participants.

West Liberty University is my alma mater. During my undergraduate and graduate studies, I was frequently engaged in community outreach. The Crayfish Conservation Lab allowed me to work with researchers, informal science learning organizations, and a number of students ranging from elementary through doctoral. The relationships formed during those years translated into my role with Pitt Bio Outreach. Both the Pitt Bio Outreach Lab and the Crayfish Conservation Lab regularly collaborate on environmental education programs in West Virginia and Pennsylvania. The S2T pilot strengthened our working relationship and increased the areas we were able to travel and groups we were able to interact with. Although the same can be said for all the partners involved in the learning series, we're better together feels especially relevant with WLU because I've seen how it's grown and changed over the past nine years.

The pilot teachers and students in Linesville also displayed transformative strides since we started working together. Pilot teachers were included in every step of the development process. The ownership that our community partners have displayed has influenced the success both in and out of the classroom. I valued feedback from the teachers and students, and each time I've worked with pilot schools I could feel how much the relationship had grown. Creating space for students to share their thoughts and ideas through the use of nature journals allowed opportunities for students to share whether they contribute on page and out loud if they feel comfortable doing so. I aspired to build a rapport with all the teachers and students that I interact with that made them feel valued and heard. The mutual respect and desire to work together in the future indicated that the process has been a success in my eyes.

1.6 Statement of the Problem of Practice

The Outreach program I belong to is situated in the Department of Biological Sciences at the University of Pittsburgh. Since 1993, the Outreach program has worked with K-12 students and instructors throughout western Pennsylvania and has an annual reach of between 8,000-10,000 individuals. As the Outreach Coordinator, my role was to develop curriculum, provide professional development training for formal educators, offer free lessons and materials for students, and facilitate programs in formal and informal learning spaces. Although biotechnology and molecular biology were at the forefront of our current offerings, I sought to provide more biologically well-rounded programming options that include both the micro and macro lens. Connections between molecular biology and the life sciences provide a more complete image of the subject matter. One of the projects I was most enthusiastic to pursue was the development of a module that allowed students to explore the animal classification system through interacting with local ecosystems, native animals, and a diverse range of natural history professionals. My goal in doing so was to help students to form relationships in the natural world and to give them a sense of belonging to a community that extends beyond the humans they know.

In addition to cultivating STEM proficiency, Pitt Bio Outreach aims to ignite the passion for students to develop as lifelong learners. Lifelong learning can be defined as a form of self-directed education that typically occurs outside of the formal education system (Dunlap and Gabringer 2003). Given that an estimated 80% of the learning an individual does over the course of a lifetime occurs outside of the formal education system, igniting the light that inspires individuals to pursue their interests is intrinsic to their long-term development (Dunlap and Gabringer 2003, Pendergast et al. 2005). From personal experiences, I can confidently say that being surrounded by passionate individuals that encouraged my quest for knowledge and

understanding, has brought me to where I am today. Pitt Bio Outreach has a unique opportunity to work with children and adults alike. Fostering enduring relationships in the community that encourage engagement and inquiry at all stages of life, will undoubtedly become part of the outreach program's legacy.

One of the goals of Pitt Bio Outreach is to reach underserved youth. Between 2021 and 2022 the S2T programs were piloted with rural high school students in northwestern Pennsylvania. The S2T aimed to connect students with the natural world through science programming that brings the textbook to life. The aforementioned group differs from the urban and suburban students Pitt Bio Outreach most frequently worked with in terms of accessibility to green spaces, in-class student to teacher ratio, and available informal science learning opportunities. Through community partnerships, S2T provided experiential, place-based opportunities for students to form relationships with greenspaces and the abundance of biodiversity found in Pennsylvania. By creating time for students during and outside of school time, we aspired to better meet their needs by removing distance from the equation and thereby increasing the time that we can work with students. We aimed to support formal instructors by developing and facilitating programming that supports state and Next Generation Science standards, encouraged the development of students' environmental identity and belonging within both learning and biological ecosystems, and cultivated relationships between students, formal instructors, and community partners that extends beyond the 2021-2022 pilot.

Through partnerships with other area outreach programs and formal educators, we were able to share our unique skill sets and backgrounds to expand students' learning ecosystems. Each community partner offered area-specific expertise. These partnerships have not only paved the way for the S2T module, but also allowed our collective work to be shared on a larger scale than

any of us could reach singularly in the future. Given the scope of the S2T initiative and the partnerships needed for long-term viability of the project, the interests and needs of community partners (i.e., stakeholders) were prioritized and met. Given that each of the groups live and work in a different geographic location, routines were established and refined to ensure that we're able to effectively communicate and collaborate despite the physical distance. To address this, I incorporated a cycle system. There are four cycles (weeks) in the month. The first Monday of the month I send an email to the high school pilot instructors with links to the shared Google drive used for the S2T project and a detailed explanation of what our goals are in the shared documents. During cycle two, I review feedback and recommendations of the high school instructors before sharing the updated documents and instructions with community partners in cycle three. The final week of the month, cycle four, I reviewed the ideas or proposed adjustments from community partners.

1.7 Review of Supporting Knowledge

The problem of practice explored in this dissertation was iteratively developed and informed by related literature. Here we'll examine school and place-based science initiatives to connect youth with nature. Natural history, citizen science, and environmental stewardship related projects highlight successful models and challenges practitioners addressed. The role of partnerships between formal educators and informal educators and researchers displays the positive cumulative effect of collaboration for youth and their communities. Given the extent to which technology is ingrained in our society, factors contributing to Nature Deficit Disorder were also discussed. S2T, a literature informed learning series, was adapted with learning ecosystems

in mind. The learning ecosystem approach was not only used to identify and build relationships, but also led to the development of nature-informed learning modules.

Learning is the result of cumulative experiences across space and time (Mujitaba, Lawrence, & Reiss, 2018). These experiences transcend formal and non-formal settings and result in the culmination of one's identity (Camasso and Jannathan, 2018; Mujitaba, Lawrence, & Reiss, 2018). Engaging in meaningful experiences aids in the development of an individual's sense of belonging, and as our society continues to be driven forward by technological advances, fostering the development of environmental identity in primary school students is a matter of great importance. Though science is a component of primary school curriculum in America, there is a disconnect between classroom material and instruction in the natural world (Turigan and Carrier, 2017). Place-based learning opportunities not only provide interactive opportunities to reinforce scientific concepts, but also create opportunities for students to form connections with the natural world (Kelemen-Finan, Scheuch, & Winter, 2018; Turigan and Carrier, 2017). Partnerships between the public school system and informal learning institutions can enhance student interest through interactions with nature-based professionals (Barthel *et al.* 2018; Kelemen-Finan, Scheuch, & Winter, 2018; Mujitaba, Lawrence, & Reiss, 2018).

Biological ecosystems are similar in role and function to learning ecosystems and can serve as a model for increasing connections through the formation of community partnerships in communities (Hecht and Crowley, 2020). In the pursuit of the advancement of humankind, humans have tirelessly engaged innovation through creativity and utilization of available resources which propel us forward as a people. Technology has provided countless improvements in medicine, agricultural practices, and technology. However, developed societies have seemingly moved farther away from their connection with the natural world in response (Louv 2008). In doing so,

children have limited time and opportunity to form connections in natural settings. Nature-Deficit Disorder, a term first described by Richard Louv, explains the unintended costs associated with the impact of disconnection between people and the non-human natural world (Louv 2008). “The Last Child in the Woods,” prompted a cross-sector movement to ensure equity and accessibility to children not only for their health and mental well-being, but also to foster a bond with the environment.

Through connections created between community partnerships formed among public-school systems and informal science learning institutions, the gap between science curriculum and the natural world can be bridged on school property (O’Connor, 2012). Integrative programs can bring nature to students. Though science is a component of public-school curriculum in America, there is a disconnect between classroom material and instruction in the natural world (Turigan and Carrier, 2017). Place-based learning provides interactive opportunities to reinforce scientific concepts and to form connections with the natural world (Kelemen-Finan, Scheuch, & Winter, 2018; Turigan and Carrier, 2017). By forming partnerships between the public-school system and informal learning institutions, students' interest in science can be enhanced through interactions with nature-based professionals (Barthel *et al.* 2018; Kelemen-Finan, Scheuch, & Winter, 2018; Mujitaba, Lawrence, & Reiss, 2018).

Partnerships between informal science educators and regional schools can provide educational experiences that allow students to work with scientific thinking processes by conducting inquiries of their own design under the guidance of professionals. Using a combination of in-class and outdoor opportunities allowed students to apply concepts covered in the classroom and experience research through hands-on, place-based learning activities. A primary aim of the S2T model is to instill confidence in the students in a branch of science, Natural History. Science

is a subject that is sometimes considered intimidating, but through the S2T program students will become more comfortable in their abilities as budding scientists and in approaching future science courses (Maison *et al.* 2020). A secondary aim of the program was to allow students to explore a local ecosystem, which created opportunities for youth to connect with nature and use deductive reasoning to determine ecosystem health. Studies have shown allowing students to directly participate in scientific inquiry gave students a sense of responsibility, pride, and instilled confidence in their abilities (Barthel *et al.* 2018; Schuttler *et al.* 2019). Symbiotic partnerships between scientists and members of the public-school system exemplify just how much can be achieved collectively. These experiences will encourage environmental stewardship and a sense of place among students in their ecosystem.

