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Renewable Energy Education at Residential Environmental Learning Centers

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by

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CHAPTER ONE

Introduction

As society assesses where we are and what we can do going forward in the climate crisis, environmental education programs have begun looking inward at the work they are doing and how they can shift to educate younger generations. Environmental education programs take many forms, from in-school science curriculum to day use nature centers. For years environmental education has focused its attention on education about and for the environment (Skamp et. al., 2017, Strife, 2010). Topics like conservation and stewardship are main themes in many programs. Another type of environmental education program takes place at residential environmental learning centers (RELCs). Typically three to five days long, RELCs offer programming for school age students in an immersive learning environment (Stern, Powell, & Ardoin, 2008). Living alongside their peers, students come with their school classmates to hike in the woods, search for aquatic bugs in the streams, learn to canoe, explore scientific processes like decomposition, and more. I believe that the environmental education field and RELCs are uniquely posed to tackle the huge educational undertaking that climate change education requires.

Programs around the world and in the US have already started teaching about sustainability, renewable energy, and climate education, while other types of environmental education programs are still searching for their place (Strife, 2010). The unique learning environment that RELCs create is the context for my project and thus this capstone research. The ultimate goal of this research is to answer the question: *What are*

effective methods for teaching middle school students about renewable energy at residential environmental learning centers? A history and background of environmental education provides readers an understanding and context for the basis of the research. Next, this capstone identifies renewable energy concepts and topics appropriate for middle schoolers by studying successful renewable energy curriculum programs, both in and out of the traditional classroom. Finally, I explore methods and strategies for teaching and learning that are successful within environmental education and RELC programs, which could be useful in designing a renewable energy curriculum to fit within these programs.

In the remainder of this chapter, I detail what has brought me to this point and my interest in renewable energy and environmental education. I share my personal and professional background in environmental education, as well as my current position in the field. At the end of this chapter, there is an overview of the goals of the project and the subsequent chapters in this paper.

Becoming an Environmental Educator

Growing up I was not particularly involved or interested in science in school or on my own time. I did, however, spend most of my days outside when at all possible. I would explore the small forest surrounding my home, walk around our pond looking for frogs, and wander through the native prairie across the gravel road. In the summers, I attended Girl Scout camp, where I fell even more in love with nature and found a strong connection to the outdoors and outdoor pursuits. I remember summers in the midwest as being hot, but not too hot, with a cool enough breeze to not need the air conditioning

most days, even in the height of summer. I know now that my parents, like many families, had an aversion to using too much air conditioning in the summer or heat in the winter. Their efforts to use less energy were purely for financial reasons and not necessarily coming from a conservation mindset. Using less energy and liquid propane saved them money on their energy bill each month. Today, this energy mindset reaches out to both sides of the issue. Reducing energy consumption and switching to renewable energy sources is both good for the environment and good for the wallet.

Throughout childhood and into adulthood, I was slowly introduced to new ways of thinking and acting in 'eco-friendly' ways. As I began my first job out of college, a teaching naturalist position at Eagle Bluff Environmental Learning Center, my science and environmental knowledge grew greatly. There, I would teach groups of 20 students about science, natural history, teambuilding, and outdoor skills. The two years spent at Eagle Bluff solidified my career path in environmental education and my interest in trying to live a more sustainable lifestyle. One of the many science classes we taught was called Energy's Potential which focused on renewable energy. Utilizing various renewable energy sources on-site at Eagle Bluff, we traveled from wind turbines to solar panels to the forest to learn about biomass. This type of place-based learning about renewables made both my students and my learning about these various resources more concrete and easier to understand.

My experiences in the environmental education field has afforded me continued professional development and learning. I have learned about many topics and best practices in the field that better my teaching and broadened my understanding of

environmental issues and the need for educating the next generation on these issues and how to take action. Teaching in various locations and programs across the country over the last eight years has allowed me to experiment with many different teaching styles and practices. It has also allowed me to see firsthand the impact that some of the more effective strategies provide students. Seeing students grow their love and understanding of nature and the importance of protecting it has been one of the most rewarding aspects of working in this field.

The Need for Renewable Energy Education at RELCs

In addition to teaching environmental education, many RELCs and nature centers 'practice what they preach' and have added eco-friendly initiatives and renewable energy sources at their program sites. Additionally, many organizations that have grown and expanded have added to or built new environmentally friendly and sustainable buildings (MN Coalition of RELCs, 2011). While many of these residential educational programs utilize renewable energy in some form, there is often a disconnect when it comes to actually educating about these energy sources and their benefit and impact on the land and organization.

I currently work at McDowell Environmental Center (MEC), whose mission is "to connect people to their environment, teach respect for the Earth and its beings, and to promote a commitment to lifelong learning" (McDowell, 2017). McDowell Environmental Center is located in rural northwestern Alabama and surrounded by both closed and active coal mining operations. As a RELC, students from across Alabama and the southeast come for three days to take classes about the environment, science, and

outdoor skills. The majority of our students are middle school age, fourth to eighth grade; however, we have students from third grade all the way through high school. On our property, we have installed over 300 solar panels over the last three years, have a geothermal heating and cooling system, and are in works to harness the power of a dam for hydroelectric power. Despite being a place-based, environmental education center, we currently do not teach about any of these on-site renewables in any of our curriculum or programming. One of MEC's current classes focuses on the history of coal mining in Alabama and briefly touches on renewable energy as an alternative to coal. Both staff and teachers have expressed interest in expanding on the teaching of alternative energy and how MEC could do more to teach about these important topics. As I reflected back on my time at Eagle Bluff and the class they offered on renewable energy, I felt a strong feeling that that type of class is something MEC should be offering.

Rationale

Little research has been done on the intersection of energy education and residential environmental education programs. However, previous studies on energy literacy have shown that hands-on, immersive approaches to energy education have had positive results (St. Onge & Eitel, 2016). Jorgenson, Stephens & White (2019) suggested that environmental education needs to take a stronger and more intentional approach to discussing and teaching about energy and renewable energy as the climate crisis excellerates. To do so, they recommended that environmental education more directly and intentionally engage students in global system-wide thinking about the needed transition to renewable energy and less on individual conservation efforts. They also recommended

that environmental education focus more on teaching energy literacy, especially about renewable systems (Jorgenson, Stephens & White, 2019). St. Ongle & Eitel (2016) agreed that a strong foundation for energy literacy is essential and that "as daunting as teaching in outdoor learning spaces might appear, the research conducted within this study and many others suggests that the advantages may be worth the effort" (p.19).

The above research shows a need for intentionally learning about renewable energy as part of environmental education. Thus, the goal of this project was to close the gap between having renewable energy sources on-site at MEC and educating guests and learners about them. Many teachers, parents, and students that attend MEC have asked questions over the years about our solar panels, what purpose they serve, why we have them, and how they work. At this time, those questions are challenging for MEC staff to answer since they themselves have not gotten to learn about the renewable energy initiatives on-site.

