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The Role of Environmental Education in Steam Education

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THE ROLE OF ENVIRONMENTAL EDUCATION IN STEAM EDUCATION

By

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CHAPTER ONE

Introduction

For the past ten years, STEAM (Science, Technology, Engineering, Arts, and Mathematics) education has been an intentional initiative in many schools across America (Mohr-Schroder, Cavalcanti, & Blyman, 2015, p. 6). In our ever-growing technological world, we want to be sure that the younger generation is prepared to handle shifting technology, computer science, and the development of new products and ideas that will inevitably turn up in their future careers. However, STEAM does not just teach our students about the tools that may turn up in their futures but also teaches them skills that are essential for our changing world. STEAM teaches our students how to be problem solvers, critical thinkers, and team players (Metz, 2014). All of these skills are important to help develop our students to be as prepared as possible for the future.

As a STEAM specialist teacher, I agree that STEAM education is important and essential for our students and their futures. However, I feel that current STEAM education has been primarily focused on technology and engineering and not as much on the natural sciences, specifically biology and environmental science. These types of sciences are important to our changing world as well. This brings me to my question*: How can incorporating more environmental education into STEAM help create students*

that are equipped with skills needed for future careers? In this chapter, I will discuss my background that brought me to my love of STEAM and nature and why I believe that these two areas should be intertwined in STEAM education.

Background

Science has always been a big part of my life. I grew up in the woods in Northern Minnesota with a mother who was a fifth-grade science teacher and a father who was an archaeologist for the DNR. My parents ensured that my sister and I were getting outside, exploring the woods, and being enveloped in nature as much as possible. My mom raised us from a very young age to embrace bugs, spiders, snakes, and other creatures that most kids may be scared of. One of my earliest memories is catching monarch caterpillars with my mom and raising them into butterflies. We watched our caterpillars eat, get bigger, form their "J"s, spin their chrysalises, and then emerge as beautiful butterflies. My sister and I became responsible for picking milkweed for our caterpillars to eat and cleaning out their enclosure. Along with raising butterflies, I also recall the other activities we did with my mom in summer including going on walks and hikes, sleeping in tents, swimming at my grandma's house, and building forts in the woods. She truly understood how important it was to play, explore, and imagine outside and she made sure my sister and I had that experience.

My dad had a big part in my love for nature as well. Every summer since I was three, my dad and his best friend would take their daughters on a canoe trip in the Boundary Waters Canoe Area Wilderness (BWCA). It was in the BWCA that I learned skills such as paddling a canoe, starting a fire, cooking, packing light, and carrying all of

my gear. I also learned that it was fun to be dirty, sleep under the stars, and be away from gadgets and technology. These outdoor experiences also helped me form one of my closest friendships with my dad's best-friend's daughter. Being out in nature helped us learn to work together, share our stories, and be in community with each other. The BWCA is still a place that I have a strong connection with, and I still treasure the time I get to go up there and spend time in nature.

I had some teachers in elementary school that also encouraged my love for nature. My fifth-grade science teacher, Mrs. Mike-Johnson, made sure that environmental education was a significant part of our science curriculum. I remember having to keep track of our nature observations so we could study phenology, or how the seasons change. Studying those changes so closely helped me learn more about the plants and animals around me, and I still use quite a bit of that knowledge today. In fifth grade, we also went to Long Lake Conservation Camp in Palisade for three days and two nights where we participated in winter activities such as snow-shoeing and cross-country skiing, learned about animal adaptations and practiced our outdoor survival skills.

It was my love of nature and being outside that led me to my college summer job as a camp counselor at a Lutheran camp in Cook, MN. While the camp was not solely focused on nature education, we did spend most of our days out in nature. We went canoeing, cooked over a fire with our campers a couple of times a week, and, depending on the age group, spent a whole day and night out in the woods doing some environmental education activities. I loved watching my campers, some of whom did not have much nature experience, grow in both their knowledge and comfortability with the

outdoors throughout the week. I also loved watching them grow in their teamwork skills, confidence, and advocacy for the natural world. It was this experience that inspired me to become a science teacher. I saw the impact that learning about nature had on my campers, and I wanted to do that work full time.

My first teaching job out of college was a sixth-grade science and language arts position. While the type of science I was teaching was physical science and not very catered to using the outdoors, I wanted to get my students outside as much as possible. I knew how important being outside was for me as a child and how much I was able to learn about myself and the world around me through my experiences. I made sure to get my students out whenever I could, whether it was to make scientific observations in the woods, track some key components of our changing seasons, or just read their books in the grass. I found that my students enjoyed the time we got to be outside and they worked harder and behaved better when we were doing some outdoor education activities.

Rationale

Currently, I am a kindergarten through fourth grade STEAM (Science, Technology, Engineering, Arts, and Math) teacher. For this capstone, I will be using STEAM and STEM interchangeably. STEM education has recently morphed into STEAM education, adding in the arts to get a more well-rounded curriculum. According to the National Science Teacher Association, STEM is defined as “an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise”

(Gerlach, 2012, para 2). While the S in STEAM does stand for science, I feel that there is too much of a focus on the technology and engineering aspects of STEAM, especially if we take into consideration the end goal of helping our students compete in our changing world. I see this in my classroom through the curriculum that I use, PLTW (Project Lead the Way) Launch. This curriculum, provided through Project Lead the Way, has four modules for each grade: two focused on engineering, one on computer science, and one on biomedical sciences (PLTW, 2019). Because I only see students for an hour a week, my school opted to purchase three of the four modules for each grade — both engineering modules and the computer science module. While I love this curriculum and what it pushes my students to accomplish, I want to be able to add more environmental science and outdoor education into these modules and truly develop an interdisciplinary STEAM curriculum.

According to the Institute for Arts Integration and STEAM (2019), STEAM education is more powerful when we interweave the different components and teach interdisciplinary. It is through combining two or more areas of STEAM that we truly start to see the development of wonder, critique, inquiry, and innovation in our students. While each of the components is important separately, cross-curricular connections make an even stronger impact. Adding in the components of environmental education and natural sciences to STEAM can bolster what students are already learning within the STEAM classroom. My hope is that it will also help inspire love and knowledge of nature that will help students develop 21st-century skills such as collaboration, communication, creativity, and critical thinking.

Outdoor education is important because our students are not having the same experiences in nature that I had as a child. More and more of our children are experiencing Nature Deficit Disorder, a term coined by Richard Louv in his 2005 book *Last Child in the Woods.* According to Louv, Nature Deficit Disorder can be found in both children and adults when we are disconnected from the natural world. It can produce negative mental health effects as well as a lack of empathy for the world around us (Louv, 2005). A study conducted by the Child Mind Institute found that the average American child spends only 4-7 minutes of unstructured playtime outside per day and seven hours in front of a screen (Cohen, n.d.). Although technology is a big contributor to Nature Deficit Disorder, there are many different reasons why children are not spending much time in nature including fear of nature, lack of green spaces, and busy schedules (Louv, 2015). Through incorporating nature education into my STEAM block, I am hoping that I can get my students outside experiencing the joys of nature and setting them up for success in their futures.