The Oxford dictionary defines natural history as, "the scientific study of animals or plants, especially as concerned with observation rather than experiment (Lexico Dictionaries)." This field has contributed to every known species description and animal life history (Bartholomew 1986). Although this branch of the natural sciences encompasses a diverse range of flora and fauna, the professionals in this field lack diverse representation. Representation can directly affect individuals' sense of belonging, and among Life Science professionals, black Americans only account for 6% of the workforce (Kennedy, Fry, and Funk, 2021). Inequities among minority populations are not only limited to the professional arena. Opportunity gaps across cities exist in part due to the persisting ripple effects of redlining that not only resource availability such as green spaces but is also evident in educational disparities (Jencks and Mayer, 1990, Logan 2011, Leventhal and Brooks-Gunn, 2000, Rutan 2016, Sharkely, 2013, Taxeria and Zuberi, 2016). Access to green spaces directly affects an individual's connection with and affinity towards nature (de Kleyn et al., 2020).

The fluid nature of cultural attitudes can shift more than practices and opinions. It can modify the very identity of individuals shaped by its influence (Nunn, 2012). Children are particularly sensitive to the cultural attitudes and beliefs prescribed to them by the adults in their lives both at home and at school (Fan, 2017; Nunn, 2012). Advancement of technology has shaped the relationship humans have with land greatly since the Industrial Revolution (Vickers and Ziebarth, 2019). Advances in technology are not limited to medical breakthroughs or development in the form of infrastructure, but also include devices that aid in the comfortability of our daily lives such as electricity, heating and cooling units, and entertainment in the form of cell phones, televisions, and video games (Vickers and Ziebarth, 2019). Though these technological advances have supported the progression of humankind in developed nations, they have inadvertently hindered our connection with and accessibility to the natural world (Louv, 2008).

Community partnerships can span from supplemental environmental education programming to citizen science projects throughout the school year. These partnerships can assist in the development of environmental stewardship among primary school students by expanding on classroom material and providing experiential learning activities that allow students to interact with native flora and fauna (Barthel *et al.* 2018; Schuttler *et al.* 2019). Additionally, students can aid in local conservation efforts through civic science (Barthel *et al.* 2018; Schuttler *et al.* 2019). In Barthel *et al.* 2018, students collected data and assisted with the conservation of an endangered salamander species through a community science effort called Project Salamander. This endeavor instilled a sense of personal responsibility and empathy for an imperiled species by allowing students to play an active role in conservation by collecting data and relocating species during school hours. Clear communication, mutually agreed upon objectives, and defined roles between

school and community partners support successful collaborations (Mujitaba, Lawrence, & Reiss, 2018).

Citizen science projects can offer professional development opportunities for formal educators using workshops. Schittler *et al.* 2019 explored the relationship between widespread data collection and the facilitation of citizen science initiatives by formal educators. Conservation Biologists trained formal educators on camera trap protocol, species identification, and data collection for project eMammal (Schittler *et al.* 2019). Additionally, educators were provided with lesson plans that were designed to be mutually beneficial among scientists, educators, and students involved in the project (Schittler *et al.* 2019). Over the course of the school year, teachers and their students monitored camera traps that had been set on school property and worked together to identify mammal species that were photographed (Schittler *et al.* 2019). This citizen science partnership increased regional natural history knowledge among students and educators alike and provided mammal data across five countries that directly aided in conservation management assessments (Schittler *et al.* 2019). Symbiotic partnerships between scientists and members of the public school system exemplify just how much can be achieved collectively.

By providing outdoor learning experiences during and outside of school hours, students can develop connections with nature and support a students' sense of belonging in their community. Addressing accessibility disparities to green spaces outside of school hours can be a difficult task. However, community-based organizations can aid in the acquisition of spaces for children to safely explore and interact with nature in their own neighborhoods (Camasso and Jagannathan, 2018). The Nature through Nurture program provided an interdisciplinary approach that encouraged students to engage with gardens in their community (Camasso and Jagannathan, 2018). This project operated during after school hours and during the summer months and provided

nature-based programming that aimed to increase proficiency in science, mathematics, and language arts in city students. The Nature through Nurture program created naturescapes that not only served as an outdoor classroom, but also provided a green space with the goal of bringing families and neighbors together (Camasso and Jagannathan, 2018).

2.0 Theory of Improvement and the Change

2.1 Theory of improvement

Community partners including high school instructors, biologists, and informal science educators partnered in the spring of 2021 to create a program series that fosters connections between in-class materials and the outdoors. The aim of this series was to create opportunities for students to explore local ecosystems and expand their conservation understanding with state and Next Generation Standard aligned curriculum. Programming was co-developed between the spring and summer of 2021. At the beginning of the fall 2021 school year a pre-module assessment was conducted to gauge students' knowledge of stream ecosystems and conservation in the local context. The lessons covered included Introduction to Stream Ecosystems, Stream Exploration Day, Crayfish Biodiversity, and Animal Classification Exploration. The day after each lesson, students had an opportunity to respond to prompts in their nature journals. At the conclusion of the fourth lesson, a post-assessment was completed.

In addition to connecting classroom lessons to the outdoors, this program aimed to encourage the development of students' environmental identity. Throughout the program series students gained a sense of belonging in their ecosystem and greater community. Through experiences with nature based-professionals, additional educational and career pathways were discussed with the goal of expanding known opportunities in life after high school. Spring of 2022 community partners discussed the successes and areas of the S2T program that should be adjusted prior to allowing the module to be available to all interested high school biology teachers and

students across western Pennsylvania. This was accomplished through surveys and focus groups. Additionally, the student data collected to date was synthesized.

The primary drivers that were utilized in my dissertation in practice included curriculum/instruction and resources (Figure 2). Through developing programming with community partners the depth of topic information was gauged by high school instructors for timeliness and best topics to support state and Next Generation Science standard learning goals. Additionally, community partners worked on pre- and post-assessment questions, journal prompts, and how co-led lessons are organized to help prepare for a successful pilot launch. Carnegie Museum of Natural History (CMNH), Pymatuning Lab of Ecology (PLE), West Liberty University (WLU), and Allegheny College (AC), and Pitt Bio Outreach have worked together to pool resources including teaching materials, volunteers, and lending their expertise in the development of the module. The combination of pooling resources and contributing to the module creation and implementation aided in the learning opportunities available to 9th grade high school students in the S2T pilot.

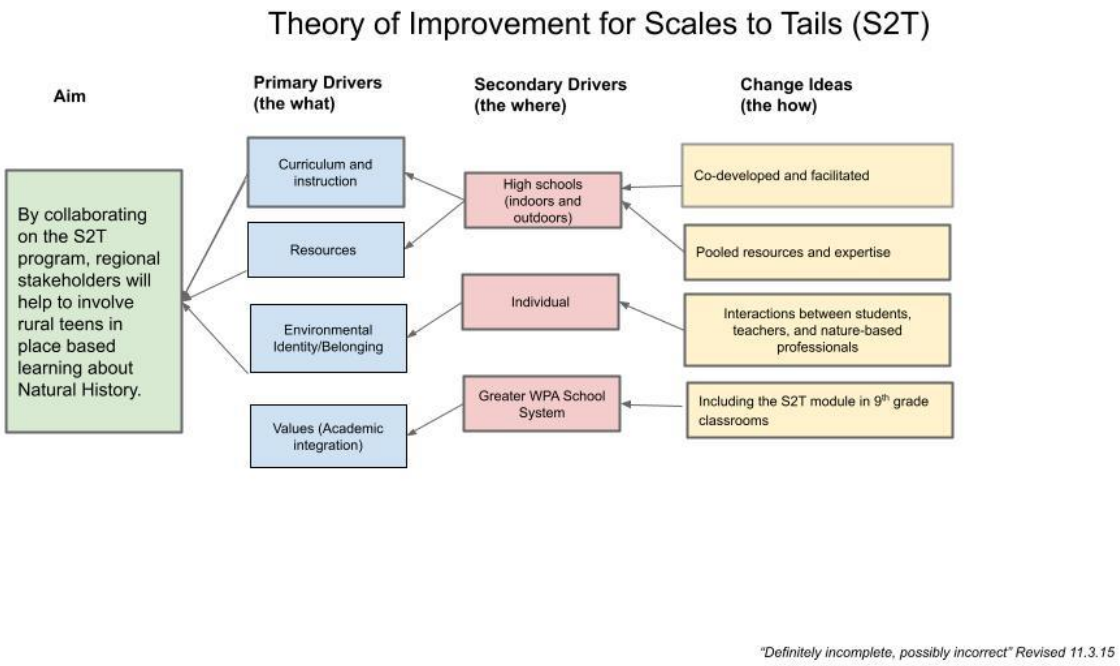


Figure 2 | Theory of Improvement

In subsequent interactions of the S2T learning series additional drivers can be further refined and explored. In the months following the S2T pilot conclusion, the learning module was revised with the goal of adding to the lesson series available through Pitt Kits. At this time, Pitt Bio Outreach reaches between 8,000-10,000 teachers and students throughout western Pennsylvania per year. Including S2T programming in classrooms across the greater western Pennsylvania region is tied to academic integration as a result of perceived value. Teacher training workshops are hosted each summer on new modules. Upon completion of the workshop, teachers will have access to all Pitt Kit materials from that point forward. At the beginning and middle of each school year, instructors are emailed with new modules or opportunities for student and teacher development. Many of the teachers we've worked with have found us through word of mouth, and they worked with an individual that utilized Pitt Bio Outreach experiments or programs.