My research into the connection of environmental education and renewable energy, specifically RELC programming, resulted in a new three hour class created for MEC. This class will be offered to our residential school groups and focuses on energy and renewable energy initiatives happening on-site as well as the bigger picture of why the transition to renewable energy sources is important. The class also aims to utilize the best practices in student learning and effective methods for teaching these topics. To go along with the class curriculum and lesson plan is an educator background document for staff to reference and gain background knowledge before teaching the class. This document will allow staff to feel more confident and comfortable answering questions

and teaching about renewable energy. My goal is that the creation of this new class will benefit both staff, students, chaperones, and the organization.

Chapter Summary

This chapter followed the personal and professional experiences that have led me to a place where I am able to create a new class specifically for my organization, using our on-site renewable energy resources as teaching tools. This journey has brought me to ask the question: *What are effective methods for teaching middle school students about renewable energy at residential environmental learning centers?* The need for a connection between having renewable resources and utilizing them as a teaching tool in environmental education was and continues to be the driving force behind this question. Additionally, the need for education on alternatives to coal, especially in the deep south and coal country where MEC is located, has driven my passion for this research and project.

Overview of Upcoming Chapters

Chapter Two takes a closer look at environmental education, its history, and goals. Additionally, renewable energy education practices and concepts are studied to see how environmental education and renewable energy intersect. Finally, Chapter Two describes educational theories and strategies that can be used to help students better learn and connect to renewable energy education, thereby increasing the effectiveness of renewable energy curriculum. In Chapter Three, a detailed description of the capstone project is given and the setting, audience, timeline and assessment of the project explained. Finally, Chapter Four reflects on the capstone project, major takeaways, and the benefits and

implications this project will have on the environmental education field and organization for which it will be implemented. Additionally, Chapter Four includes major learnings I have gained along the way and my hopes for the continuity of the project.

CHAPTER TWO

Literature Review

Overview

This chapter gives a review of the literature that guided this capstone project, which asks the research question: *What are effective methods for teaching middle school students about renewable energy at residential environmental learning centers?* First, the definition, history, and goals of environmental education are explored. The chapter then looks at literature on renewable energy education both in and outside of the traditional classroom and particularly that which is being taught to middle school students. For the purpose of this research, middle school refers to students in grades fourth to eighth grade. Finally, effective instructional methods and strategies, specifically best practices to teach middle school students, are explored as they relate to renewable energy instruction and application at RELCs.

Environmental Education

This research takes place within the context of environmental education, more specifically within residential environmental learning centers (RELCs). There is a lot of history and broad meanings associated with environmental education. Therefore, this section first looks at the definition and goals of environmental education, the role the RELCs, and the role environmental education can play in helping society become environmentally literate.

Defining Environmental Education and Its Goals

Environmental education as defined by the Environmental Protection Agency (EPA) aims to "increase public knowledge about environmental issues and provide the skills necessary to make informed environmental decisions and take responsible actions" (Potter, 2010, p. 23). Hungerford (2010) also added that environmental education is an interdisciplinary effort that allows people to understand complex environmental problems facing our world and deal with them "effectively and responsibly" (p. 2).

In the 1970's, the term environmental education expanded in use and popularity on a national and international scale. During this time, President Nixon signed multiple environmental policies into law, the National Association for Environmental Education was founded in 1971, and international workshops and conferences were held to discuss and develop the goals of environmental education (Hungerford, 2010; NAAEE, 2020; Potter, 2010). In 1975, at a United Nations meeting the Belgrade Charter was published and described global goals, objectives, and principles of environmental education. The Belgrade Charter was adopted unanimously at the end of 10 days of discussion. The framework and objectives for environmental education included as written in the Belgrade Charter include: awareness, knowledge, attitude, skills, evaluation ability, and participation (UNESCO-UNEP, 1976). Two years later, at the first Intergovernmental Conference on Environmental Education, the Tbilisi Declaration further defined the global goals of environmental education (NAAEE, 2020; Potter, 2010). Goals from the Tbilisi Declaration include the following:

- Foster an understanding of the complex relations between socioeconomic development and the environment
- Provide opportunities for gaining knowledge, attitudes, and skills needed to protect and improve the environment
- Create effective solutions to environmental problems and new patterns of behavior towards the environment (Potter, 2010, p. 23)

These points and others in the Tbilisi Declaration were the launching point for increased education in response to growing environmental issues (Hungerford, 2010; NAAEE, 2020, Potter, 2010). Both the Belgrade Charter and Tbilisi Declaration are still used today to help define, describe, and outline the goals for environmental education as a field and are reflected in many programs' own goals and objectives. There are many ways that environmental education is presented and taught about including at parks, day use nature centers, in schools, at informal programming, and at RELCs.

Residential Environmental Learning Centers

Residential environmental education programs create an immersive learning environment for students to explore the outdoors, gain new knowledge about nature, and develop stewardship skills, all in an active outdoor setting (Stern, Powell, & Ardoin, 2008). Residential environmental education also allows students to learn, understand, and conceptualize important science content outside the traditional classroom setting. This type of experiential science program can lead to interest in environmental and science related careers in the future (Bourke, Buskist, & LoBella, 2013). The goals of these programs often closely reflect those laid out in the Belgrade Charter and Tbilisi

Declaration. These residential programs aim to increase environmental knowledge, enhance attitudes towards the environment, and encourage responsibility for the environment (McDowell, 2017; Sellmann & Bogner, 2013; Stern, Powell, & Ardoin, 2008).

While RELCs have their own programmatic goals for student learning, the curriculum is often aligned with state and national learning standards for science and social studies (Bourke, Biscuit, & Lobello, 2013; McDowell, 2017)**.** Outdoor settings for content lessons provide opportunities for class material to be better observed and conceptualized, especially when the topics being covered relate back to the natural world. Learning done in outdoor spaces can complement the learning done inside the classroom while providing first hand experiences and peaking student interest in a topic (St. Onge & Eitel, 2016).

In addition to providing a setting that lends itself to learning, residential environmental education programs provide increased time and exposure to lessons and pro-environmental behaviors. Ranging from two-five days in length, a typical day at an RELC includes two or three class blocks, meal times, discussion of food waste and other environmentally friendly actions, free time outdoors, and an overnight stay (McDowell, 2017; Stern, Powell, & Ardoin, 2008). For example at MEC, students have a three hour morning class and three hour afternoon class. Evening programs are also offered which are 90 minutes long. There are 30 day and evening classes offered that schools and teachers can pick from to meet their goals for the trip (McDowell, 2017). Students participating in RELC programs are learning outside of these structured class times as

well. At meal times students learn about reducing their food waste, how to compost, and use reusable napkins. In cabins, students are reminded to turn off the lights when they leave the room (McDowell, 2017). Studies have shown that environmental education programs with a longer duration have longer lasting impacts on both content knowledge retention and on environmental attitudes and awareness (Sellmann & Bonger, 2013; Stern, Powell, & Ardoin, 2008).

A study done by Stern, Powell, and Ardoin (2008) at The Tremont Institute, a RELC in the Great Smoky Mountains National Park, showed that students' gains in stewardship and awareness were still present three months after a three, four, or five day residential program. They also found that the longer the stay was at a RELC program, the higher the retention of knowledge and attitudes about the environment (Stern, Powell, & Ardoin, 2008). Another study, done by St. Onge and Eitel (2016), showed that students taught in an outdoor setting had greater knowledge retention rates than the control group of students taught the same lesson in a traditional indoor classroom. Despite the positive effects of residential environmental education, busy school schedules and jam-packed curriculum and testing throughout the year make taking time for out of school trips challenging (Sellmann & Bogner, 2013). However, the positive outcomes in student learning, as well as the connection to state and national learning standards, allow schools and teachers to justify the time spent away from the classroom (Bourke, Buskist, & LoBello, 2013).