Environmental education also has many benefits for a child's health and well-being. According to the Child Mind Institute, nature exposure helps build confidence, promote creativity and imagination, teach responsibility, get kids moving, and makes them think about the world in new ways (Cohen, n.d.). These areas are also important to STEAM education. Through STEAM, we are hoping to build our students' confidence, promote their creativity, and teach them responsibility. We are also preparing them for future careers by teaching them 21st-century skills such as communication,

critical thinking, collaboration, and creativity. Adding nature education into STEAM will help bolster these 21st-century skills and best prepare our students for the future.

Summary

STEAM education is important to our students and our world as we start to integrate more science, technology, engineering, art, and math into our school curriculums to best prepare our students for the future in the workplace. However, most current STEAM education focuses too much on engineering and technology and not enough on natural sciences or environmental education. While all aspects of STEAM are important, natural science and outdoor education are important too. These fields help our students experience the natural sciences through being immersed in nature and also build important skills such as confidence and teamwork. Environmental education can work together with the other fields in STEAM to make an even stronger and more-well rounded curriculum. It is my background in science education and my love for the environment that led me to my question: *How can incorporating more environmental education into STEAM help create students that are equipped with skills needed for future careers?*

In chapter two, I will be presenting the history of STEAM education and environmental education. I will also be looking into the benefits of both STEAM and environmental education on a student's social, emotional, and physical well-being as well as the benefits of these educations for our future world. Finally, I will be showing how we can merge these two fields and use them in tandem with each other to improve STEAM education.

CHAPTER TWO

Literature Review

Overview

STEAM (science, technology, engineering, art, and math) education and environmental education both have similar goals; prepare students with the skills they need to succeed in their future careers. However, STEAM education has been primarily focused on technology and engineering, while natural sciences, specifically environmental education, seem to have fallen by the wayside (National Science and Technology Council, 2018). This type of science is also important in preparing students with the skills that they need to succeed in the future. One of the best ways to teach environmental education is through giving students hands-on experiences, specifically getting students outside to teach about our world and how it works (Sobel, 2004). This project will focus on writing a supplemental STEAM curriculum to incorporate more environmental education into a kindergarten through fourth grade STEAM class. To better understand the project, we first need to gain an understanding of the research question: *how can incorporating more environmental education into STEAM help create students that are equipped with skills needed for future careers?*

In this literature review, there are a few components that will be broken down to understand the question fully. First, STEAM education in general needs to be examined.

The history of STEAM education, as well as the goals, benefits, and challenges of this education, are important to understanding environmental education's place in the curriculum. Secondly, environmental education will be examined. The history and goals of environmental education, as well as the benefits and challenges to environmental education, are important to understand to see where it fits in with STEAM. The last subtopic that will be explored is the relationship between environmental education and STEAM education. This section will also look at some examples of environmental education in STEAM curriculums already in place and how these two areas can work together to equip students with essential skills they will need for their futures. This literature review begins in the next section with STEAM education.

STEAM Education

STEAM or STEM education (the A was added recently) has been a rising trend in United States schools for the last ten years. In 2009, President Obama launched a STEM initiative called *Education to Innovate* to better prepare our students for the competitive future (Mohr-Schroeder, Cavalcanti & Blyman, 2015). The goal of *Education to Innovate* was to prepare our students to be problem-solvers, work collaboratively, and think critically about the problems in our world in hopes of building a generation of students who can thrive in the future workforce (Educate to Innovate, 2013). This section of the literature review will explore the history, goals, benefits, and challenges of STEAM education in schools.

History of STEAM education. According to Mohr-Scroeder, Cavalcanti, and Blyman (2015), STEAM education has a long history in the United States. In 1957,

Sputnik was launched by Russia and caused fear that the United States was falling behind competitors in technology and engineering. This fear caused NASA to be formed and more money to be poured into engineering and technology research. In the 1980s, after Halley's Comet was seen, President Reagan saw the need for more science education and passed benchmarks for science literacy for all United States citizens. However, these benchmarks still were not enough to keep up with our quickly changing world. In 2009, President Obama launched the *Education to Innovate* initiative, which focused on creating more diversity in STEM fields, increasing teacher training in STEM fields, and having the government invest more in STEM (Mohr-Scroeder, Cavalcanti, and Blyman, 2015).

Education to Innovate had some other goals as well. According to the Educate to Innovate website (2013), there were three main goals of this initiative. First was building a CEO-led committee to utilize the capabilities of private businesses, including expanding STEM education programs, developing new leadership and training tools for CEOs, and creating a new plan for how companies can invest in new STEM programs. Second was to prepare 100,000 new STEM teachers through a program called 100Kin10. This program increased, and is still increasing, the supply of STEM teachers through hiring, training, and retaining teachers. Finally, *Education to Innovate* focused on increasing diversity in STEM by focusing on underrepresented groups, involving more women and girls in STEM fields, and ensuring that all people had access to technology in school (Educate to Innovate, 2013).

Educate to Innovate was very influential to the start of STEM programs in schools

across the country. While a few STEM programs and STEM specialized schools started right after Sputnik launched in the 1950s, the amount of STEM specialty schools and STEM specialty programs has drastically risen in the last decade. According to a study by Thomas and Williams (2010), “The 20th century saw the evolution of the specialized STEM high school from manual training centers for boys to highly specialized curricula in maritime science, biotechnology, health and medical science, and information technology” (p. 18). This shifting of STEM from training centers to a more accessible form has made it so that more of our students are exposed to STEM and can benefit from the many goals of STEM education.

Goals of STEAM. Along with the goals that were provided by President Obama in the *Educate to Innovate* initiative, STEM education has evolved to incorporate other goals as well. In 2018, the Trump administration produced its own set of goals for the future of STEM education. According to a report by the National Science and Technology Council, a department overseen by the Executive Branch of the United States, the main goal of STEM education is to promote science, technology, engineering, and math education with a particular focus on computer science. This report also stated that creating a generation that has a strong STEM knowledge, specifically in computer science, will prepare future workers for careers in “agriculture, energy, healthcare, information and communications technologies, manufacturing, transportation, and defense, along with emerging areas like artificial intelligence and quantum information science” (National Science & Technology Council, 2018, p. 6). This council saw the needs of the careers of our future and is working towards ensuring that our students have

access to STEM education so they will be best suited to work in those careers.

Along with preparing students for future careers, STEM education also teaches students skills that can transcend into all areas of their lives (PLTW, 2019). STEM teaches our students how to apply their science understanding to solving problems that are relevant and important in their lives and in the world. It also helps develop critical-thinking and problem-solving skills as they solve engineering challenges (Metz, 2014). According to Project Lead the Way, a leader in STEM curriculum and education, STEM also inspires our students to think outside the box, increase their collaboration and communication skills through working in teams, and explore the world around them through hands-on learning (PLTW, 2019). All of these skills are important in shaping the types of people that we want to work in and for the future. “Whether it is researchers, science and mathematics teachers, the aerospace industry, or the construction industry, they all have one thing in common: It is about moving forward, solving problems, learning, and pushing innovation to the next level” (Gerlach, 2012, para 9).