The role of nature-based professionals on students' acquisition of environmental identity is of particular interest to me. The framework of the S2T program series aimed to support participants' view of themselves as part of local ecosystems. Evaluating students' sense of belonging and personal responsibility and the influence of both their views of stewardship. Interactions among peers, biology instructors, and nature-based professionals through the learning module can impact or stimulate conversation and personal growth. I'm also interested in how the S2T series might inspire students to participate in environmental clubs at school or participate in competitions like Envirothon in the future. Following student directed engagement is a secondary or tertiary layer that can be followed in subsequent school years. Preliminary data from pilot schools indicated an interest in pursuing science related internships and volunteer opportunities.

2.2 Inquiry Questions and Intervention

The S2T change idea involves community partners combining resources for nature-based programming and instruction. In the months prior to the pilot launch, community partnerships formed between Pitt Bio Outreach, Pymatuning Lab of Ecology, Allegheny College Creek Connections, West Liberty University's Crayfish Conservation Lab, and three high school biology instructors. We discussed how best we could work as a collective to support environmental identity and conservation understanding among 9th grade biology students. Together we designed a four-lesson series for the pilot including in-class and outdoor content and activities, nature journal prompts, and pre- and post-assessments. We employed this pilot between fall of 2021 and spring of 2022. In processing the nature journal responses, I'm interested to see student feedback and if and how the S2T series impacted them. Additionally, I'm interested in the observations of the high

school instructors, if they'd adjust any of the lessons, and to what extent they would feel comfortable running the program in the future.

The inquiry questions selected to evaluate this DiP included the questions listed below. Additionally, a brief description of the data each corresponds with is outlined.

1. Does a program that combines field experience with classroom programming increase student conservation knowledge and attitudes?
    1. Student pre- and post- tests
    2. Journal prompt responses
    3. Teacher observation and feedback
    4. Personal observations
2. Does the level of involvement of project partners influence their connection to the project?
    1. Qualtrics survey
    2. Personal observations
    3. Teacher feedback
3. To what extent does involving teachers in co-development improve or create obstacles throughout the learning series?
    1. Personal observations
    2. Focus group responses

During the pilot launch, communication was one of the early indicators of success. Verbal and nonverbal cues among students offered preliminary insight into the student experience. Instructors and co-facilitators that observed the lesson offered feedback at the conclusion of each lesson for fine tuning or adjusting in subsequent iterations. At the conclusion of or the day

following each monthly lesson, there was time for students to respond to prompts in their nature journal. Coding journal/reflection responses helped to discern personally held beliefs or perceptions relating to their place in the world and in relation to nature. In addition to qualitative data, a pre- test was employed prior to any of the S2T lessons, and at the completion of the final lesson, students took a post-assessment to measure conservation knowledge related to environmental stewardship and natural sciences gained over the course of the learning series. A series of online surveys and focus groups were also conducted among community partners.

Throughout the improvement process, the dynamics of the system were evaluated. Given the scope of the S2T learning series, it was imperative that there were regular check-ins between the community partners involved. Perhaps one of the partners was overwhelmed and needed support of their own. Without an intentional system to support the groups and individuals involved in the S2T effort, the system would break down. All relationships require a degree of give and take, and to create sustainable relationships, all parties need to feel supported in and outside of the collaboration that brought them together. Communication with participating teachers about how the curriculum timing and effectiveness of the programming is to state standard goals was key to maintaining a balance in our system. Perhaps of even greater importance is intentionality in developing meaningful relationships.

2.3 Study Sample/Population

The study population included three high school Biology teachers and a total of 14 classes of 9th grade biology students in northwestern Pennsylvania. In spring of 2021 a pilot interest survey was shared among the teachers from the Pitt Bio Outreach emailing list and individuals our

colleague Chris Davis (Pymatuning Lab of Ecology, PLE) worked with in the past. Respondents completed an eleven-question application through Qualtrics that included demographic, multiple choice, and short answer responses. Three of the four applicants were selected to participate in the S2T pilot of which all worked in high schools in and near Linesville, PA. The fourth applicant moved between submitting their application and our follow up. PLE is located in Linesville, PA and is no more than 30 minutes from any of the participating pilot schools.

Upon joining the Pitt Bio Outreach team in 2020, I was interested in evaluating to what extent we're reaching underserved students and teachers. Over the past 29 years, Pitt Bio Outreach has worked with between 8,000-10,000 individuals annually, but upon further inspection, it appeared that the majority of the teachers and schools were almost exclusively in suburban and urban regions. Single digit percentages accounted for the annual work with rural instructors and students. Further discussion revealed that there was a concerted effort to expand offerings to rural teachers from 2009-2012, but teacher turnover rates and the limited number of regional schools impacted continued Pitt Kitt participation (Personal Communication.) I couldn't help wondering if proximity to the University of Pittsburgh (I.e., "Out of sight. Out of mind.") played a role in what teachers and schools we'd historically worked with. This is not to say that important work to create equitable opportunities in an urban context is less important. Pitt Bio Outreach has done considerable work with the Pittsburgh Public School system to provide curriculum, hands-on skill, college preparation, and higher education pathways. My goal was to incorporate intentional opportunities to increase opportunities for rural students in addition to urban and suburban students.

2.4 Methods

Between fall of 2021 and 2022, qualitative and quantitative data was collected from students, teachers, and community partners. In addition to pre- and post- module assessments, students' nature journal responses were reviewed and coded for emerging themes. All pilot classes were primarily facilitated by Pitt Bio Outreach and observed by the high school biology teachers. Observations and feedback from the biology teachers were also examined through one-on-one interviews, focus groups conversations, and online surveys. Additionally, personal field notes were taken both in and outside of the classroom time to document observations and wonderings. Upon synthesizing the data collected, an additional conversation was conducted with the S2T community partners to re-evaluate participation and future directions.

Prior to the first lesson a 10-question pre-assessment was completed by 9th grade biology students. At the conclusion of the final lesson, a post assessment was conducted. All assessment scores were put into Excel. Possible scores for each question ranged from incorrect (0) and partially correct (0.5) to correct (1.0). Sheet one houses complete data for all schools, and separate sheets were made for each school and assessment type (I.e., pre- assessment, post-assessment). Descriptive statistics including minimum, maximum, average, and standard deviation were completed for each grouping. Differences among pre- and post- assessment scores were explored among singular institutions. Excel was also used for student nature journal responses to four journal prompts. Sheets were separated by school and prompt number. Responses were coded and evaluated for emergent themes based on singular words and phrases.

Among instructors, online surveys were completed using Qualtrics. One on one conversations took place at each high school with instructors between and following classes. Notes

were recorded during conversations and revisited at the conclusion of the school day. When focus groups were held, Zoom was employed due to variability in geographic location and time constraints among pilot teachers. Closed captioning was utilized and was recorded for further analysis. I was interested in exploring similar and differentiating perceptions of instructors about the overall success, improvement ideas, and level of comfortability in leading future iterations of the S2T series as individuals. Transcripts were examined at the conclusion of Zoom focus groups. Focus group responses were coded at the conclusion of the meeting and evaluated.

2.5 Overview

The S2T aims to connect the gap between science curriculum and the natural world for rural youth near Pymatuning Lab of Ecology. Our goal is to bridge the gap between nature and children through hands-on experiential learning opportunities that bring the subject of science to life. Biological ecosystems depend on living and nonliving components in order to function properly (Face, Norris, and Fitter, 2012). Without an organism to fill an ecological niche or provide specific services, the system as a whole would not work as it was designed to do so. Learning ecosystems function in a similar way. The community partners that participated in this endeavor each bring their own unique skill sets and backgrounds to the table. Together we were able to create more well-rounded and engaging opportunities for the students we worked with than any of us could provide singularly. The participants included in this implementation included three high schools (Conneaut Area Senior High School: CASH, Northwestern High School: NWHS, and Jamestown High School: JTHS) and a total of 16 class sections.

2.6 Data Gathering and Analysis Description

Google Drive offered an excellent platform for collaborating with community partners and recording data. The Google Drive platform allowed each individual to contribute to a system of living documents synchronously (i.e., during meetings, in class, on calls) or asynchronously. Through curriculum co-development with community partners the depth of topic information was gauged by high school instructors for timeliness and best topics to support state and Next Generation Science standard learning goals prior to pilot launch. Additionally, community partners worked on pre- and post-assessment questions, journal prompts, and co-led lesson organization, which helped prepare us for a successful pilot launch.

Improvement science is a continuous process. Instructors and co-facilitators that watched the lesson offered feedback at the conclusion of each lesson for fine tuning or adjusting in future iterations. The day following each monthly lesson, there was time for students to respond to prompts in their nature journal. Coding journal/reflection responses helped to discern personally held beliefs or perceptions relating to their place in the world and in relation to nature. In addition to qualitative data, a pre- test was employed prior to any of the S2T lessons, and at the completion of the final lesson, students took a post-assessment to measure knowledge gained over the course of the learning series. A series of surveys and a focus group were conducted among community partners. Together qualitative and quantitative data can offer a larger body of information to draw upon for student growth.