Environmental Literacy

One of the positive outcomes that often comes from a residential environmental education experience is increased understanding and commitment to environmental action (Stern, Powell, & Ardion, 2008). In 1970, President Nixon signed into law multiple environmental policies and Nixon (as cited in NAAEE, n.d.) stated in an address to Congress that,

> ...it is also vital that our entire society develop a new understanding and a new awareness of man's relation to his environment—what might be called "environmental literacy." This will require the development and teaching of environmental concepts at every point in the education process. (Policy section, para. 1).

Later, Congress passed the National Environmental Education Act of 1990, which called for the EPA to increase citizens' environmental literacy (Potter, 2010, p. 23). An environmentally literate citizen is someone who is aware of and understands environmental issues, demonstrates pro-environmental actions daily, and seeks solutions to the problems (Potter, 2010). Many scholars and researchers believe that environmental education is an essential tool in working towards an environmentally literate society (Hungerford, 2010; Potter, 2010; Strife, 2010).

Summary

The definition and goals of environmental education make it clear that knowledge is just the first step towards a more sustainable future. Human engagement, motivation, and action is needed to resolve and handle environmental problems. Residential

environment learning centers are one way students, as well as parent chaperones and teachers, can become actively involved in this process. The knowledge gained and their experiences at a RELC can impact them for the rest of their lives. These programs also aim to help students become environmentally literate and critical thinkers who understand complex issues. The next section takes a closer look at one of these complex issues, energy and particularly a shift towards renewable energy.

Renewable Energy Education

It is well known and accepted in the environmental and science fields that our society's dependence on fossil fuels and non-renewable energies must change in the near future (Edsand & Broich, 2020). By most estimates, the world's oil, gas, and coal supplies will run out within the next 100 years at our current rates of use (Ritchie, 2017). The young people in school today will be the generation most impacted by the much needed transition from non-renewable to renewable energy sources. For years, energy education and renewable energy have been a part of local, state, and national standards (Bodzin, 2012). The Next Generation Science Standards (NGSS), released in 2013, include standards about energy, renewable resources, and energy conservation for fourth grade and up (Next Gen Science Standards). However, there has been little research or progress in the RELC and environmental education field about energy education, particularly with a focus on renewables, in these spaces (St. Ongle & Eitel, 2016). Many studies point to the success of immersive and hands-on experiences when students, particularly middle school students, are learning about energy (Chou et al., 2015; Fortner, 2009; Friman et al., 2018; Karpudewan & Khan, 2017). This section focuses on the need

for renewable energy education, key areas of renewable energy education for middle school students in grades fourth to eighth, and why energy education can and should become a part of RELC programs.

The Need for Renewable Energy Education

Global climate change has placed increased attention on renewable energy technologies in recent years as a possible mitigation strategy to reduce the impact of a warming world (Edsand & Broich, 2020). Currently, around 80% of energy around the globe is produced by fossil fuels and half of greenhouse gas emissions come from their use (Skamp et. al, 2019, p. 297). In 2015, only 23% of electricity generation came from renewable resources, such as solar, wind, geothermal, hydro-electic, and biomass (Skamp et. al, 2019, p. 297). Energy and how the world uses it is one of the major factors affecting the environment and driving climate change (Bodzin, 2012).

Energy Literacy. Energy literacy, similar and related to environmental literacy, aims for people to understand the role energy plays in our lives and how to apply that knowledge to solve problems, such as climate change (Merritt, Bowers, & Rimm-Kaufman, 2019; St. Onge & Eitel, 2016). Energy literacy programs are crucial so that citizens have the knowledge and skills necessary to make informed sustainable decisions. Unfortunately, most people in the United States have low energy literacy and understandings of the importance of renewable energy sources and how these energy sources function (Bodzin, 2019; Merritt, Bowers, & Rimm-Kaufman, 2019).

It is not just adults who need to become energy literate. Children of all ages can learn about the part they play in energy consumption and begin gaining knowledge and

forming opinions about energy. Children are agents of change who can convince and influence adults towards energy efficient and sustainable behaviors (Aguirre-Bielschowsky, Lawson, Stephenson, & Todd, 2017). Traditionally, children have learned most of what they know about energy in the classroom, often creating a disconnect between their energy knowledge and the application to their communities, homes, and daily life (Merritt, Bowers, & Rimm-Kaufman, 2019).

Renewable Energy Education in Middle School: 4-8th grade

Science curriculum in school plays an important role in shaping and educating students and society in a sustainable way (Edsand & Broich, 2020). Limited knowledge and misconceptions about renewable resources and how energy choices impact humans and the environment must be addressed (Bodzin, 2012; Skamp et al., 2019). According to Bodzin (2019), energy education in schools should aim to provide students with "knowledge about energy and the issues related to energy use" and how to critically analyze information, in order to make informed decisions in the future (p. 1256). However, few studies have been done that focus on middle school age students' understanding of energy in general, and more specifically on subsections like energy generation, consumption, acquisition, and conservation (Bodzin, 2019, p. 1258). In addition, few studies have looked at middle schoolers knowledge specifically about renewable resources (Bodzin, 2019).

One study done by Bodzin (2019), involved 1,043 eighth grade students in urban Pennsylvania who participated in a survey investigating their energy resource knowledge following instruction over the school year. The five schools that participated used the

same basel textbook and standards for instruction during the year. The survey assessed three main areas: energy acquisition; energy generation, storage, and transport; and energy consumption and conservation. The findings showed a lack of solid knowledge and understanding of basic energy principles and low conceptual knowledge about renewable and nonrenewable resources.

The Next Generation Science Standards (NGSS) are the most recent push to make science education connect to the interests and experiences of students and make science more applicable to today's world (Antink-Meyer & Alderman, 2020; Next Gen Science Standards, 2013). Teaching about renewable energy allows students opportunities to learn about "electricity, renewable versus non-renewable energy, and devices that are designed to convert one form of energy to another for human use" (Antink-Meyer & Alderman, 2020, p. 3). In teaching about renewable energy, students gain knowledge in a wide range of science concepts and meet many science education goals and standards, including those in NGSS and state standards throughout grade levels (Alabama State Department of Education, 2015; Antink-Meyer & Alderman, 2020; Next Gen Science Standards, 2013).

Despite energy topics and renewable energy being part of dozens of state and national standards, students of all ages struggle with the difference between renewable and nonrenewable resources, are unable to list more than one energy source, and struggle to understand where fossil fuels come from (Merrit, Bowers, & Rimm-Kaufman, 2019, p. 1079). Before students can care and take action in reducing their energy use, they must understand the basics of how energy impacts people and the environment. However, energy is a broad topic with nuanced vocabulary that is often challenging for students to

conceptualize. The processes involved can be misunderstood by students and must be acquired and understood through multiple learning experiences (Merrit, Bowers, & Rimm-Kaufman, 2019).