Benefits of STEAM education. Exposing our students to STEM education is essential to our future as a scientific nation and our students’ professional and personal futures as well. According to 100Kin10, a national network committed to adding 100,000 more STEM teachers to America’s classrooms by 2021, the earlier we expose students to STEM education the more successful they will be in high school, college, and throughout their lives. In particular, early exposure to science and math has been shown to improve socioeconomic status well into adulthood (100Kin10, 2018). With the cost of college continually increasing and more uncertainty around the economic future, STEM jobs are

seen as the most practical careers for students to pursue. However, STEM is not just about the high-paying careers. As the 100Kin10 (2018) initiative pointed out,

> It (STEM) nurtures opportunities for inquiry and curiosity; to collaborate, experiment, fail, and persevere; to better understand our bodies, nature, and the built environment; and to practice the kind of critical thinking and creative problem-solving that will be useful in all arenas of life. (para 12)

These life skills that STEM teaches, including inquiry, collaboration, perseverance, and problem-solving, are not only skills that are beneficial to our students in STEM subjects, but in other areas of their academic and personal lives as well.

STEM exposure also helps our students develop 21st-century life skills that help them with their social-emotional development. According to a 2016 study by Garner, Gabitova, Gupta, and Wood, STEM helps students gain skills in communication, the ability to work collaboratively, and critical thinking. They also gain global citizenship, confidence, and empathy. All of these skills are important for developing one's social-emotional learning. This study developed a handful of STEM challenges that required students to collaborate and work together to solve a problem. After completing the challenges, the researchers asked the students what they learned about themselves. Ninety percent of the children identified at least one 21st century skill learned during the lessons such as working together with a team, motivation, and never giving up (Garner, Gabitova, Gupta, & Wood, 2017).

Challenges of STEAM education. While there are many benefits of STEM education, there are challenges as well. Although there are specialized STEM schools,

many students are not receiving the quality of STEM education that they could be. While some schools have a specialized STEM class, most teachers are expected to integrate STEM into their own classrooms. However, many teachers do not have time, knowledge, or experience to feel that they can integrate STEM successfully. According to a 2018 study put out by the NSSME (National Survey of Science and Math Education), most primary teachers are only, on average, spending 17 minutes a day on science instruction while they are spending 89 minutes on reading/language arts and 55 minutes on math a day (Plumley, 2019, p. 15). In the short time they are spending on science, many teachers do not feel comfortable teaching STEM or STEM components. According to the same study, only one-third of teachers feel prepared to teach science in their elementary classrooms, and only ten percent feel comfortable developing student's awareness of STEM careers (p. 8).

Another challenge of STEM education is the lack of resources. While there are highly successful STEM curriculums out there, many teachers do not have access to those curriculums. According to 100Kin10 (2019), the NGSS or next generation science standards, are meant to add more engineering and technology into the typical science curriculum. However, many teachers say that the transformation is slow in coming and there is not enough training to fully adopt these new standards. This lack of training and materials are making it difficult for STEM education to be as immersed in our student's education as we would like.

Finally, there is a disconnect between the different components of STEM. For example, using an iPad to read a book online does not equal a STEAM lesson.

Technology and engineering are not just subjects that should be added to what is taught daily, but they have to be integrated into what is being taught (Portz, 2015). According to the Institute for Arts Integration and STEAM (2019), if we are not integrating one or more components of STEM into our STEM lessons, then it is going to have little to no effect on our students. If we can interconnect two or more areas of STEM in an inquiry-based problem-solving manner, then we can truly start to see the benefits of collaboration, inquiry, social-emotional health, problem-solving, and critical thinking in our students. These are skills that will ultimately help them for the rest of their schooling and in their futures.

Summary. The push for more STEM education in schools began in the 1950s but picked up in the late 2000s with the Obama Administration's *Educate to Innovate* act. This act pushed for more government involvement in STEM, training STEM teachers, and creating more diversity in STEM. The goal of this STEM program was to create students that were prepared for our ever-changing world and future careers. The goals of STEM also include establishing 21st-century skills such as collaboration, creativity, communication, and critical thinking.

Students who have exposure to STEM programs are more successful in life, both socioeconomically as well as socially emotionally. STEM programs also help build students' confidence, perseverance, and collaboration. These skills are important to the total well-being of a child and help our students be more successful in high school, college, and adulthood. However, there are some challenges preventing STEM exposure in schools. Underprepared and under-trained teachers, lack of time and resources for

teaching science, and a disconnect of the different components of STEM are all challenges to implementing STEM. If these challenges can be overcome, then we can make large steps towards having a generation of students who are prepared for the future.

STEM education is clearly important in the current education climate, both in developing important skills in our students and for the changing world. However, there is another component of science education that is, arguably, more important to our changing world and also helps develop critical skills in our students. The next section of this literature review will discuss environmental education and the impacts that it has on our students and our world.

Environmental Education

Environmental education (EE) is defined by the Environmental Protection Agency (EPA) as "a process that allows individuals to explore environmental issues, engage in problem-solving, and take action to improve the environment" (2018, para 1). EE is usually experiential and taught outside in a natural setting. The goal of EE is to provide students with real-world learning experiences so that they can build connections between cultural, political, and social issues (Graham, 2007). EE also strives to make our students more confident and responsible as well as promoting students' creativity and imagination (Cohen, n.d). This section of the literature review will explore the history, components, goals, and the benefits and challenges of EE.

History of EE. In 1970, the United States Congress passed the National Environmental Education Act. This act created an office of environmental education in the U.S. Department of Health and started to establish grants for environmental education

programs. A few years later, in 1976, the American Forest Foundation was founded and developed *Project Learning Tree*, a curriculum that helps students gain knowledge of the natural world, how they belong in it, and how they can take care of it. In 1983, the first National Congress for Environmental Education Futures was held and out of it spun Project WILD, a K-12 curriculum focusing on wildlife education (McCrea, 2006). In 1990, Congress passed the National Environmental Education Act of 1990. This act accomplished quite a bit of progress towards environmental education reform including an office of environmental education in the EPA (environmental protection agency), government-sponsored environmental education and training programs, grants for student fellowships, and founding Project WET, a K-12 water curriculum (McCrea, 2006).

Although there are many different EE curriculums and initiatives, EE in schools has mostly fallen by the wayside. According to a 1971 article, EE in elementary schools should:

- Be experience centered so that all children have the opportunity to work with living plants and animals
- Place an emphasis on processing skills such as observing, making inferences, and predicting
- Use organized groups to develop a social conscience
- Use environmental information from print and media materials to develop critical thinking
- Connect art, music, and literature to the environment
- Be interdisciplinary

The article concluded by stating, “Only now are we realizing that both of these areas [the environment and science] need to be involved if we are to live in harmony with our environment” (Roberts & Dyrli, 1971, p. 455). This article, written nearly 50 years ago, contains many of the same ideas that we believe about EE today. However, many of these components have not been, and are not currently being, taught in schools.

One explanation of this is Graham (2007), who argued: “American education neglects the local and the ecological in favor of the logic of standardization and high stakes testing designed to get children ready for competition in a global economy” (p. 376). He went on to say that when schools are too focused on standards, our curriculum becomes decontextualized and we lose many things that EE teaches our students such as connection to our community, a sense of caring for place, and how other cultures care for the earth (Graham, 2007). While the ideas behind teaching our students about the environment have been percolating for years, the way our schools are structured and the lack of resources available are preventing these ideas from being applied the way they should be.