2.7 Analysis of Data

2.8 Student Data: Pre- and Post- Tests (By School)

Pre-tests and post- tests consisted of 10 questions including multiple choice, true/false, and short answer (Figure 5). Pre- and post- tests were completed at the three following schools: Conneaut Area Senior High (CASH), Northwestern Senior High School (NWHS), and Jamestown Area Senior High (JTSH). For each pre- and post-test, the following descriptive statistics were performed: Number of Respondents (n), Minimum Score (min), Median Score (med), Max Score (max), Mode (mode), and Standard Deviation (StDev). Data was analyzed using Google Sheets and rounded to the nearest 10th of a point with percentages included in parentheses. Pre-test and post test scores for each school are aggregated below. Questions 1-10 can be further separated into two categories: Environmental Stewardship and Science. Questions 5, 7, 8, 9 relate to Environmental Stewardship, whereas questions 1,2,3,4,6, and 10 relate to Ecology. To gauge gains in both categories, each pre- and post- assessment question was evaluated. The totals for each correct and incorrect response were recorded and divided by the total number of students (n) that completed the assessment and converted to percentages.

CASH

CASH pre-test results were as follows: n= 59, min=1.5 (15%), mean= 6.1 (61%), max= 9 (90%), mode= 80%, StDev= 2.1. CASH post-test scores were: n= 66, min=1 (10%), mean= 7 (70%), max= 10 (100%), mode= 8.5 (85%), StDev= 2.2. Between the months of August 2022 and January 2023, the average scores increased by 9%. Assessment data indicates a ~14% increase

among science comprehension questions, and an increase of ~1% among environmental stewardship comprehension questions.

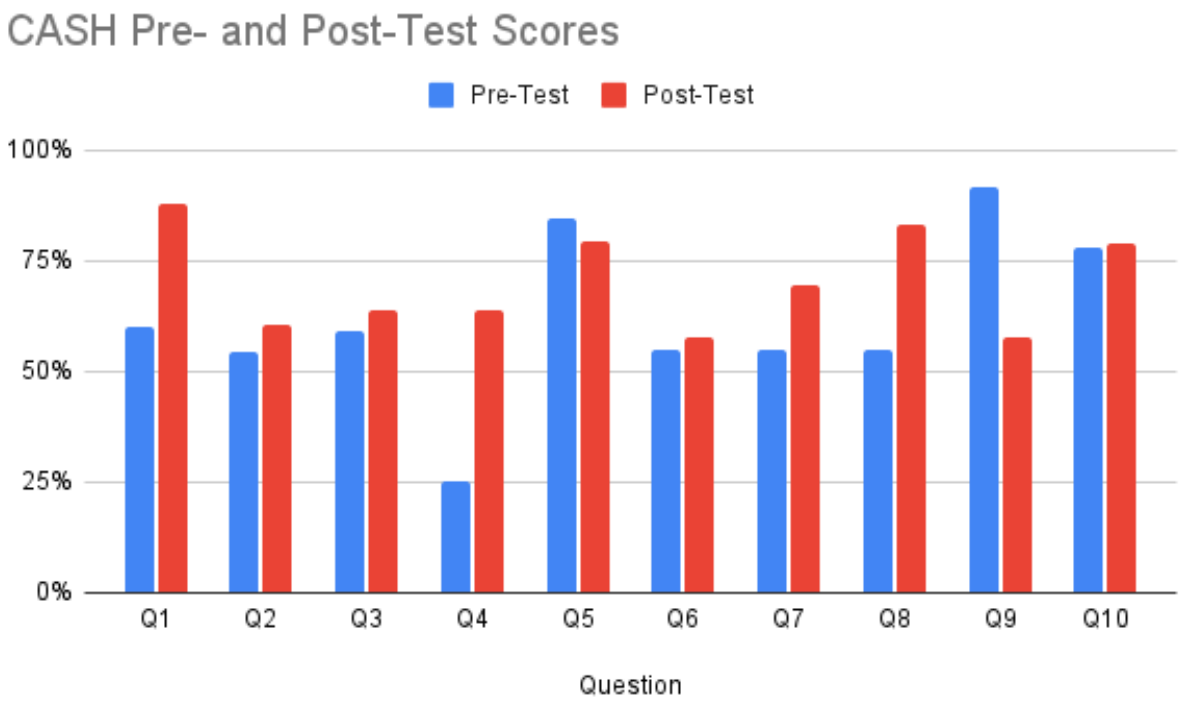


Figure 3 | CASH Pre- and Post Test Scores.

Students at CASH had high baseline environmental stewardship scores (Figure 3) and showed little score improvement between pre- and post- tests. I learned that many of the students at CASH had prior knowledge and experiences with the resource (I.e., nature, streams, stewardship) during and outside of school time. Science related questions indicated greater gains overall (Figure 3). However, the timing of the final lesson and completion of post assessments may have had an impact on scores. At the request of their teacher, the final lesson was pushed from the second week of December 2021 to the second week of January 2022. This was due to high Covid-

19 cases and the winter break holiday. Only ~37% of students completed the final journal response, which further demonstrates that timing may have played a role in student engagement.

NWHS

Pre-test scores at NWHS were: n= 85, min=0 (0%), mean= 5 (50%), max= 9 (90%), mode= 6 (60%), StDev= 2.0. Post-test scores were as follows: n= 72, min=1 (10%), mean= 7.5 (75%), max= 10 (100%), mode= 9.5 (5%), StDev= 2.3. The average score increase between pre- and post-tests was 25%. Assessment data indicates a ~28% increase among science comprehension questions, and an increase of ~9% among environmental stewardship comprehension questions.

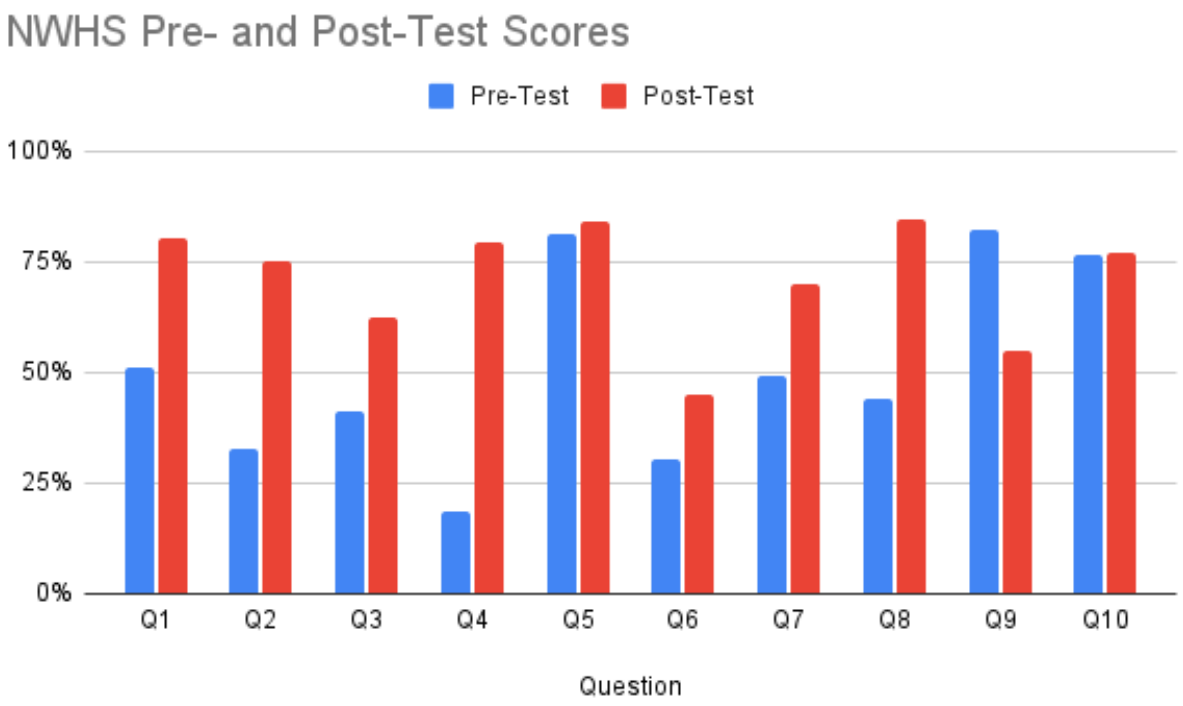


Figure 4 | NWHS Pre- and Post Test Scores.

Students at NWHS had high baseline environmental stewardship scores (Figure 4) and ~10% score improvement between pre- and post- tests. Science related questions indicated greater

gains overall (Figure 4). ~52% of NWHS students chose to complete the final journal response. Given that journal prompt responses ranged from 39-46 students over the course of the pilot, my interpretation of engagement was consistent as NWHS. NWHS was one of two schools that participated in a schedule with about two weeks between each module.

JTHS

Given the small sample size at JTSH (pre-test: n=6; post-test: n=4), pre- and post-test data were excluded from quantitative analysis. Absences influenced low participant volume. Additionally, pre- and post- test responses illustrated that students copied one another for many if not all questions.

2.9 Student Data: Journal Responses

Within one day of the conclusion of a learning module, students had the opportunity to respond to open-ended prompts in nature journal folders provided for the pilot. Folders were color coded by school and included looseleaf paper. The opportunity to self-select provided a snapshot of students' thoughts and feelings. The purpose of the writing exercises was to provide an outlet for students that felt more comfortable expressing their thoughts and feelings on paper than verbally. Journal responses offered insight into the minds of rural teenagers. The questions included topics that ranged from retrospective experiences in nature to contemporaneous experiences relating to the S2T pilot and their futures. Students had the opportunity to choose to participate or not and to what extent they wanted to share. Some students were enthusiastic to share what they wrote in class whereas others preferred only to write.