When the science classroom and learning process spark student interest and the topics are personally relevant to students, there tends to be more student engagement and knowledge gained. When students see science that is relevant to their lives, they are more motivated to action and knowledge retention (Mettit, Bowers, & Rimm-Kaufman, 2019, p. 1078). This is true for understanding energy conservation and energy resources. A study done by Merrit, Bowers, & Rimm-Kaufman (2019), found that fourth to sixth grade students, engaged in a 10-lesson energy curriculum program incorporating service learning in their local community, showed gains in knowledge about renewable sources and in connecting energy use with natural resource impact. After the lessons, 88% of students could list three renewable energy sources, and 90% of students could explain their reasoning for selecting a preferable energy source. In addition, the study found that solar and wind energy are two forms of renewable energy most comprehensible to elementary and middle school aged students. Overall, the students liked learning about things that affected their community and became motivated to apply energy conservation ideas to their community (Merrit, Bowers, & Rimm-Kaufman, 2019).

Energy Education at Residential Environmental Learning Centers

Energy education is not just taught in the classroom, but can be extended to environmental education programming, including residential environmental education (St. Onge & Eitel, 2016). A study done by St. Onge and Eitel (2016) showed an increase

in middle school students' energy literacy after a five day stay at a RELC. In the study, students were split into groups that were taught the same four, 30 minute energy lesson. Half of the groups were assigned indoor class settings for all their lessons, and half were assigned outdoor settings for their lesson. Despite low energy literacy skills across the board, the group who had classes outdoors, had a greater gain in energy knowledge and knowledge retention rates one month after the program. All students in the program, regardless of setting, showed an increase in energy attitudes after the four lessons. St. Onle & Eitel (2016) conclude that energy education is "well suited and potentially best taught within the residential outdoor environmental education setting" (p. 56).

According to Wals et al. (as cited in Skamp et al., 2019), there is a strong argument that science education and environmental education should merge (p. 300), especially due to both fields aiming for environmental and science literacy and sharing common goals. However, Edsand & Broich (2020) point out that environmental education is not the 'silver bullet' for environmental action and literacy. They go on to argue that schools should not exclude or limit environmental education programs, but that school curriculum is not the only factor impacting students' environmental attitudes, and that family and community influence plays a big role as well (Edsand & Broich, 2020).

Summary

It is clear that renewable energy education is needed for our world's citizens to become energy literate and reduce our dependence on fossil fuels. Renewable energy education is already a part of middle school, fourth to eighth grade, state and national standards and learning through the lens of renewable technologies addresses many other

standards as well. However, traditional science classroom lessons often result in a disconnect from the topics and their real world application. Environmental education and RELCs can provide hands-on, place-based learning that allows students to make connections and increase their energy knowledge and attitudes. In further seeking to answer the question, *what are effective methods for teaching middle school students about renewable energy at residential environmental learning centers,* the next section examines methods and strategies for teaching and learning that are successful, particularly in a RELC setting, and can be applied to renewable energy education.

Effective Teaching Methods of Environmental Education

As seen, renewable energy is a large and complex topic that can be taught both inside and outside the traditional science classroom. St. Onle & Eitel (2016) argued that perhaps renewable energy and energy education are best taught and applied in a hands-on, outdoor, environmental education setting. There are a number of best practices for teaching environmental education concepts that can be applied to science and energy education (Monroe et al., 2019, p. 800). However, this is not an exhaustive list of methods or strategies as there may be additional ways of meeting the goals of environmental education and content standards. This section focuses on effective methods and strategies that may help learners better understand renewable energy content, are easily applicable, well researched, and commonly used in residential environmental programming. Additionally, these strategies were viewed through the lenses of environmental education, application at RELC programs, and their use with middle school students.

Educational Theories

Constructivist Approach. Constructivism, as defined by Novak (as cited in Ballantyne & Packer, 1996), is the idea that people construct ideas about how the world works through experiences, both individually and collectively with others, and that these ideas can change over time (p. 349). These ideas influence the way we interact with the world, how we understand the world, and our belief systems. Since beliefs are tied to our understandings, experiences, and existing concepts, changing someone's beliefs or misconceptions is challenging (Ballantyne & Packer, 1996). Additionally, children adopt many beliefs from their families and role models, many of whom themselves do not have a complete understanding of environmental issues and energy concepts (Merrit, Bowers, & Rimm-Kaufman, 2019, p. 1078). A constructivist framework to environmental education can connect concepts and beliefs to new knowledge, attitudes, and experiences which may ultimately help students become aware of their misconceptions (Ballantyne & Packer, 1996). Many of the strategies detailed below are similar or based on the constructivist approach to teaching and learning.

Experiential Learning. Experiential learning is an approach that combines students' experiences, ideas, questions, and interests. It is a student centered approach to teaching and learning that places the students in the lead, instead of the instructor or teacher (Karpudewan & Khan, 2017). Developed by Kolb in 1984, the experiential learning cycle consists of: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb & Kolb, 2008, p. 44). Learners cycle through these four stages as they gain new experiences and develop their own beliefs and

actions. It is a recurring process where learners cycle or spiral through the four steps - experiencing, reflecting, thinking, and acting - over and over as new information is added (Kolb & Kolb, 2008).

A study by Karpudewan and Khan (2017) suggested that experiential learning increased students' motivation for pro-environmental behaviors and choices. In their study, 62 sixteen-year old students participated in lessons on climate change for six weeks. The control group were taught in a lecture style while the experimental groups' lessons were taught following the experiential learning process. The experimental group showed greater increases in environmental motivation than the control group after the lesson. Karpudewan and Khan (2017) also found that field trips that utilized experiential learning strategies helped students understand environmental issues better and feel more confident in their knowledge (p. 218).

Inquiry-based. Similarly to experiential learning, inquiry-based learning has its roots in constructivism (Hunt et al., 2010, p. 467). Inquiry-based learning places students at the center of constructing their knowledge through asking questions, investigation, problem solving, analysis, and perspective taking. Not only do students learn about science and other subjects, but they learn to think and communicate as scientists, taking on both content and the processes and metacognition at the same time (Hunt et al., 2010, p. 467). Implementing inquiry-based learning can be challenging for many educators, especially when school systems place emphasis on textbooks and standards particularly for middle and high school students. However, when implemented intentionally, educators can incorporate standards and content while scaffolding student learning.

Ultimately, inquiry-based education and its multi- and interdisciplinary approach can prepare students to become active and engaged citizens (Hunt et al., 2010, pp. 467-468).

The use of inquiry-based lesson plans was used in a study with fourth and fifth grade students learning about renewable and non-renewable energy. During two of the three lessons, students built and evaluated models as a small group, then reflected on their models, utilizing multiple aspects of inquiry learning. Between the pre and post tests, students' knowledge of energy resources grew from 43.8% to 76.2%. The improved results show that inquiry-based investigations and lessons were an effective way for students to learn about energy resources. Additionally, students were excited about their models and the lessons they participated in and felt an increased sense of stewardship afterward (Fortner, 2009, p. 126).