Goals of EE. Environmental education was formed to create a sustainable future through the power of education (EPA, 2017). The environment sustains all aspects of our lives. It provides us with our basic necessities such as food, water, and shelter. Our economy needs a healthy environment. Studies show that time out in nature provides both physical and psychological benefits for our health (Cohen, n.d.: Louv, 2005; Reese, 2018). Many times, both our cultural and personal identities are tied to the environment around us (NAAEE, 2017). However, we know that the quality of our environment is

declining at a rapid pace. Environmental education strives to help teach our students about the environment so that they will be inclined to help protect it (Louv, 2005).

There are several different components of environmental education that will help our students create a sustainable future. According to the EPA (2018), the components of environmental education are as follows:

- *Awareness and sensitivity* to the environment and environmental challenges
- *Knowledge and understanding* of the environment and environmental challenges
- *Attitudes* of concern for the environment and motivation to improve or maintain environmental quality
- *Skills* to identify and help resolve environmental challenges
- *Participation* in activities that lead to the resolution of environmental challenges (para 3)

A successful EE program has incorporated, and will incorporate, all of these components to work towards a sustainable future and to inspire our students to make a difference. The EPA continues to state that not only does EE teach our students how to care for and protect our environment, but it should do it from an unbiased perspective. EE does not advocate for a particular viewpoint, but teaches individuals how to think through different sides of an issue and helps develop their problem-solving and decision-making skills (EPA, 2018).

Benefits of EE. The many goals of environmental education programs, such as promoting awareness of the environment, knowledge of the environment, concern for the environment, and identification and resolution of environmental challenges, create many

benefits for both the environment and the people who are participating in the program. The first major benefit is the protection of the environment. According to Reese (2018), outdoor environmental education increases nature connection, reduces fears related to outdoor play, develops pro-environmental attitudes, and increases environmentally responsible behaviors in students. Advocating for the environment and teaching our students how to connect with and protect the environment will lead to a more sustainable planet for future generations.

Along with providing our students' tools to create a more sustainable future, EE also helps our students learn skills that are essential to their own futures. First, environmental education teaches students how to think through different sides of an environmental issue and, through doing so, increases their problem-solving and decision-making skills (EPA, 2018). EE also builds confidence in our students, promotes creativity and imagination, gets kids moving, and teaches responsibility (Cohen, 2019). Along with life skills, environmental education also teaches 21st-century skills. Project Learning Tree, a highly regarded environmental education program, states that EE develops essential 21st-century skills such as "questioning, investigating, defining problems, analyzing, interpreting, reasoning, developing conclusions, and solving problems" (Project Learning Tree, 2019).

EE can also increase a student's critical thinking skills. A 2006 study of 165 high school students found that students that participated in environmental-based programs had better critical thinking skills than their peers, even the ones enrolled in traditional environmental science classes. This was especially true for programs that integrated

multiple disciplines, involved open-ended projects, and empowered students to take responsibility for their own learning. The study concludes that when we expose students to real-life situations, we provide our students with opportunities to practice their critical thinking (Ernst & Monroe, 2006).

Environmental education not only teaches life skills but is also important to a child's physical and mental health. Between the years 1991 and 2000, obesity rates increased by over 60 percent. While there are many different factors that lead to this increase in obesity rates, one contributing factor is more time on technology and less time outside (Louv, 2005). The average American child is said to spend four to seven minutes a day in unstructured play outside, and over seven hours a day in front of a screen (Cohen, n.d.). Having our students spend time outside, whether in structured or unstructured learning and play, helps decrease obesity and increase fine motor control (Louv, 2005). Along with increasing physical health, EE also helps improve mental health. According to Louv (2005), studies show that children with more nature near their homes have less anxiety and depression because nature offers both social interaction with peers and a place for students to go if they need solitude.

Challenges of EE. Although there are many benefits to using environmental education in the classroom, there are also some challenges to implementing EE in schools. First, teachers do not feel that there is enough time to get their students outside. Many teachers stated that participating in environmental education is not a choice they can make due to the school district's focus on the core curriculum. Subjects such as math and reading have become scheduled down to the number of minutes required and there

becomes very little time to teach science, let alone teach science outside (Reese, 2018). Even when science is a part of the curriculum, many textbooks do not address the types of environmental issues that teachers feel comfortable teaching outside. According to a 2006 study, most science textbooks tend to cover issues that teachers do not feel comfortable teaching, or cannot teach, outside such as nuclear waste disposal and acid rain. On the other hand, issues that occurred less frequently in textbooks such as air pollution and habitat destruction were subjects that teachers felt more comfortable with (Kim & Fortner, 2006).

Teachers also feel that they do not have the skills to be able to teach environmental education. According to a 1998 study, there were five personal barriers that teachers felt prohibited them from teaching EE. First, was knowing the appropriateness of a particular setting for EE. Some teachers had access to a setting right outside their schools, but many struggled with the amount of preparation that went into taking EE learning off-campus such as busing, permission slips, and finding additional supervision. Also, teachers struggled with being confident in their own knowledge to teach EE. Similarly, teachers reported that there was a need for more training in EE and environmental issues before they would feel comfortable teaching these issues to a class. Finally, teachers worried about student safety and behaviors and natural hazards out of their control such as getting lost or the presence of poisonous plants and animals (Simmons, 1998). All of these factors contribute to the struggle of exposing students to environmental issues and implanting more EE programs in schools.

Summary. The environmental education movement started in the 1970s with a push towards more environmental education in schools. Throughout the next twenty years, two big environmental curriculums were published to be used in schools, Project Learning Tree and Project WILD. In 1990, Congress passed the National Environmental Education Act which led to many advances in EE in schools. The goals of these EE programs are mainly to teach our students how to protect our changing earth through developing knowledge and awareness of environmental challenges, attitudes of concern for the environment, and skills to identify and resolve environmental challenges.

There are some other benefits to environmental education as well. EE increases problem-solving skills, confidence, creativity and imagination, and responsibility in our students. EE also helps develop 21st-century skills including questioning, defining problems, developing conclusions, and critical thinking. Environmental education is also beneficial for the health of our students, both physically and mentally. However, there are barriers to implementing EE in schools. Many teachers feel that there is not enough time to implement EE in schools and they also do not feel prepared to teach environmental education. However, with more teacher training we can help overcome these barriers and make EE a more widespread program to be taught in schools.

The first section of this literature review examined STEM education and the importance it has on developing problem-solving skills in our students to shape our future world. The second section of the literature review looked at environmental education and its importance to our planet as well as to developing problem-solving and critical-thinking skills in our students. However, both STEM education and

environmental education have similar barriers to implementation including lack of time and resources. Some of these barriers can be addressed by combining both STEM and EE curriculums. The last section of the literature review will examine how these two areas can, and should, work together to best prepare our students for our changing world.