Written journal responses were scanned and transcribed in Google Sheets. I separated journal entries by school and module number. As I read through each response series and took notes of recurring themes, words, and phrases. At the end of the response series, I reviewed the notes I made and combed through the entries again taking a tally of each of the themes, words, and phrases that stood out to me. I took care to note the number of times students made references instead of the number of times a word was used. From beginning to end, I read and confirmed tallies roughly ten times during the review and writing process. This helped me to refine the coding process and ensure that the findings were accurately reflected. Below are the journal prompts by module and data collected from each school.

- Module 1: In a few sentences, please describe a memory you have in nature.
- Module 2: Yesterday you got to explore the creek! What was your experience like?
- Module 3: If you could change one thing about the world, what would it be and why?
- Module 4: What would you like to be when you grow up and why?

CASH

Module 1: In a few sentences, please describe a memory you have in nature.

39 students responded to the first journal prompt, and 36 of these students shared positive experiences in nature. The remaining 3 students shared experiences about falling in a creek, being pinched by a crawfish, and cutting their finger on a rock. Bodies of water including creeks (n=16), streams (n=5), rivers (n=3), ponds (2), and the ocean (n=1) were mentioned by 27 students. Two terrestrial location types mentioned included the woods (n=8) and the forest (n=1). Memories about searching or catching invertebrates were shared 19 times: bugs (n=4), crawfish (n=9), crayfish (n=6). Stories about amphibians were accounted for by 4 students: salamanders (n=1),

newts (n=1), frogs (n=2). Fishing was mentioned by 6 students. Hunting or seeing deer was included by 5 respondents. Of the reflections, 7 students referred to memories from childhood or, "when they were little." Family was mentioned by 14 students and included: cousin (n=2), sister (n=5), brother (n=1), dad (n=1), grandma (n=1), grandpa (n=1), family (n=3). A friend or friends were included in 4 reflections.

Module 2: Yesterday you got to explore the creek! What was your experience like?

26 students responded to the journal prompt following Stream Day. Of the 26 students, 2 shared that they didn't get into the water or didn't like getting into water. 1 of the 2 expressed they still enjoyed being outside because they got to, "breathe in fresh air." Among the other 24 respondents, positive words were used to describe their experience including: fun (n=15), enjoyed (n=7), interesting (n=5). 5 students shared about what they learned, and 1 student expressed that although they didn't learn anything new, they still had fun. Identifying organisms was mentioned by 9 students and learning to identify the sex of crayfish was mentioned by 1 student. 3 students referenced water quality including: pH (n=2), oxygen (n=3), and temperature (n=1). The invertebrate animals shared in student reflections included: bugs (n=3), insects (n=2), larva (n=1), moth (n=1), crayfish (n=10), and crawfish (n=6). Vertebrates were referenced 7 times: fish (n=5), minnows (n=1), darters (n=1).

Module 3: If you could change one thing about the world, what would it be and why?

Of the 52 students who responded to Journal Prompt 3, all except 1 wanted to change something about themselves, people, or the world itself. 6 students wrote about their desire to see shifts within the government including a wish to have a different president (n=2), "high prices and taxes" (n=1), laws (n=3) including changing the legal drinking age to the age in which they can

enlist to serve in the military. 4 students expressed a desire for illnesses including Covid (n=3) and cancer to be cured (n=1). 7 students expressed concerns about the state of our planet including global warming (n=2), pollution (n=1), resource scarcity (n=2), habitat destruction (n=1), nuclear power/war (n=1). 11 students shared their thoughts or wishes about how people can change to make the world a better place including peace (n=4), empathy/understanding (n=5), and finding happiness (n=2). 5 students shared their hopes about behaviors that people could heal from or change including trauma (n=1), hate (n=3), and lying/being fake (n=1).

Module 4: What would you like to be when you grow up and why?

23 students responded to the journal prompt following the final lesson in the pilot. Of the 6 students expressed that they weren't sure what they wanted to be when they grew up, 3 shared their subject interests. 4 students expressed the desire to work in the medical field including medical doctor (n=3) or therapist (n=1). 2 students shared their hope to become parents in the future. 2 students expressed their desire to make a lot of money in the future. 1 student indicated that they would become an artist when they grew up. 1 student shared their plan of becoming a teacher when they grew up. 1 student shared that they would become a diesel mechanic in the future. 2 students expressed a desire to help people.

NWHS

Module 1: In a few sentences, please describe a memory you have in nature.

40 students responded to the first journal prompt. 39 students shared positive experiences in nature. The remaining student shared an experience about discovering their waders had a hole in them once they'd gotten into a cold stream. Memories with bodies of water including creeks (n=15), streams (n=4), lakes/reservoirs (n=5), and the ocean (n=2) were shared. 20 terrestrial

location types mentioned included the parks (n=2), hiking (n=4), camping (n=5), four wheelers/ side by side riding (n=2), forests (n=8), and cave (n=1). Two students included plants in their reflections including moss (n=1) and thorn bushes (n=1). Memories about catching invertebrates were shared 9 times: aquatic critters (n=2), crawfish (n=6), crayfish (n=7). Stories about amphibians were accounted for by 4 students: salamanders (n=1), tadpoles (n=2), frogs (n=1). Fishing was mentioned by 8 students, and kayaking was mentioned by 2 students. Students reported hunting (n=3) or seeing terrestrial mammals including deer (n=5), bear (n=2), squirrels (n=1), coyote (n=1), and rabbits (n=1). Students also shared stories including fish (fish: n=11, shark: n=2, dolphin: n=1, and stingray: n=1), reptiles (painted turtles: n=1, snapping turtles: n=1, snake/water snake: n=2), and birds (pelican: n=1). Of the reflections, 8 students referred to memories from childhood or, "when they were younger." Family was referenced by 43 times and included: mom/mother (n=7), dad (n=4), parents (n=4), family (n=11), sister (n=5), cousins (n=4), grandma (n=2), grandpa (n=2), grandparents (n=2), uncle (n=2). A friend or friends were included in 0 reflections.

Module 2: Yesterday you got to explore the creek! What was your experience like?

44 students responded to the journal prompt following Stream Day. Of the 44 students, 1 shared that they didn't get into the water because they'd forgotten to bring an extra pair of shoes. 3 students expressed they enjoyed stream day because they got to have a mental breather (n=1), breathe (n=1), or found their time outside refreshing (n=1). 36 respondents used positive words to describe their experience including: fun (n=18), enjoyed (n=5), good (n=2), great (n=1), interesting (n=6), neat (n=2), love (n=2), or hoped they could go out to the creek again (n=1). 11 students shared what they learned. Identifying organisms was mentioned by 7 students and learning to identify the sex of crayfish was mentioned by 8 students. 5 students referenced water quality

including: sediment (n=2), dirt (n=1), visibility (n=1), and water level (n=1). The invertebrate animals shared in student reflections included: crayfish (n=21), crawfish (n=11), crawdads (n=1), lobsters (n=2), dragonfly nymph (n=1), stonefly (n=1), water pennies (n=1), flatworms (n=1), water striders (n=1) and aquatic organisms (n=3). 1 student said that they saw a crawfish as big as a lobster. Vertebrates were referenced 4 times: fish (n=2) and deer (n=2).

Module 3: If you could change one thing about the world, what would it be and why?

Of the 46 students that responded to Journal Prompt 3, all except 1 wanted to change something about themselves, people, or the world itself. 14 students wrote about their desire to see shifts within the government including a wish to lower fuel prices (n=5), lower cost of food (n=4), laws (n=2) reduce pollution and protect wildlife (n=3). 1 student expressed a desire to "get rid of Covid (n=1)" and another wished to improve world health standards/treatment (n=1). 11 students expressed concerns about the state of our planet including climate change (n=3), pollution (n=4), resource scarcity (n=3), habitat destruction (n=1), and biodiversity loss (n=1). 13 students shared their thoughts or wishes about how people can change to make the world a better place including acceptance (n=3), empathy/understanding (n=2), people of the world caring more (n=3), improving outlook on life (n=2), being more giving (n=2), and finding happiness (n=1). 1 student wished they could find more crayfish. 1 student wished there were no more bees in the world. 1 student wished there was no more school. 1 student wanted children to be raised, "An eye for an eye. Tooth for a tooth."

Module 4: What would you like to be when you grow up and why?

39 students responded to the journal prompt following the final lesson in the pilot. Of the 9 students who expressed that they weren't sure what they wanted to be when they grew up, 8

shared their subject interests including CSI investigator/forensic technician (n=1), medical examiner (n=1), law enforcement (n=1), forensic psychology (n=1), signal intelligence analyst (n=1), business management (n=1), history teacher (n=1), and health care/social worker (n=1). 7 students expressed the desire to work in the medical field (n=1) including biomedical engineering (n=2), equine chiropractor (n=1), neonatal nurse (n=1), pediatric nurse (n=1), medical doctor (n=1). No students shared their hope to become parents in the future. 3 students expressed their desire to be rich (n=2) or make a lot of money (n=1) in the future. 1 student shared that they will do, "Whatever I have to in order for my s/o to achieve her goals." 1 student indicated that they would become an archeologist when they grew up. 3 students shared their plan of becoming a teacher when they grew up, including an elementary teacher (n=2) and history teacher (n=1). 1 student shared that they would become a welder in the future. 2 students expressed an interest in computer science including computer engineering (n=1) or software engineering (n=1). 2 students expressed a desire to help people.