Hands-On. Often hand-in-hand with inquiry and experiential learning is providing students with hands-on activities and learning experiences. Ballantyne, Fien, & Packer (2000) found that hands-on experiences and field trips such as water quality testing, planting trees, canoeing, etc., increased students' awareness and environmental attitudes compared to before such activities (p. 11). In addition, these hands-on experiences were frequently cited by students as the biggest aspect contributing to their learning (Ballantyne, Fien, & Packer, 2000, p. 11). Hands-on activities are not only fun and interesting; they have a large impact on student awareness of and interest in environmental problems (Ballantyne, Fien, & Packer, 2000, p. 14).

Place-based. Being aware of and interested in environmental issues can seem overwhelming, as often environmental and energy based concepts students are introduced

to are complex and seem to lack relevance to their daily lives. Place-based education puts added emphasis on the study of place, in addition to and in connection with content and skills, in the environment that students live in or interact with often (Zeece & Wells, 2007). Place-based education, as stated by Gruenewald, "can help increase student engagement and understanding through multidisciplinary, experiential, and intergenerational learning" (as cited in Strife, 2010, p. 187). Taking real life situations farther and connecting them to the local community and the social, environmental, political, and economical implications, can empower students to take action at the local level, as well as to begin to better understand the complex nature of environmental issues (Strife, 2010).

Conclusion. The above educational theories provide a solid foundation and are all useful in an environmental education and RELC setting. As shown by Stern, Powell, and Ardoin (2008) in their study into The Tremont Institute, an RELC in the Great Smoky Mountains National Park, RELC programs effectively and intentionally apply methods like experiential learning, inquiry-based learning, and place-based learning to their programming (p. 33), leading to gains in knowledge, attitudes, and skills.

Educational Strategies

In addition to the above theories being used to shape programming at RELCs, certain strategies may help students understand and learn content better. The strategies below were chosen and researched due to their use in many RELC programs or their potential for success in being implemented. These strategies are also applicable and adaptable for a wide range of student ages, especially fourth to eighth grade students.

Models and Teaching Aids. In addition to students having an active role in their learning process, engaging multiple learning styles is essential for reaching a wide range of learners. The use of visual aids, models, and other tangible objects are helpful for students to conceptualize big ideas and processes, especially in energy education (Ying-Chyi et al., 2015, p. 39). A study by Ying-Chyi et al. (2015) with fourth grade students, revealed that the use of models of renewable energy technologies such as wind, water, and solar, gave students a more positive attitude towards renewables and an increase in knowledge. Additionally, the group of students using the models and teaching aids understood the benefits of renewable energy over non-renewables better than the control group who did not use the models (Ying-Chyi et al., 2015, p. 44).

Impact of Role Models. Students will have a wide range of role models throughout their lives ranging from family to celebrities to their peers. Peers serve as role models where students can see their action or inactions reflected, often leading to increased motivation or action (Stern et al., 2018). Older role models such as parents, teachers, and other adults are particularly influential in forming beliefs and attitudes (Stern et al., 2018). People learn from the people around them through observation and interactions. Research showed that having a positive role model who exhibits environmentally friendly actions and feelings towards nature has an effect on children (Stern et al., 2018).

In a case study of four innovative secondary schools in North America, Higgs and McMillan (2006), found that students picked up on their teachers sustainable behaviors such as biking or walking to school, composting and recycling, picking up litter, and

turning off the lights when leaving a room. The teachers, who unintentionally modeled these behaviors, became role models for students (Higgs & McMillan, 2006). Similarly, Pintrich and Schunk (2002) stated that teachers are effective role models as students pay attention to their teachers and their actions (as cited in Higgs & McMillan, 2006).

At RELCs, staff come from across the country to work as seasonal instructors and educators. These staff come with varied experiences, backgrounds, and knowledge but many have a passion for the outdoors and the environment. This is reflected in the behaviors that they model. For example, staff at MEC often ride bikes or walk to work each day, are intentional about their food waste, recycle what they can, and practice other environmental conscious habits (McDowell, 2017). It is likely that these behaviors, while unconsciously demonstrated by RELC staff, have an impact on the attitudes and actions of the students attending these programs.

Journaling. Taking time to reflect on new experiences and knowledge is one way to solidify learning and is a key step in the learning cycle (BEETLES, 2015.; Kolb, 2017). The use of personal journals in environmental education programming allows students to record and reflect on experiences and new ideas. Journals may be a place where students reevaluate prior misconceptions and their attitudes about the environment (Ballantyne & Packer, 1996). Journaling is utilized in many outdoor and environmental education programs, where instructors provide a prompt or activity incorporating the use of students' journals. Journaling also supports science practices like observation, questioning, and constructing explanations. If a student writes something down, there is a

higher chance of them remembering later, as they have had to intentionally put their thoughts into words on paper (BEETLES, 2015, pp. 49-50).

Summary

The literature on effective methods and strategies suggests that students learn more by being engaged in interactive ways of learning. A constructivist approach can be applied broadly to all of these strategies in that students are creating their own knowledge and beliefs after being presented information and first hand learning experiences (Ballantyne & Packer, 1996). Experiential learning, hands-on experiences, inquiry, place-based education, and journaling are all effective strategies for environmental and science education (Monroe et al, 2019, p. 800). The use of modeling provides yet another tool for educators to use in giving students first hand experience that allows them to better understand complex content (Ying-Chyi, 2015). Additionally, role models such as teachers, instructors, and other adults play a role in developing students' attitudes and motivation about the environment (Higgs & McMillan, 2006). Furthermore, learning in an outdoor setting allows students to investigate the world around them and engage directly with the natural processes they are learning about (Landis, as cited in Karpudewan & Khan, 2017).

Chapter Summary

This literature review gives context, background, and recommendations for this capstone research question: *What are effective methods for teaching middle school students about renewable energy at residential environmental learning centers?* First, environmental education was defined and its goals to help society become more

environmentally aware and literate were explained. Next, the importance of renewable energy education was examined, particularly as it related to middle school students. The need for renewable energy education is clear as many students and adults do not have a solid grasp on fundamental knowledge about the need for renewable resources. Finally, effective methods that could be used in environmental education, at RELCs, and with middle schoolers to teach about renewable energy topics were identified and discussed. These methods point to the importance of a constructivist approach to learning. The findings from this research and literature review directly informed the design and content of the curriculum for the capstone project.

The following chapter gives an overview of the capstone project, the setting and audience, and the curriculum framework for the lesson plan aimed to answer the question of what are effective strategies for teaching middle school students about renewable energy at a residential environmental learning center. The timeline for the project as well as how the project will be assessed are detailed as well.

CHAPTER THREE

Project Description

Utilizing the information reviewed in the literature, this chapter details the process of creating and developing the capstone project seeking to answer: *What are effective methods for teaching middle school students about renewable energy at residential environmental learning centers?* This chapter includes an in depth look at the project and its goals, the setting, audience, curriculum framework, timeline for implementation, and how the project will be assessed for effectiveness.

Project Overview

This capstone project culminated in the creation of a new three-hour long, stand-alone class about renewable energy that will be taught at McDowell Environmental Center (MEC). The class will utilize the on-site renewables at Camp McDowell to teach about solar, wind, hydropower, geothermal, and biomass energy. Additionally, the class aims for students to understand the difference between renewable versus non-renewable energy sources. The class created for this project has a fully detailed lesson plan, an outline, and learning goals. The lesson plan is written in detail to help guide new instructors in their teaching. Instructors are allowed and encouraged at MEC to pick and choose activities in the lesson plan, add their own if they wish, and create their own personalized lesson plan based on their students knowledge, needs, and trails and spaces available to teach the class. While class was designed to be implemented specifically at MEC, the lesson plan includes strategies, techniques, and activities that staff can take with them and apply to any future teaching experience.