Environmental Education and STEAM Combined

As seen throughout this literature review, STEAM and EE have similar goals - to increase critical-thinking and problem-solving skills in order to prepare our children for the future world and workplace. However, these two areas are not working together as often as they could be (Kennedy, 2014). While there is a science component of STEM, STEM education has been mostly focused on technology and engineering and the natural sciences have fallen to the wayside (National Science & Technology Council, 2018). This section of the literature review will focus on how these two areas can work together to best prepare our students for the future. It will examine how STEAM and EE are best taught interdisciplinary and how EE can enhance the STEAM experience. It will also explore how a combination of EE and STEAM will teach our students skills they will need for the future. Finally, it will examine some current ways that EE has been incorporated into STEAM education.

Interdisciplinary teaching. There are four (five) subjects that make up a STE(A)M program: science, technology, engineering, (art), and mathematics. In order for a STEAM program to be as effective as possible, these areas need to be intertwined. According to a study by Honey, Pearson, and Schweingruber (2014), all of the STEM disciplines are connected in life and should be connected in an education setting as well.

Science is the study of the natural world and knowledge of science helps inform the engineering design process. Technology is a tool that is used to meet human wants and needs and is a product of both science and engineering. Engineering uses concepts from science and math as well as technology to solve problems and create new things. Therefore, connecting these disciplines in school is a must to help develop our students' understanding of these different fields to prepare them for their future careers in our changing world.

Integrating STEM also helps develop students' 21st-century skills. According to the Institute for Arts Integration and STEAM (2019), STEM is based around questioning, curiosity, and being creative in finding a possible solution to a problem. Through integrating the different components of STEM, and also integrating STEM into other components of the school day, students will start to view the world differently and be able to think critically about the problems we are facing and how to solve them. Honey, Pearson, and Schweingruber (2014) also found the benefits of integrating STEM in the development of 21st-century skills. They found that "social and cultural experiences such as those which require students to work with each other and actively engage in discussion, joint decision making, and collaborative problem solving may be particularly important in integrated learning" (2014, p. 4). When we can integrate the different STEM subjects, both within each other and to the rest of our student's learning, we are able to increase the impact of the 21st-century skills that we want our students to learn for their futures.

Environmental education also needs context and integration in order to be effective. According to Schliecher (1989), environmental education should consider the environment as a whole, not as small, unconnected units. This can include looking at environments as natural and built, technological and social, and local and international. The more holistic we can look at the environment and the many interconnected parts, the better we can learn to protect it. When we bring other subjects into EE, we are able to provide more insights into the environmental challenges that we face as a society and can further enhance learning to help solve problems (NAAEE, 2017).

EE Enhances STEAM. The main goal of environmental education is to protect our environment through both sustainability education and creating problem-solvers and critical-thinkers that can solve our world issues (EPA, 2018). One of the best ways to create these problem-solvers is through integrating STEM into the EE curriculum. According to Kelley and Knowles (2016), many global problems that we face, including climate change, overpopulation, shrinking water supplies, and habitat loss need further development in science and technology to solve. As of now, there is little integration of the environment and STEM as STEM is more focused on preparing students for future STEM careers and bringing more engineering and technology into the classroom. However, "an integrated curricular approach could be applied to solve global challenges of the modern world concerning energy, health, and the environment" (Kelly & Knowles, 2016, p. 2).

Combining EE and STEM can also further enhance the 21st-century skills that we want our students to have. Both EE and STEM teach our students skills such as

critical-thinking, problem-solving, collaboration, and decision-making (EPA, 2018; Garner, Gabitova, Gupta, & Wood, 2017; Metz, 2014; Project Learning Tree, 2019). However, we can take those goals even further with some integration of the two areas. By introducing EE problems into STEM, we are able to provide our students with a global perspective, further developing critical-thinking and problem-solving skills (Kennedy & Odell, 2014). Developing these skills with an ecological approach also helps our students be able to find "measured yet creative solutions to problems which are today unimaginable" (Kennedy & Odell, 2014, p. 249). Combining STEM and EE also helps our students get excited about solving problems for our future. According to Tomovic, Train, and Train (2015), if we can engage our students in exciting and interactive activities related to sustainability, then we can create more scientists, technologists, and engineers who can discover and implement solutions to environmental sustainability.

Even if our students are not going into careers in STEM or environmental studies, the skills gained by combining STEM and EE are still valued by many employers. According to a 2011 study published by The Edge Foundation, employers across many different fields valued teamwork and problem solving as the two most important characteristics of job applicants. These were followed by knowledge of the career and good communication skills (Elliot, Hall, Lewin, & Lowden, 2011). A similar study published in Australia in 2015 found that in STEM fields specifically, employers value critical thinking, problem-solving, and interpersonal skills (Baranyai & Prinsley, 2015). The skills that are taught to our students through STEM and EE are skills that all students are going to need to know to be successful in both higher education and beyond.

Examples of EE in STEAM. While we need more EE in STEM, there are many examples of places that are integrating EE and STEM with great results. One such example comes from the Billion Oyster Project Curriculum and Community Enterprise for New York Harbor Restoration or the BOP CCERS. This program was created to engage students and teachers throughout New York City in habitat restoration, marine science, and computer science. This program has provided over 5,500 New York City students with access to the New York Harbor to participate in oyster restoration, collecting data, and logical problem-solving. Through this program, students gained mathematical skills in statistics, learned the history of their community through the lens of the oyster which once was a key species in the New York economy, and became more aware of how they can protect the essential habitat that is the New York harbor (Birney & Cronin, 2019).

Another example of STEM and EE comes from a four-day summer camp exposing students to soundscape ecology. Soundscape ecology is a STEM area of research focused on the combination of different sounds in a particular location at a specific time. Because soundscape ecology relies heavily on listening to your surroundings, it can be taught in any outdoor setting and can help serve as an example of an authentic learning experience. The students at this camp learned the concepts related to sound, active listening, and used sound to read the landscape around them. They also created their own research questions in collaborative groups on comparing and contrasting the different soundscapes of different ecosystems using authentic recording technologies. Through this activity, students learned how to interact with nature, use new

technologies, and collaboratively work together in a group. They also became more motivated to understand different environmental topics, raise questions about these topics, think critically about environmental problems, and take action against these problems (Khanaposhtani, Liu, Gottesman, Shepardson, & Pijanowski, 2018).

Both of the examples listed above are large-scale examples of STEM and EE being integrated to teach students skills such as collaboration, critical thinking, and advocacy. However, this teaching can be done on a smaller scale as well. The North American Association of Environmental Education (NAAEE) is currently developing programs to advance E-STEM, with the E standing for environmental education. The hope for these programs is to increase environmental literacy and civic engagement through education. One of these programs is their Guidelines for Excellence, standards for high-quality environmental education. While these standards are mostly EE based, there are also opportunities for STEM education intertwined within these guidelines. The NAAEE also has a blueprint in collaboration with New Knowledge identifying 9 priorities for the future of E-STEM, a book on climate change action that incorporates STEM activities, and an early childhood network to connect young children to both STEM and the environment. All of these programs are doable at any school and are a great start to integrating EE and STEM (Kunkle, 2018).

Summary. STEAM and EE have similar goals and can be combined to help both the future of our planet and our students develop essential life skills. In order for STEAM to work the most effectively, it needs to be taught interdisciplinary. When it is taught interdisciplinary, it both helps students understand the different components of STEAM

and also further develops skills such as collaboration, problem-solving, and decision making. These skills are also important to future employers. Similarly, EE also has to be taught in context to help students understand the whole picture and also develop problem-solving skills. Therefore, EE and STEAM can be taught together to help solve global problems and to implement solutions to environmental sustainability, as seen in the examples from New York City and the soundscape ecology day camp.