JTSH

Module 1: In a few sentences, please describe a memory you have in nature.

Of the 5 students that responded to the first journal prompt, all shared a memory from nature that included animals including: crawfish (n=2), frogs (n=1), rattlesnake (n=1), catfish (n=1). 4 students shared experiences in streams or creeks where they caught animals. 3 students recounted memories they shared with friends (n=2) and family including cousins (n=1), sister (n=1), and grandma (n=1). 4 of the five students shared memories from when they were "little" or "younger."

Module 2: Yesterday you got to explore the creek! What was your experience like?

Of the 6 students that responded to journal prompt 2, 5 students described their experience in the creek as great (n=2) or fun (n=3). The weather conditions were mentioned by 5 students including the temperature (n=4) and visibility (n=1). Animals were mentioned by all 6 students including crayfish (n=2), water pennies (n=1), creatures (n=1), and macro organisms (n=1). 2 students described the experience as interesting, and 1 student shared that they'd learned new things.

Module 3: If you could change one thing about the world, what would it be and why?

Of the 6 students that responded to Journal Prompt 3, all wanted to change something about people or the world itself. Students expressed concerns about the state of our planet including climate change (n=1), pollution (n=1), and habitat destruction (n=1). Students also shared their thoughts or wishes about how people can change to make the world a better place including acceptance (n=1), empathy/understanding (n=2), and equality (n=1). 2 students shared concerns about racism (n=2), homophobia (n=1), abuse (n=2), and cruelty (n=1). 4 students including wildlife and animal welfare in their responses.

Module 4: What would you like to be when you grow up and why?

5 students responded to the journal prompt following the final lesson in the pilot. Of the 2 students who expressed that they weren't sure what they wanted to be when they grew up, both shared what they'd like to study in college including zoology (n=1) and environmental science (n=1). 3 students expressed the desire to work in the medical field including nurse (n=1) or psychologist (n=2). No students shared their hope to become parents in the future or expressed a desire to be rich in the future. 1 student considers becoming a teacher when they grow up. 4 students shared that they want to help people (n=1), the environment (n=1), and animals (n=2).

2.10 Student Data Synthesis

I learned that many of the students at NWHS had prior experiences with the resource (I.e., nature, streams, stewardship) in and outside of school time. This may explain their high Environmental Stewardship scores in pre- test scores and the low increase in the post- test Environmental Stewardship category. Without the journal responses, I wouldn't have known about the breadth of lived experiences students had prior to S2T. There was a score increase across the board at NWHS both in science knowledge and environmental stewardship. CASH also demonstrated gains in science knowledge in post- assessments. This illustrates the science related questions were appropriate for the age and experience level of the students in the pilot. Both quantitative data and qualitative data were needed to better understand student comprehension and connection.

Qualitative data including journal responses, personal observations, and teacher conversations offered a more nuanced understanding of students' engagement and understanding of nature. Similarly to CASH, qualitative data provided a more well-rounded understanding of students' engagement and relationship with nature at NWHS and JTHS. Journal responses allowed us to see the world through the eyes and hearts of students. The love, joy, and compassion in their reflections offered a supercut of experiences ranging from their first memories of nature and family traditions and their present and their hopes for the future. Students from each S2T school chose to share their journal reflections with the class. Others preferred only to write or to have conversations. Though the overall qualitative and quantitative data varied among students, students enjoyed engaging and learning in the S2T series.

In part, Richard Louv's work on Nature-Deficit Disorder inspired the mission of ST2. Though the teens I worked with grew up with technology, their proximity to nature also shaped their identities through formative experiences. Perhaps without knowing the term, students were already practicing environmental stewardship in their lives outside of school. Through conversation, I discovered many of the students from CASH participated in stream studies during school time from as early as the 4th grade through the ACCC program. In their own words, rural students experience painting a picture rich in green and empathy for the environment and living things within it. With that said, adjusting the depth and range of the S2T program can inform the reflection of the students that participate by taking their lived experiences into account and bring them to the next level of understanding. If I hadn't been in person for S2T, I wouldn't have the insight conversations and observation requires.

Though all participating schools were located within 30 minutes from Linesville, PA, I chose to separate the data for each school. The schools varied in the number of sections, students, and proximity to nature (I.e., walking distance of streams, wooded areas, etc.). Each of the teachers also had different styles of teaching. The teacher from CASH weaved Environmental Education throughout her curriculum whereas the teacher from NWHS incorporated technology and the hard sciences in her classes. The teacher from JTHS had a blended style that emphasized the organismal lens and student engagement in Envirothon. The teacher from CASH would've liked her students to continue nature journaling for the whole school year. However, at NWHS the teacher realized her students were more likely to choose to write if the prompts were shared through the Google platform because they all regularly used their laptops in their science classes. The class at JTHS would journal but preferred to engage in discussion.

2.11 Collaborator Data: Qualtrics Responses

At the conclusion of the S2T pilot, I aimed to gauge the experience of collaborators including Pymatuning Lab of Ecology (n=1), Allegheny Creek Connections (n=1), West Liberty University's Crayfish Conservation Lab (n=1), and the high school instructors (n=3). I used Qualtrics to share 12 questions including name, organization, email, 5-point Likert scale, and open-ended questions. 5 of 6 individuals responded to some or all survey questions including representatives from Pymatuning Lab of Ecology, Allegheny College's Creek Connections, and the high school instructors. The survey questions related to the pilot and responses collected are listed below. Of the 13 questions in the survey, the number of responses to each question were as follows: Q1 Name (n=5), Q2 School or organization (n=5), Q3 Primary email address (n=5), Q4 Level of involvement in lesson planning process (n=5), Q5 How well the S2T pilot program was organized (n=5), Q6 Student engagement (n=4), Q7 Personal level of comfort leading lessons and activities (n=4), Q8 Number of lessons (n=4), Q9 Meeting institutional learning objectives, Q10 Likelihood of recommending S2T to other institutions/instructors (n=4), Q11 New connections (n=4), and Q 12 Likelihood of future participation (n=4). Questions 1-5 were answered by all 5 respondents, and questions 6-12 were answered by 4 respondents.

On a scale of 1-5 for lesson planning involvement 5 responses were recorded with the minimum score being 2.0, the maximum score of 5.0, and a mean score of 4.0. On a scale of 1.5, how well the S2T pilot was organized 5 responses were submitted with a minimum, maximum, and mean score of 5.0. On a scale of 1-5, how engaged were students with the materials covered in S2T, 4 responses were submitted with a minimum, maximum, and mean score of 5.0. On a scale of 1-5, how comfortable would they feel leading the lessons and activities from the pilot, 4

responses were submitted with a minimum, maximum, and mean score of 4.0. Based on their experience and observations, respondents were asked if they would recommend decreasing the number of lessons, keeping the same number of lessons, or increasing the number of lessons. Of the responses, 0 recommended decreasing the number of lessons, 3 recommended keeping the same number of lessons, and 1 recommended increasing the number of lessons. When asked if the S2T lessons and activities supported their institution's learning objectives, 5 respondents selected yes and 0 selected no. On a scale of extremely unlikely (1) to extremely likely (5), how likely were they to recommend the S2T program to other institutions/instructors, 4 responses were submitted with 1 individual selecting they were extremely unlikely to recommend the program, 1 selected they were somewhat likely to recommend the program, and 2 selected they were extremely likely to recommend the program (min=1.0, Max=5.0, and Mean=3.75). When asked if the S2T pilot helped them make additional connections within or outside of their institution, 4 responses were recorded including yes (n=2), no (n=1), and maybe (n=1). On a scale of likely they were to participate in the S2T series in future school years (extremely unlikely (1) to extremely likely (5)), 4 responses were submitted with 1 selected they were neither likely or unlikely (3) to participate in the future and 3 selected they were extremely likely to participate in the future (5).

2.12 Collaborator Data: Teacher Focus Group

At the conclusion of the S2T pilot, I held a focus group with the high school instructors on Zoom. Since I worked most closely with the high school instructors, I was interested in more detailed feedback about their experience, observations, and ideas for future iterations of the program. Our meeting lasted approximately one hour and included a meeting overview, five open

ended questions, and an allotment of about ten minutes for each of the following questions: Q1 How would you describe your experience in the S2T pilot?, Q2 Did you or your students develop relationships with the community partners involved in the pilot, and if so, how would you describe that?, Q3 What observations did you make about the students during the S2T lessons?, Q4 Were there any lessons or activities that you would adjust, and if so, in what ways?, and Q5 How do you think the S2T program impacted your students?.

For question 1, the teachers reflected on their experience in the S2T pilot. Words including good (n=3), nice (n=2), positive (n=1), inspirational (n=1), incredible (n=2), and impactful (n=2) were used to describe both their own and their students' feelings about the pilot. One teacher went on to say, "(My students) couldn't wait for project days when Audrey came in!" Relating to the information covered during the pilot responses with the words hands on (n=1), extension (n=2), depth (n=1), and experts (n=1) were shared. In their own words, one teacher shared, "I guess to be very complimentary and an extension of the experiences that I had previously provided for my students, so I felt that it added like a layer of depth to what we currently taught, and it created a bit of a novel experience because usually when I saw kids outside, it was just me and them and having other people there really validated what we were doing in the classroom already. So I thought that was an excellent thing, like the extension of that I had never done a lot of. We found crayfish, but it was always just discover, put them back, not really look at the different anatomical features that would allow us to identify them. And having experts in the field was incredible, like an incredible experience. It also was inspirational for my students. So, when we went out again after that day, I saw them apply many of the techniques and things that they had learned. So that made me feel good that it was not only a time that program coordinators were there, but also they transferred that knowledge to the next level experience, and I think that was really impactful for them."