In addition to the class, an educator background document was created for use by MEC staff. This document provides more in depth information about energy, the various renewable energy sources discussed in the class, a background of Camp McDowell's renewable energy initiatives, and facts that are valuable to know. Staff and instructors at MEC come from various backgrounds and many may not be familiar with the topic of renewable energy as in depth as others. I did not come into the environmental education field having a strong science background so I wanted to create an additional resource for the staff who may have a limited background knowledge about renewable energy concepts. Having a background document to study and use in preparing for teaching this class will aid staff in feeling more comfortable and confident in teaching about this topic and answering student and chaperone questions.

A curriculum project about renewable energy was chosen for this capstone as a way to incorporate the effective strategies discussed in the literature review and to answer the research question connecting strategies and renewable energy at RELCs. The creation of this class provides a positive outdoor, hands-on learning experience which the literature review showed is conducive to learning and gaining knowledge about science concepts and renewable energy. St. Onge and Eitel (2016) stated that based on their research, energy education, particularly renewable energy education, may be best taught in outdoor, environmental education settings. These settings allow for increased hands on, place-based, and experiential learning. Additional research done at other RELCs by Stern, Powell, and Ardoin (2008) supported incorporating science based learning into a residential setting. This combined with the fact that Camp McDowell, the location and

parent organization of MEC, has on-site renewable energy sources that lend themselves to place-based learning and hands-on, concrete experiences, make the teaching of renewable energy at this RELC a good match for the capstone project.

Setting & Audience

The setting of this project is at Camp McDowell, specifically MEC. The renewable energy class becomes one of 30 classes offered at MEC. McDowell Environmental Center is located in Nauvoo, Alabama on over 1,200 acres and is a RELC serving 8,000 people each year. Camp McDowell and MEC are located in Winston county Alabama, one of the poorer and more rural counties in the state. There has been a push at Camp McDowell in the last five years for involvement of the immediate local community, though the majority of people who attend the program are from larger cities in Alabama such as Birmingham, Montgomery, and Huntsville. The majority of students who attend this program are from Alabama schools and are in third through eighth grade, with fifth, sixth, and seventh graders being the most common participants in the program.

An average school field trip to MEC is three days and two nights. Students come to MEC with their school and are separated into field groups, or learning groups, of 10-15 students. Students stay with the same group the whole program and take all their day time and night time classes with this group. Each day, there is a three-hour morning class, three-hour afternoon class, and a 90 minute evening program. Teachers and parent chaperones are also with the same group the entire time. Adults numbers range from one to five per field group, depending on the number of chaperones a school brings. MEC

instructors have the choice to teach the same group multiple times, or to teach multiple groups over the course of a week.

The staff at MEC consists of 10-15 seasonal instructors and five full time staff. Seasonal staff work August-December and February-May. In an average week, MEC instructors teach seven three-hour daytime classes and two evening programs. Staff get to create their own schedules and can choose what classes they would like to teach for the upcoming week, based on what the schools in session are taking. Some staff return for multiple seasons, while others work just one season. On average, 40-50% of staff are from Alabama and the rest are from across the county. McDowell Environmental Center staff come with varied educational backgrounds, some with a college degree and others without. Some staff have a background in environmental science or biology, while others have a background in education and others still have no prior experience in either. Each season, all staff, both new and returning, go through a two week staff training where they learn the majority of MEC classes, best practices in environmental education, and participate in additional teaching technique seminars.

McDowell Environmental Center is part of a larger camp and conference center called Camp McDowell which has over 1,200 acres of forest, streams, fields, trails, and buildings. Camp McDowell is part of the Episcopal Church, though MEC is a secular program. Camp McDowell has over the years added a number of eco-friendly initiatives, including renewable energy sources in an attempt to someday be totally off the power grid. The renewable energy sources include:

- Solar panels on many building roofs and a large solar array located in a large field

- Geothermal technology located under a man made pond that provides heating and cooling for multiple buildings waterheaters
- A plan for future construction and implementation of Alabama's first Archimedes Screw, utilizing hydroelectricity at a dam along Clear Creek

This class is one of 30 classes that teachers can select from for their students to take during the trip. Often, teachers select their classes based on grade level standards, goals they have for their students, and/or based on personal preference. Teachers have access to the learning goals and a description of the class in MEC's teacher planning packet prior to being asked to choose their classes for the trip.

The participants in this capstone project are students in grades four through eight attending the residential program at MEC. The grade level recommendation for this class will be listed in the upcoming edit of MEC's 2023-2024 school year teacher planning packet and discussed during the planning stage of the trip between the lead teacher and MEC Assistant Director. The overall lesson plan is the same for any age student taking the classes; however, classes are led by a MEC instructor who is trained in teaching the class and has prepared their own version of the lesson plan based on the grade level of the students. Additionally, the educator background document provides further information as instructors prepare for their class. The group sizes are 10-15 students and their one to five adult chaperones with one MEC instructor.

Curriculum Framework

A backwards design approach was taken for this project (Wiggins & McTighe, 2011). In backwards design, first, the learning goals for the class were created. These

goals were based on the 2013 Next Gen Science Standards, the 2015 Alabama Science Standards, and key topics for middle school renewable energy education discussed in Chapter Two. The learning goals created for this class include:

- Define the terms renewable and non-renewable resource
- List and explain the pros/cons of at least four energy sources
- Describe the connection between energy resource use and natural resources
- Identify ways individual and community use of energy affects the environment

After the goals were created, a plan for assessing students at the end of the class was created. This will include a journal prompt reflection activity. Finally, the research and analysis of effective strategies done in Chapter Two provided the background for how the lesson activities will be taught. Methods such as experiential learning, hands-on, place-based, and inquiry-based all formed the foundation for this class. Additional strategies including the use of modeling and journaling were incorporated into the class activities.

The BEETLES (Better Environmental Education, Teaching, Learning, and Expertise Sharing) Project, based out of the Lawrence Hall of Science, and their learning cycle was the framework for lesson planning and curriculum design utilized in this capstone project. The BEETLES Project provides resources for teaching and learning in the environmental education field that are research based and have been tested by dozens of environmental education and RELC organizations across the country. The BEETLES

learning cycle was used in creating this plan to keep experiential, inquiry-based learning at the center of this project. The learning cycle is currently used at MEC in planning, creating, and revising lesson plans and is taught at staff training as the framework for lesson planning at MEC. The steps of the learning cycles are: invitation, exploration, concept invention, application, and reflection (BEETLES, 2015).

The lesson plan template for this class was based off of other classes at MEC to keep with consistency and to make a seamless transition for this class into use by MEC staff. This template includes: the learning goals, a brief synopsis of the class, quick facts, instructor tips, McDowell themes, NGSS science practices, NGSS crosscutting concepts, an outline, procedure, activities, materials, and additional resources.