Summary of the Literature Review

The subtopics of STEAM education and environmental education, including their history, goals, benefits, and barriers, are important to understand how these two areas can work together interdisciplinary. With this background information in mind, we can start to answer the question: *how can incorporating more environmental education into STEAM help create students that are best equipped with skills needed for future careers?* So far, this paper has addressed why STEM and nature are important to the author. It has also covered the different components of STEM and nature and how teaching interdisciplinary can enhance students learning and help prepare them for the changing future. Chapter three will discuss the project of a supplemental nature curriculum for an elementary STEM classroom. This chapter will contain an overview of the project, research that supports this project, the method and audience, and a detailed description of the project.

CHAPTER THREE

Project Description

Introduction

As shown through the literature review, environmental education and STEAM education have similar goals. They both are focused on preparing our students for the future through teaching our students critical life-skills such as collaboration, communication, and problem-solving (EPA, 2018; Garner, Gabitova, Gupta, & Wood, 2017; Metz, 2014; Project Learning Tree, 2019). However, there is currently a lack of environmental education incorporated into STEAM education (National Science and Technology Council, 2018). Through incorporating more EE into STEAM, we are able to provide our students with a global perspective, further developing critical-thinking and problem-solving skills (Kennedy & Odell, 2014). Introducing more EE into STEAM also helps our students get excited about solving problems for our future and can create more scientists, technologists, and engineers who can discover and implement solutions to environmental sustainability (Tomovic, Train, & Train, 2015).

In order to implement more EE into STEAM, we need to have lessons in place that can cover STEAM concepts with an environmental component. Therefore, I designed supplementary lessons to accompany my STEAM curriculum, Project Lead the Way (PLTW) Launch. These supplemental lessons tie into each STEAM module that I teach and help answer the question: *how can incorporating more environmental*

education into STEAM help create students that are equipped with skills needed for future careers?

In this capstone, chapter one has explained my personal journey in science and environmental education. Chapter two discussed prior research in both STEAM and EE including history, intended goals, and both the benefits and challenges of these programs. It also explored how STEAM and EE need to be integrated and how combining these two areas further enhances their benefits. In chapter three, a detailed description of my project is provided including the rationale behind my project, the setting of my project, the participants in my project, and a timeline of my project.

Project Overview and Rationale

My project, completed in the spring of 2020, was to create ten supplemental STEAM lessons that will be tied into my current curriculum, Project Lead the Way (PLTW) Launch. These lessons were designed to get my students outside while also incorporating STEAM concepts from the curriculum. The goal of this project was to incorporate more environmental education into STEAM and encourage my students to get outside. It also was designed to teach sustainability and increase the essential skills that EE teaches students such as collaboration, communication, problem-solving, and critical thinking.

I am lucky enough to teach in a school where my students get one hour of STEAM each week as a special. However, I know that my situation is not always the case. One reason for writing this project was to encourage not only myself, but other teachers as well, to do more with STEAM and EE. While both environmental education

and STEAM education provide great benefits for our students, schools are still shying away from teaching both of these areas due to several factors including time, resources, and the inconvenience and the liability that can come with taking students outside (100Kin10, 2019; NSSME, 2018; Portz, 2015; Reese, 2018; Simmons, 1998).

I also wanted to write these lessons to further develop skills my students need to know to be successful in life. EE teaches students these essential life skills that will both help protect our planet and help our students with their future careers. Outdoor environmental education increases nature connection, reduces fears related to outdoor play, develops pro-environmental attitudes, and increases environmentally responsible behaviors in students (Reese, 2018). These skills are essential to ensure that we are teaching our students sustainably and instilling in them a want and need to protect our environment. EE also teaches our students essential 21st-century skills such as problem-solving and decision making (EPA, 2018). It also builds confidence, promotes creativity and imagination, gets kids moving, and teaches responsibility (Cohen, n.d). EE is also a great way to improve a child's physical and mental health. When we are getting kids away from screens and outside, we are able to decrease obesity, increase fine-motor control, and decrease anxiety and depression in our youth (Louv, 2005).

These environmental education lessons will be incorporated into my STEAM curriculum, PLTW (Project Lead the Way) Launch. This STEAM curriculum is designed to build a strong foundation for middle school, high school, and beyond. According to the PLTW Launch website:

> Each PLTW Launch module engages students in cross-disciplinary activities that spark a lifelong love of learning and build knowledge and skills in areas including computer science, engineering, and biomedical science. In addition, each module empowers students to develop essential skills such as problem solving, critical and creative thinking, communication, collaboration, and perseverance. (PLTW, 2019, para 4)

This curriculum has four modules per grades PreK through five. Each grade includes two engineering modules, one computer science module, and one biomedical science module. Each module consists of three set-up activities, ranging in length from 40 minutes to 120 minutes, to teach foundational knowledge of the topic. After these three activities, the modules have a larger project that combines all of the knowledge that the students have learned. This project then feeds into a larger problem that is usually connected to a real-world issue. This final problem is an engineering design challenge that students need to solve using the Engineering Design Process. PLTW Launch closely follows the Next Generation Science Standards (NGSS) and the Common Core State Standards for math and English language arts. In my project, I used this curriculum to develop an EE lesson to tie into each PLTW module to further enhance the curriculum.

Each module of PLTW Launch is accompanied by a curriculum framework. This framework follows the three stages of the Understanding by Design (UbD) framework created by Wiggins and McTighe (2011). Stage one of the UbD covers the desired results of the unit including the standards and learning goals. This stage also breaks down each learning goal into understandings, learning objectives, and knowledge and skills. For

example, in the third-grade PLTW Launch module on the science of flight, students are expected to understand that a force is a push or a pull on an object. Out of this understanding, students should have the learning goal of understanding the effect of forces on the stability and motion of an object. Finally, students should be able to identify a push or a pull, describe the motion of an object with balanced and unbalanced forces, and identify the forces working on an aircraft in flight (PLTW, 2019). Stage two of UbD covers the evidence of learning for each activity. In the PLTW curriculum guide, this stage of UbD has some assessment opportunities listed such as discussion questions, things for the teacher to observe, or more formal worksheets. Stage three of UbD covers the step-by-step learning plan for assuring that the students are achieving the desired results that are laid out by the first two stages. In my lessons, I utilized all three stages of the UbD framework. Each lesson has the standards and essential questions listed including understandings, learning goals, and knowledge and skills. The lessons also address assessment opportunities that can go with that lesson. Finally, there is a description of the lesson, materials needed for the lesson, and a detailed step-by-step guide to teaching the lesson.

Audience and Setting

I am a K-4 STEAM specialist teacher in a small, northern MN school. All of my K-4 students (about 340) get STEAM class for an hour a week, besides my kindergarteners who only get a half-hour. There are four sections of kindergarten, first grade, and second grade with about 15-20 students in a class and three sections of third and fourth grade with 20-25 students in a class. All of my students will participate in this

project as I developed two EE lessons for each grade. I will teach these lessons as part of my curriculum starting in fall 2020.