In question 2, instructors were asked if they or their students developed relationships with the community partners involved in the project, and if so, how they would describe that. The words, yes (n=1), no (n=1), and definitely (n=2) were shared. One teacher explained that they personally had relationships with the community partners before they participated in the pilot program. However, she went on to say that some of her students learned about volunteer opportunities because of the affiliations (I.e., community partners). Further, students that didn't participate in S2T heard about the pilot program and came to the teacher to ask if she knew of, "internships or volunteer work they could do." Another teacher shared that her, "students have indicated numerous times that they would like to work with them all again." She expressed that some of her "students learned about additional career pathways through talking with the community partners." She went on to say, "It meant a lot to me to see that my students could see a future in a field doing something they already enjoyed but didn't know existed in the form of a career."

For question three, teachers shared their observations of students during the S2T lessons. Smiling (n=2), happy (n=2), and "looked forward to project days (n=1)," were words and phrases teachers used to describe their students' feelings. Words relating to behavior including discovering (n=1), absorbing (n=1), engaged (n=3), and learning (n=6) were shared. Conversations were also highlighted. One teacher said after lesson days, "they would randomly reflect positively regarding the experience." Another teacher observed that one of the students, "loved learning the answers in the first sessions and later one. He was absorbing and then able to communicate that information. I could see them becoming more and more comfortable with the fact that you were in my classroom, which was really nice, like they saw you as an extension of the learning, I think, which was really cool." She also went on to say, "I think sometimes the journaling didn't always reflect the depth of what they were thinking, you know, when they were asked to journal by prompt

because we had really good conversations afterwards about it and I could tell that it had impacted them." One teacher shared that, "We put the classes together because they began to see that, you know, that the classroom really didn't have those walls that we were kind of like as a group, as the Northwestern and I thought that was really cool, too."

In the fourth focus group question, teachers were asked if there were any lessons or activities they would like to adjust, and if so in what ways. Time spent outside was most frequently discussed. One teacher said, "I think they would have liked to have gone outside every time they saw you, but I think the props and learning manipulatives and things that you brought, really kind of enhanced that experience." The teachers all shared that their students would have liked to have more time spent outside, especially on the stream day. Relating to the journals, one teacher shared that, "I think they really preferred to have conversations, and I know you need the written evidence, but I think they got way more from the conversations than they did from the journaling. I think it felt like they didn't ever want to do it for me. When you were there, it was like, 'Oh, yeah, sure, absolutely.'" Relating to lesson adjustments, another teacher shared lessons that were, "corrected well throughout the day because we did like the whole day, so we had like seven eight groups go through over the course of the day."

In the fifth and final focus group question, teachers were asked how they thought the S2T program impacted their students. One teacher shared that her students "gained classroom experience outside of my area of expertise through this series." Another teacher said, "So I think they're considering their environment more and what's going on in their environment, even if they're not all going to be biologists." She went on to say that her students would randomly reflect on being in the creek on the weekend and wondering why they didn't find crayfish. One teacher shared that because of the "outside, hands-on component, they're more likely to enroll in those

future environmental-science based courses." She went on to share a shift in the perspective of her students, "They see me in chemistry, and they see me in front of the room and teaching very structured structure science, and then we get outside where it's more discovery exploration. I think their perspective of me changed a little too. And the fact that I'm in a community of scientists, right? Their perspective also changed. Learning doesn't stop just in the classroom. I felt like my students maybe saw me as more approachable because they saw me in that more natural setting outside.

3.0 Section Learning & Actions

The initial focus of S2T aimed to explore how informal learning organizations can aid in the development of students' environmental identity. The S2T pilot laid the groundwork for how the University of Pittsburgh can be useful to formal educators outside of the greater Pittsburgh area and provide engaging nature-based programming for students. The strength of this program came in the form of collaboration. Intentional co-design allowed teachers and project partners to combine their varying areas of expertise to create more than experiential learning opportunities for students. During our time together, I found myself reimaging relationships in learning ecosystems.

Investing in one another and building on experiences over time not only allowed us to provide a rich programming, but also a new set of eyes to see one another, for students to see their teachers, and the natural world. Students saw their teachers explore nature and learn alongside them. Teachers became more than who they saw Monday through Friday. They were people who knew how to catch salamanders and were every bit as excited as their students to learn about the classroom that existed beyond the walls of their schools. The strength of the project is the reflection and continuous improvement. The little adjustments between classes and overnight, and the bigger changes from module to module exemplified the program's iterative, reflective design.

The findings from the S2T pilot indicated higher baseline environmental stewardship than suburban or urban students I interacted with during my time with Pitt Bio Outreach. In addition to personal and teacher observations, students themselves shared experiences and connectedness with nature through conversations and their journal reflections. Given pilot students' inclination for environmental stewardship, an approach that is more reflective of the prior knowledge and

experiences should be explored for future iterations of this program. S2T should be responsive to student experience to encourage greater impact. Perhaps the intervention was not strong enough for the students that I worked with. It's also possible that the assessments I chose couldn't fully discern the learning outcomes of the pilot.

In future iterations of S2T, I would recommend sharing Journal Prompt 1 prior to a pre-assessment. Journal Prompt 1 said, "In a few words, please describe a memory you have in nature." The science-based assessment questions would be consistent with the grade level and related to the learning series. However, the environmental stewardship related questions could be adjusted if journal revealed that students have extensive experiences in nature versus little experience in nature. The students involved in the first iteration of S2T had a rich understanding of nature and conservation. Their journals revealed that they returned animals to where they found them including putting rocks in streams back after looking underneath. I expect very different journal responses from students in suburban and urban contexts given the amount and types of green spaces that exist in those regions. Understanding student background in their own words can allow the experience S2T offers to be tailored to better support student understanding and development.

Continued co-development with teachers that participate in S2T can offer adjustments to help students better connect with the material. Written journal responses were utilized among pilot schools until one of the pilot instructors realized that because her students were used to typing responses to coursework on laptops, sending journal prompts through a Google push might be more successful. She was right. In the future written versus typed journal responses could be considered. Additionally, small group discussions could be considered because all the pilot instructors observed that their students enjoyed sharing stories. Some preferred to share with the students sitting close to them, where others preferred to share with the whole class. The qualitative

data open-ended student responses offer is robust, and considering other methods for evaluation can be explored to enable conversation-based reflection. If students work in pairs, perhaps they could take turns listening to their partner, recording, and sharing. Provided there is teacher support and institution permission, whole class discussion could be recorded by an observer. Field notes provided by an observer including written or typed could be used in addition to auditory recording for future coding.

The co-development process with teachers both improved the learning series and created opportunities to diversify my communication style. Their understanding of each respective high school's learning goals and baseline student knowledge shaped the subject matter and depth of S2T content. Teachers also helped determine what order would best service their students and the timing of lessons during the school year. Each of the teachers and I lived and worked in different regions of the state. I used a Doodle poll to determine when to set recurring Zoom meetings in the spring of 2021. The morning before each meeting, I sent an email reminder, a brief meeting overview, and links to the documents we'd be covering later in the day. During the meetings, we'd agree on action items from that time until we next met. Action items ranged from accessing 2021-2022 school calendars, permission for me to be on-site, reviewing module content (I.e., outlines, assessments, journal prompts, PPTs, etc.). We established a flow and comfortable rapport.

When the pilot began, I had to adjust my communication strategies. I learned that one teacher got a new email address, which explained the lack of responses prior to the pilot launch. Another teacher preferred text reminders to emails because they were inundated with emails with the start of the new school year. Although we made adjustments along the way, I should have asked them what communication style they preferred prior to the fall of 2021. Shortly after the 2021-2022 school year began, two of the three teachers requested to adjust when the first and

second module took place. Although my schedule was flexible at that time, not all project partners were able to adjust their schedules to be present for the stream exploration day. The offer perspective, the partner that agreed to be present prior to the schedule change was going to bring five additional volunteers. Fortunately, a volunteer from a different lab was able to come in their stead, but I realized that we should have established a plan a and a plan b farther in advance.

My formal training as a scientist and as an informal educator shaped my view of data analysis. Pre- and post- tests were used in every module developed in the years preceding my time in Pitt Bio Outreach. Numbers offer one view of knowledge acquisition. However, over the course of the S2T pilot, I realized the breadth of information qualitative data offers may be a more powerful and direct means to gauge student learning. In the future, I will also take greater care to consider how to assess multiple learning types. There were students that I had conversations with, and I knew they understood the content, but answered the questions incorrectly in the post-assessments. One of my concerns going into the pilot was if asking students to complete pre- and post- assessment would further contribute to testing fatigue of youth.