Timeline

In creating this capstone project, first the 2013 NGSS and 2015 Alabama State Standards for grades four through eight were referenced for standards that addressed renewable energy topics. Then, there were four overarching learning goals developed for the class that met the various NGSS and Alabama State Standards. After that, resources and potential activities were gathered, evaluated for ease of use and effectiveness, and added to the lesson plan. Camp McDowell's on-site renewable energy sources are incorporated into the lesson as a place-based learning tool. Using the BEETLES Project learning cycle as the curriculum framework, the main lesson plan was created and activities and instructions were written and described in detail. Visuals and teaching aids were also created as they related to activities in the lesson plan. Additional class materials needed to lead the activities will be developed upon completion of this capstone project

and solidification of the lesson plan with MEC leadership staff. These class materials will then be stored in bins specific to this class, along with other class materials bins at MEC.

Following the creation of the curriculum, lesson plan, and materials, the class will first be piloted sometime in Fall 2022 with a few school groups. I want to pilot the class before offering it to all of MECs schools in order to get feedback and assess any changes that need to be made to the layout, activities, or materials. It will then be taught at the next MEC staff training in February 2023 and be gradually implemented with a handful of schools and field groups that spring. During this time, other MEC staff besides myself will teach the class with students. Based on feedback from staff, students, teachers and chaperones during the pilot and gradual implementation phase, any changes to the class and materials will be made before implementing the class into MEC's core class selection for teachers to choose from in the trip contract and teacher planning packet for Fall 2023. Beginning in Fall 2023, any school attending MEC can choose to sign up and take the class and all staff will be trained to teach it.

Assessment

In order to assess the effectiveness of this new class, feedback from teachers whose students take this class will be gathered in an end of trip interview on the last day of the residential trip. This interview includes the MEC Director and Assistant Director and the lead teacher from the school. While in the pilot and implementation stage, a short survey will be given to chaperones and teachers who attended the class to give feedback on the activities, discussions, and effectiveness of the class in meeting the learning goals. There is also informal student assessment written into the class for instructors to use with

each group of students including discussions and journal reflections. Journaling, which as found in Chapter Two, is an effective way to engage learners in the reflection process and solidify their learning (BEETLES, 2015).

McDowell Environmental Center staff will provide informal feedback on the class during staff meetings and one-on-one meetings with MEC leadership staff. This feedback will also assess the usefulness of the educator background document which will have been provided to staff at the start of the season. Formal feedback may also be gathered at the end of staff training when a survey is sent to each staff member to reflect on the classes and session they received training in during those two weeks.

Another way the class will be assessed in the long term is by both informal and formal discussion with teachers who attend MEC. Every year, MEC and Camp McDowell host a teacher workshop called Teacher Advisory Board (TAB), where teachers from across the state of Alabama come and provide feedback on our programming, classes, systems, and provide new ideas. Most of these teachers are ones who have participated in our programming over the years, though that is not a requirement to attend. Each year prior to TAB, MEC leadership staff prepare up to five big questions we want feedback on from the teachers attending. It is likely that in the first year or two of the new class being offered, we will request their feedback on the renewable energy class, any changes they would like to see, or suggestions for improvement in the class.

Chapter Summary

This chapter described the process and details regarding this capstone project which seeks to answer the questions: *What are effective methods for teaching middle school students about renewable energy at residential environmental learning centers?* This included a detailed description of the project and its goals, the setting and audience, curriculum framework used in designing the class, the timeline for implementation, and how the project will be assessed. The final chapter concludes the project and gives my reflection on the process, learnings, and implications, as well as my goals for the project in the future.

CHAPTER FOUR

Conclusion

My experiences in environmental education and working students at multiple RELCs over the years has led me to ask the question: *What are effective methods for teaching middle school students about renewable energy at residential environmental learning centers?* Growing up, I was not familiar with the basic concepts of renewable energy and did not connect the idea of energy use and consumption to our natural world until I began my work as an environmental educator. Over the years I have seen a disconnect in students' understanding of renewable energy and its connection to the world around them. Additionally, many of the middle school students I have worked with often have misconceptions or lack basic understandings of renewable energy concepts.

This project was created out of a need for McDowell Environmental Center (MEC) to begin to utilize its onsite renewable energy resources to educate students and adults who come through the program. This project resulted in a new, stand alone three hour class about renewable energy for middle school students aimed to fit this need. This class incorporates multiple effective teaching methods and utilizes the outdoors as the classroom. Additionally, an educator background document was created for staff at MEC to use as they go forward in preparing to teach this class to students.

This chapter concludes the capstone project by looking at the lessons learned from my research and the creation of the project, reviewing the literature from Chapter Two that was most helpful in guiding this capstone, and discussing the broader implications and limitations of the project. I also expand upon future projects and next steps to

implement the curriculum, how the project and its resources will be shared and communicated with others, and finally how this research and project will benefit the greater field of environmental education.

Major Learnings

One thing I learned very quickly in my research and work on my project was to keep the resulting curriculum 'narrow and deep' rather than 'wide and shallow.' This refers to the breadth of learning, topics, and objectives covered in a learning experience. Going deeper into one or a few topics likely will result in better understanding and comprehension for students rather than briefly addressing a wide range of topics. For example, in my lesson plan and class, I chose to focus on more basic ideas in energy education like defining renewable versus nonrenewable resources and exploring a few forms of renewables instead of going wider and including topics like climate change, other types and sources of energy. In avoiding mentioning climate change and having that topic be a part of the project and resulting class, I also hoped to keep climate doom at bay which, for a first year MEC instructor, could potentially be a challenging conversation to have with both students and adults. While I do believe this project and the topic of renewable energy parallels and connects with climate change education, tackling that topic and addressing it within an existing program such as MEC seemed too large a topic and process to tackle during this capstone.

Another learning experience I had as I created the curriculum was how to balance the information-heavy topic of renewable energy with my goal of teaching through effective methods and strategies for student learning. I have both taught and taken classes

in environmental education that are too information-heavy and not active enough. I wanted to make sure that the class I created would engage learners in the learning process and keep them engaged while also helping them learn new concepts or expand their prior knowledge. Incorporating things like journaling and place-based education fit in well into the established learning model at MEC, but finding activities and planning for learning that incorporated hands-on activities, inquiry, and using models was a more challenging balance to find. The goal for instructors at MEC is to be a guide and facilitator of student learning, rather than a fountain of knowledge pouring information into students.

The BEETLES Project highlights three typical roles that instructors can take in learning: "the sage on the stage," "the guide on the side" or "the entertainer" (BEETLES, 2022). These roles and ways instructors teach can either help to draw out student discussion and interest on a topic, or shut down students' ideas and learning. The "sage on the stage" style of teaching consists of an instructor information-dumping and filling their lesson with more knowledge and facts than students are able to grasp in the allotted time of the learning experience. The "sage on the stage" might also tend to give students the answers to things rather than allow space for student exploration, discovery, and discussion. The "entertainer" is someone who prioritizes making learning fun often over content and comprehension. My goal in writing the curriculum was for the lesson plan to help MEC instructors teach in the role of the "guide on the side." In this type of instructor role, the instructor is seen as more of a facilitator. They are guiding the students through the learning process, answering questions as needed, filling in spaces with content knowledge, but overall allowing students to lead their own learning. I found that aiming

for MEC staff to fulfill this instructor role would pair the best with the effective methods found in my research for student learning.