My school is a K-12 public school in Northern Minnesota. In the elementary (K-6), we have 473 students. Of those students, 95.6% are White, 1.1% are Latino, 0.6% are American Indian, 0.4% are Asian, and 0.2% are African-American. We also are 53% Free and Reduced lunch and 22% special education. My school is in a rural community serving two towns with a combined population of 1,178. Many of my students live on farms or in other rural areas and have the opportunities to spend time outside at their homes. However, I am unsure how much my students do get outside to play. I am hoping that by incorporating more EE into STEAM, my students will be encouraged to do more outside play at their homes.

My school also has a large school forest that I utilized in my lessons. While we do have to cross the football field to reach it, the school forest is easily accessible for my hour STEAM blocks. In the school forest, there is an outdoor classroom, many walking trails, and a pond with some wildlife activity. My school has also had solar panels built by the Rural Renewable Energy Alliance (RREAL), a non-profit in our community. These solar panels power 80 percent of our school and provide great education opportunities. We have also recently partnered with RREAL to develop a solar for schools curriculum, some of which were used in my lesson plans.

Project Format

PLTW Launch has four modules per grade, but I only have the time to teach three: two engineering and one computer science. For this project, I developed an EE lesson to

tie into all of the engineering modules that I teach. I chose not to write a lesson for the computer science modules because they rely heavily on technology and are not entirely conducive to an environmental component. The engineering module subjects that I teach are as follows:

- Kindergarten - Structure and Function and Pushes and Pulls
- First Grade - Light and Sound and Light: Observing the Sun, Moon, and Stars
- Second Grade - Materials Science: Properties of Matter and Materials Science: Form and Function
- Third Grade - Stability and Motion: The Science of Flight and Stability and Motion: Forces and Interactions
- Fourth Grade - Energy: Collisions and Energy: Conversions

For each topic listed above, I developed one EE Lesson to deepen my students' understanding of the material we are studying. Some of these lessons are taught in addition to the curriculum lessons and some are a lesson from the curriculum that is adapted to add an environmental component. Each lesson is designed to take between 30 minutes and 90 minutes to complete and includes the standards, essential questions, learning goals, the knowledge and skills the students should gain, opportunities for assessment, equipment needed, a learning plan, and a step-by-step procedure for teaching the lesson. There are also student worksheets attached to the resources that students may need to complete the lesson.

Assessment

Students will be assessed on both how well they understand the material being taught and how well they are able to use the communication, collaboration, and problem-solving skills they will need for their future careers. Most lessons include some type of group-work component and includes a rubric for students to self-assess their teamwork skills. Teachers will also be assessing students on the material being learned and the way students collaborate, communicate, and problem-solve through observations and student work. In the PLTW Launch curriculum, each student has a Launch Log to record observations, sketch ideas, and answer questions. For each supplemental lesson, there are Launch Log pages that can be added to students' current Launch Logs. There is also a rubric for teachers that includes ways to assess knowledge learned as well as collaboration, communication, and problem-solving for each student.

While these lessons were designed with the PLTW Launch curriculum in mind, they can be adapted for any type of EE learning. Each lesson includes a recap of the module and the knowledge students should already know in order to be successful in the lessons. Both the lessons and the supplemental materials can stand on their own and be adapted for any grade or any setting.

Timeline

The first three chapters of this capstone were finished in December of 2019. In early March, the first three chapters were finalized and I started to write the lessons. As I was writing the lessons, I tried a few of them with my students to get feedback and adjusted my lessons as necessary. The lessons were completed by early April. The project

was presented to classmates in late April. The paper and project were completed at the end of May 2020. These lessons will start to be taught in the 2020-2021 school year.

Summary

My project was to write lessons to supplement a K-4 STEAM curriculum, Project Lead the Way Launch. These lessons are environmentally based and used in each module to both further expand on what we are learning in STEAM and to get my students outside. This project consisted of ten lessons in total, two for each grade, and utilized the school forest and the solar panels behind our school. The hope for this project was to tie in more environmental education into STEAM. They also were developed to teach my students how to advocate for the environment and grow in their critical thinking, problem-solving, and communication skills. These skills are essential for future 21st-century careers. I also hope that these lessons developed a love of nature in my students and encouraged them to spend more time in nature at their homes. In chapter four, I will revisit the literature review as well as discuss the limitations and outcomes of my project and how I will use it in the future. I will also summarize my final thoughts about the entire capstone process.

CHAPTER FOUR

Project Reflection

Introduction

My project was to create a supplemental K-4 STEAM (Science, Technology, Engineering, Art, and Math) curriculum to share my love for nature and the environment with my students while simultaneously forming and shaping communication, collaboration, and teamwork skills. My project started with the question, *how can incorporating more environmental education into STEAM help create students that are equipped with skills needed for future careers?* Chapter one of this paper explained my background with science and nature and what led me to this research question. Chapter two explored the background, benefits, and challenges of both STEAM education and Environmental Education and how both of these areas work together to help prepare students with essential 21st-century skills they will need for their future careers. Chapter three explained the supplemental curriculum I created to answer my question and included a description, audience, and setting for my curriculum.

This chapter is a reflection on the process of researching and creating my supplemental STEAM curriculum. It begins with what I learned during the process of creating these supplemental lessons including the changes from the original project description in chapter three. The second section explores the areas of the literature review

in chapter two that were the most relevant to me as I was creating my curriculum. The implications of the project are discussed next, including why these 21st-century skills are important for our students to learn. Limitations of the project are also presented. The last few sections of the chapter focus on how the project could be shared with others, how the project adds to the field of STEAM education, and ideas for future projects related to my curriculum.

Learning Outcomes and Project Changes

The hardest part of writing my project was familiarizing myself with the Understanding by Design (UbD) curriculum framework that is explained by Wiggins and McTighe (2008). While I had a basic understanding from reading their book, I still had not wrapped my brain all the way around the best way to format my lessons to fit within the UbD framework. My Project Lead the Way (PLTW) Launch curriculum, which I based my lessons on, includes a UbD framework for every module but I did not find the layout very user friendly. It took me a while to figure out a framework and a lesson plan layout that I was happy with. However, once I found my format I found that I could shape my lessons to address all three levels of UbD and fit within the template I developed.

There were some smaller struggles as well when working on my curriculum. The first was finding ideas to base my lessons on. Once I had an idea, writing the lesson came easy. However, finding an environmental lesson concept that also fit in with the large concept of each module proved to be tricky. Through my content expert and some friends, I had many resources available to me but sifting through them took some time. I also struggled a bit with finding what standards fit into my lessons. While my curriculum

had many standards I could pull over, there were standards listed in the PLTW curriculum that did not fit with my lessons. It took some time to sift through the standards and find the standards that worked the best for my lessons that I developed.

It also took some time to figure out the best way to assess my lessons. While I wanted my students to be assessed on the content presented in the lesson, I especially wanted them to be assessed on their communication, collaboration, and teamwork. These skills are the essential skills that are needed for 21st-century careers (Elliot, Hall, Lewin, & Lowden, 2011) and I wanted to focus on assessing those skills specifically. I decided to create a rubric for the students to self-assess their teamwork and an area on the teacher rubric for the teacher to assess the student's teamwork. I wanted to test out these rubrics in my classroom this spring, but due to COVID-19 school was closed until May and I never had the chance to test them out. I hope that these rubrics prove to be an acceptable method of assessing teamwork, which is a difficult thing to assess, and I hope to try them in the fall.