Working with community partners and formal educators over the past year has been such a joy. I will say that the community partners were not as involved with the teachers and students. Because all participants were given the choice of to what extent they wanted to be involved in the project, teachers implied that both themselves and their students didn't feel as connected to the community partners outside of Pitt Bio Outreach. Although relationships did not appear to affect the ability of students to connect with the material, this may need to be addressed for the longevity of the program. If a project partner isn't actively invested in the success of S2T, they may not continue to participate. Turnover in the nonprofit world is also a very real factor to consider in the capacity of programs like S2T to endure. I would recommend including more than one contact

person from each project partner to better enable relationship longevity. Pre-recorded video clips of project partners or offering accompanying Zoom calls may also reduce the lift among partners for in-person classroom support. This would allow project partners to share their expertise or explain lesson components without having to be physically present.

From idea inception to pilot implementation, S2T was impacted by Covid-19. Prior to Covid-19, Pitt Bio Outreach would host in-person professional development trainings in the summer months. During the training, teachers would be able to walk through new modules or those that are more technical. By working through the materials with Pitt Bio Outreach, teachers were not only more confident in their ability to lead programming in their classrooms in the coming school years, but also given real-time trouble shooting support. Had the S2T teachers been able to work through the curriculum during a summer workshop, I feel they would have been more confident leading the activities with their students during the pilot. Given the infrequence of teachers requesting in-person support for Pitt Kits, offering teacher training workshops prior to Covid-19 indicated a more efficient system. I would venture to say that the connection students have with Pitt Bio is related to the amount of time they receive in-class support.

Since the pilot's completion, I've been reflecting on the impact of the S2T design versus previously existing Pitt kits. The work that went into developing relationships with collaborators was a big lift. Although the design may have been inefficient given the amount of travel time (2 hours one-way) and frequency (5+ visits) in addition to the amount of time spent at each school (CASH: 7 hours/day, NWHS: 8: hours/day, JTHS: 2 hours/day), this time was instrumental in forming relationships with the students and teacher and gave me a more accurate means of improving the program. The time I spent in-person also supported a greater impact on teachers and students than simply bringing kits would have allowed. The students saw me as more than the lady

that brings kits. They saw me as a scientist and an extension of the University of Pittsburgh. Pilot teachers have continued to work with Pitt Bio Outreach even after I moved (Personal Communication).

Our work has also improved our respective organization's relationship with Allegheny College Creek Connections (ACCC). Prior to agreeing to participate in the pilot, there was an unspoken agreement that Creek Connections was the only group in the area to offer creek programs in western Pennsylvania (Personal Communication). Once we began working more closely with ACCC, the tension surrounding creek programming has all but dissolved because we have a shared understanding that our groups aim to serve students, and we're better able to do so by working together. Discussing resources and roles in the shared learning series should be part of quarterly meetings or email threads in the future. The tension may have stemmed from regional differences, concerns that their work would be taken over by a larger university, or due to the newness of our working relationship.

From beginning to end, this development of S2T offered invaluable insight into developing relationships in learning ecosystems. Establishing scaffolding with the appropriate support is critical to successfully creating novel partnerships between universities, informal science learning organizations, and formal educators. Between May and August of 2023, I intend to devise a guide for others interested in exploring co-development of curriculum spanning geographic locations. From identifying potential collaborators and navigating levels of partnership to practical concerns such as understanding the needs of project partners and mechanisms communication including for feedback. My goal is to submit the guide to an open-access publisher. The S2T pilot illustrated

that so much more can be accomplished to the benefit of students through intentional collaboration.

4.0 Reflections

The Dissertation in Practice (DiP) and Doctor of Education (EdD) process has been transformative. I entered the EdD program in May of 2020. The world slowed to a crawl, and as a practitioner I was met with the challenge of persisting in the work that is most dear to me. Through the support and guidance of my supervisor, instructors, and cohort, I was able to attain the tools I needed to meet the needs of our students. Throughout the writing process I couldn't help but find myself amazed at the life that was breathed into what simply began as an idea in the summer of 2020. My goals are still larger than life, but I now know how to build something meaningful from the ground up.

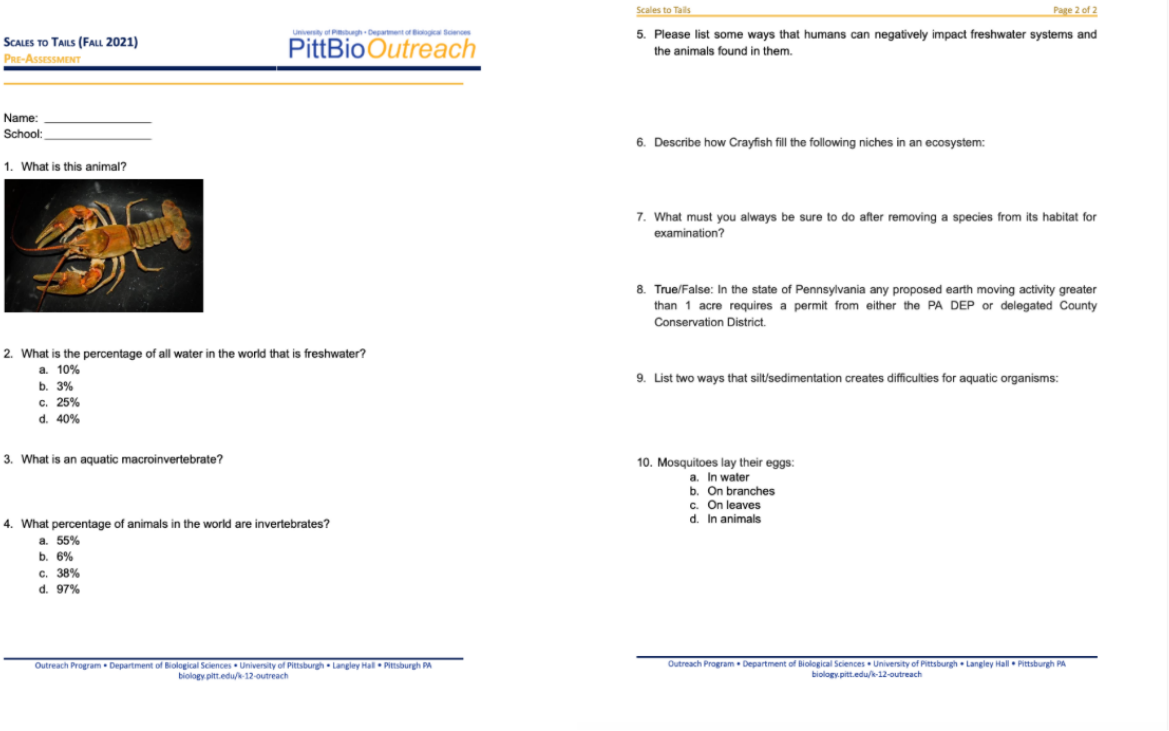
Throughout the DiP experience, I had to learn how to find a balance among my identities as a person of science and an informal educator. Early in the EdD program, my training as a biologist inadvertently caused me to question the importance of qualitative research. However, over the course of the DiP process I realized that research never had to be either quantitative or qualitative. In fact, projects that collect both offer a more holistic understanding of what's actually happening. Without the personal observations and journal prompts, I would still be questioning the connection the students I worked with had with nature, environmental stewardship, and the project partners.

Despite our best efforts, deficit thinking influenced the development of the S2T project. Growing up in, "Sportsman's Paradise," where nature experiences were weaved throughout my formative years, I had very little conservation understanding until I was an undergraduate in college. There were no Environmental Education classes or activities throughout my K-12 years

during school hours. During undergrad, I was introduced to *Last Child in the Woods* by Richard Louv, and I made it a personal mission to create opportunities for children to safely get to know the natural world. Funding provided by the University of Pittsburgh's Year of Engagement Grant, allowed me to develop the S2T program for underserved youth in a rural region of western Pennsylvania. The teachers that were part of the program expressed due to their location both they and their students lacked opportunities and resources.

Improvement science has transcended my work as a practitioner and become a part of nearly every part of my life. Great things can come from a series of small steps. The continuous nature of this field of study requires an open mind and inspires a deeper level of contemplation. Throughout the EdD and DiP process kept me inspired to better understand the systems in which I find myself and to share the tools I've gained to help others. Along the way I also found my voice. The supportive nature of my teachers and cohort in the program and project partners helped me to keep imposter syndrome at bay. I learned the importance of asking the right questions. Training in improvement science in addition to traditional research methods used in the natural sciences, have given me a new perspective. Similar to the conclusion I can come to about S2T collaborations, qualitative and quantitative data are stronger together than on their own.

Appendix A References



SCALES TO TAILS (FALL 2021)
PRE-ASSESSMENT

University of Pittsburgh • Department of Biological Sciences
PittBio Outreach

Name: _____
School: _____

1. What is this animal?

2. What is the percentage of all water in the world that is freshwater?
   a. 10%
   b. 3%
   c. 25%
   d. 40%

3. What is an aquatic macroinvertebrate?

4. What percentage of animals in the world are invertebrates?
   a. 55%
   b. 6%
   c. 38%
   d. 97%

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Scales to Tails Page 2 of 2

5. Please list some ways that humans can negatively impact freshwater systems and the animals found in them.

6. Describe how Crayfish fill the following niches in an ecosystem:

7. What must you always be sure to do after removing a species from its habitat for examination?

8. True/False: In the state of Pennsylvania any proposed earth moving activity greater than 1 acre requires a permit from either the PA DEP or delegated County Conservation District.

9. List two ways that silt/sedimentation creates difficulties for aquatic organisms:

10. Mosquitoes lay their eggs:
    a. In water
    b. On branches
    c. On leaves
    d. In animals

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Figure 5 | S2T Pre- and Post- Assessment Questions

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