I did change some things from my project description in chapter three to my final supplemental curriculum. The COVID-19 outbreak this spring caused some road bumps in my plans. I intended to partner with the Rural Renewable Energy Alliance (RREAL) and their Solar for Schools curriculum to create my fourth-grade lessons. However, due to COVID-19 shutting down both school and their office, their curriculum was not finished and I was not able to utilize it so I had to develop lessons for fourth grade on my own. I also wanted to test my lessons this spring with my classes and make some changes based on the experiences of my students. However, school was closed and moved to

distance learning in the middle of March until May, so the lessons never got taught to my students this year. However, I am still hoping to teach them starting in the fall of 2020.

I also intended to use our school forest and solar panels more in my lessons, but after reflecting on my goals, I realized that I would rather have my lessons be accessible to anyone who wants to teach them and may not have access to the same things I do. Therefore, I made some things optional in regards to using a school forest or solar panels so that anyone who wants to teach my lessons can teach them with the resources available to them.

The most important thing I learned while developing my lessons is that Environmental Education (EE) and STEAM education should be tied together as much as possible. There is quite a bit of research, as discussed in chapter two, that shows the benefits of both STEAM education and EE, especially when relating to preparing students with essential 21st-century skills. However, putting this research into action was extremely helpful in seeing this play out. I found it was easy to develop lessons that use the components of STEAM, such as engineering and creating, and pair it with learning about the environment and getting outside. I saw the amount of collaboration, communication, and critical thinking that my students would work on developing through these lessons and I am excited to provide these lessons for my students in the future.

Literature Review Connections

Of all of the research completed for chapter two, the literature review, I found that two components were the most helpful to keep in mind when I was writing my supplemental curriculum. First, was remembering the intended goals of both EE and

STEAM. According to the EPA, the goal of EE is to create a sustainable future through the power of education (2017). A successful EE program includes an understanding of the environment, attitudes of concern for the environment, and participation in activities that lead to the resolution of environmental challenges (EPA, 2018). Also, a successful EE program teaches individuals how to think through different sides of an issue and helps develop their problem-solving and decision-making skills (EPA, 2018). I wanted to keep all of these goals and components in mind when I was developing my EE lessons. However, I also was trying to keep in mind the goals of STEAM such as preparing students for future STEM careers (National Science & Technology Council, 2018), developing critical-thinking and problem-solving skills as they solve engineering problems (Metz, 2014), and increasing collaboration, communication, and teamwork skills while exploring the world around them through hands-on learning (PLTW, 2010). I think that I was successfully able to include the goals of both of these areas as I wrote my lessons to both teach about the environment and build critical-thinking, problem-solving, communication, and teamwork.

I also found the section of my literature review on how EE enhances STEAM helpful while writing my lessons. According to Kelley and Knowles (2016), many global problems that we are facing can be solved by integrating EE into the STEAM curriculum. Adding more EE into STEAM can help solve global challenges such as energy, health, and the environment. I tried to introduce some of these bigger world environmental concepts into a handful of my lessons, especially for my older students. My PLTW curriculum did a bit of that already, but I tried to take it one step further with my EE

lessons. I also looked at how adding EE into STEAM helps boost communication, collaboration, critical thinking, and problem-solving (EPA, 2018; Garner, Gabitova, Gupta, & Wood, 2017; Metz, 2014; Project Learning Tree, 2019). In my lessons, I incorporated ways to boost communication, collaboration, and problem-solving for all students.

Implications

I hope that my curriculum will, above all, equip my students with the skills that they need for their future careers and the changing world. While learning about science and the environment is important, as is getting kids outside and experiencing the natural world, I believe that the skills they are gaining through these lessons are the most essential for our changing world. Our future workers will need to know how to collaborate with a team, communicate their ideas, and problem solve. These lessons are helping to build those skills in my students, as well as getting them passionate about the natural world. Both of these areas work together to create students that are prepared for the future, and I hope that my supplemental curriculum can equip students with the skills they need to greatly contribute to society.

Limitations

As with any project, there are some limitations to this curriculum's use. While these lessons can be taught individually, they are designed to closely tie into the PLTW Launch Curriculum. Therefore, if you do not teach that curriculum you may have to amend the lessons slightly. Also, all lessons have an outdoor component, which may limit use slightly regarding space and weather. Urban teachers may not have the space or the

natural resources to teach some of these lessons. Depending on the weather, some lessons may not be able to be taught to their full capacity. A few lessons require snow so they may not be able to be taught in an area that does not get snow in the winter. Finally, while the value of STEM education and EE is important, and standards are included in every lesson, these lessons are not required to be taught in most school settings. Therefore, some educators may struggle with finding the time to incorporate these lessons on top of the requirements in most school systems.

Communicating Results

This curriculum will be altered into a PDF format that can be easily shared with other STEAM and Environmental Educators. Other educators could use the whole curriculum or just the sections that fit within what they are teaching. I plan to make this a living document and add changes as I test these lessons out with my students next year.

Also, I plan to share this curriculum with other PLTW Launch teachers. The PLTW Launch Curriculum has an educator forum on their website for teachers to ask questions and share ideas. I am also planning on posting my supplemental curriculum there (with permission from PLTW). I want other PLTW Launch educators to have this resource to add in these environmental lessons as they are teaching their curriculum if they wish. I hope other STEM educators will see the value of incorporating EE into their classes and utilize at least some of my lesson plans.

Future Projects

I am excited to implement these lessons into my STEAM curriculum next school year. I hope that through teaching my students these lessons, they are able to further

bolster their 21st-century skills while learning about nature and the world around them. After teaching these lessons for the first time, I plan to make some edits and changes to my guide to adapt for unforeseen roadblocks. In the future, I also would love to add more sustainability to these lessons. While I did cover some sustainability in my lessons for third and fourth grade, I could add a sustainability lesson for K-2 as well. Right now, this curriculum covers two modules for each grade in PLTW Launch. There are four modules per grade in the curriculum, so lessons for the other two modules could be written as well. Finally, I only teach K-4 but the curriculum goes PreK-5. EE lessons could be written for the Pre-K modules and the fifth-grade modules as well.

Conclusion

I am so glad that I chose to research and develop a supplemental curriculum in something that I am so passionate about. We need to teach our future generations how to love and protect the environment while simultaneously teaching them communication, collaboration, and problem-solving skills that will help them in their future careers as scientists, environmentalists, engineers, teachers, caregivers, farmers, managers, accountants, and contributing society members. I learned many lessons while developing my curriculum and ended up changing it a bit from my initial intentions. The goals of STEM and EE along with the skills needed for future careers these areas teach were what I kept in mind while I was writing my curriculum. There are many implications for my project, but preparing students for our changing world is the most important. Limitations to my project include weather, setting, and time, but these limitations can be worked around. In the future, I hope to add to my curriculum to include more modules or grades

from the original PLTW Launch curriculum. I am so thankful for the NSEE masters program at Hamline University and I am excited to take what I developed and use it for many years to come.

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