In addition to writing the lesson plan in a way that would incorporate effective methods of learning and encourage a more facilitator role for the instructor, I also realized I needed to decide on the level of detail and tone in the lesson plan and educator background document. Often, MEC staff are new to teaching and to outdoor environmental education. After viewing multiple other types of lesson plans MEC has utilized over the years, I decided that lesson plan instructions for the staff needed to be brief but detailed, often providing details that a seasoned teacher might not need. For example, instead of saying "put students into groups", I have attempted to provide detail that will help newer instructors by saying: "split students into 3-5 groups depending on the number and age of students. Ideal group size is 3-5 students per group." Along with adding in more detailed notes and instructions, I also decided to write the lesson plans in second person. Other past MEC lesson plans I looked at included notes like "students will discuss energy conservation and which energy form they think is best." I chose a second person narrative throughout both documents, saying instead things like "lead a discussion on energy conservation and which energy form is best." This will hopefully allow new instructors to use the curriculum I have written with more ease and understanding.

Revisiting the Literature

The information and research found in Chapter Two helped guide this project greatly. Despite finding limited research on the connection of renewable energy education

and RELC programming, the few studies I did find proved helpful and informed the direction of my project. The studies done by Stern, Powell, and Ardoin (2008) and St. Onge and Eitel (2016) provided the biggest benefit in connecting my themes of RELC programs with renewable energy education. Both of these studies showed that students increased and retained information in multi-day RELC programming about sustainability and renewable energy topics, as compared to the traditional classroom or in shorter environmental education experiences. These studies confirmed my initial question that led to the creation of this capstone project in seeking to connect a longer RELC experience with a content heavy topic such as renewable energy.

The research done by Merrit, Bowers, and Rimm-Kaufman (2019) also helped narrow down the scope of my project and is what encouraged me to create a curriculum that focused on “narrow and deep” over “wide and shallow” learning. They pointed out the struggles middle school students experience with energy topics and renewable energy basics and how connecting these concepts to real life and relevant issues created better comprehension and learning to take place. Their research, along with the NGSS and AL State Standards, were what guided the creation of my learning goals. Merrit, Bowers, and Rimm-Kaufman (2019) also argued that multiple learning experiences are key to comprehension of renewable energy concepts, which unfortunately is something I was not able to account for in my project. However, it provided context for a potential future project linked to this capstone of creating pre- and post-visit experiences for teaching to continue building on students' knowledge after taking the renewable energy class at MEC.

Broader Implications

While this curriculum is focused on the student and helping them learn in the most effective ways about renewable energy, this project extends beyond the student. The lesson plan and educator background document will hopefully be a tool and a positive teaching and learning experience for the instructors teaching with this material. Through this experience, they will learn first hand how effective teaching methods help their students learn best and grow their own personal knowledge and understanding of renewable energy. The strategies and teaching tools utilized in the lesson plan are skills instructors can take with them after leaving MEC and are not only useful at an RELC but in teaching and many other fields working with people.

Another group of people this curriculum will hopefully impact are the teachers, parents, and chaperones who attend MEC with their students. Many adults also do not have a solid understanding or background knowledge of renewable energy topics and might have a politicized view of the topic. In attending this class with their students and seeing them learn, discuss, and apply the information, it could in turn change or add another level to an adult's understanding of renewable energy. It could also begin to correct common misconceptions they hold about the topic. In Alabama, there is currently an additional taxation on the use of solar panels by the main energy company Alabama Power at a rate of $5.41 per kilowatt. This ‘solar tax’ has prevented Alabamaians from installing and utilizing solar for years (Lang, 2022). Potentially by exposing more adults around the state to renewable energy ideas through this capstone, which includes teaching

about solar panels, more people would sign the petitions and vote against the use of the solar tax in our state.

Limitations

One of the possible limitations of the project is the use of journaling in the lesson plan. Research suggests that journaling is a good way for students to reflect on the material they have learned and to improve comprehension and information retention. Much of the research on journaling in outdoor settings comes from the BEETLES project which is based in California. Part of being an RELC means that learning takes place almost one hundred percent outside, in all types of weather. Alabama experiences a good bit of rain throughout the year, particularly in the spring season. Journaling in these conditions is improbable, so I will need to come up with a creative backup for how MEC instructors can incorporate the assessment piece that utilizes journaling when having journals out in the rain is not an option. Perhaps a group discussion or journaling upon returning indoors at the end of class will be tried and implemented as a backup option.

Another limitation I will have to consider as I implement the project is that much of the class I have created relies on transportation around the 1,140 property of Camp McDowell. In utilizing place-based education to see and learn about renewable resources on-site, students will be driven from place to place, learning about each energy source. MEC has two trucks currently in use to transport students to other class sites that are not within walking distance on property. However, there is likely to be overlap and multiple classes going that require the use of the trucks for transportation. Additionally, students with limited mobility or wheelchairs often are unable to travel in the trucks and an

alternate class hike or path is chosen instead. I am not sure yet how I plan to address these issues, but my initial thoughts are to try to schedule MEC classes that utilizes the trucks more strategically, and add to the renewable energy class lesson plan more hands-on backup options should students not be able to travel from place to place.

Future Projects

Prior to the class being taught, a staff training session must occur where MEC instructors are taught the class as if they were the students. This allows them to see the material and work through the learning process as their students would. This would likely be taught by myself or another full time MEC leadership staff member. Following the training, staff would be able and encouraged to give feedback and ask questions about the class, lesson plan, and accompanying educator background document. Throughout the season, there also needs to be a full time staff to support the instructor and observe them the first time teaching the class.

Another future project that could result from the implementation of this project would be the creation of shorter classes at MEC focusing more in depth on a specific renewable energy source. For example, a 90-minute class focused on wind energy where students create and carry out an investigation or hands-on project. The same could be done with solar and hydro power. Once feedback is collected from staff, students, and teachers about the current renewable energy class, we will have a better understanding of if adding these shorter classes is something teachers would want MEC to offer.

Communicating Results

In addition to this research and project being shared on the Hamline University Digital Commons, the lesson plan and educator background will be shared with all staff at MEC. As with all curriculum at MEC, the both documents will be stored in Google Drive for easy access by all MEC and Camp McDowell staff. Staff are encouraged to take these lesson plans with them in their future jobs at other programs. A brief description of the class, the standards it meets, and the learning goals will also be available on the MEC website for teachers and those planning a trip to reference as they choose what classes to sign up for during their trip. Additionally, MEC often shares documents with environmental educators, teachers, and others who inquire about lesson plans and resources for their own use. In summary, the lesson plan and educator background document will be available to anyone who inquires and will be shared in a non-editable version via Google Drive or PDF.

Benefit to the Profession

As I was researching, I did not find a lot of information about renewable energy instruction specifically at RELCs. My hope is that this research will add to this and be a useful tool for others in environmental education, outdoor education, and or at RELCs who are looking to incorporate this topic into their programming. This is especially useful information for programs that have on-site renewables but currently are not teaching about or utilizing them as learning tools for place-based education, like Camp McDowell was prior to the creation of this class.

In addition to adding to the existing research on the topic, I hope this project will be a benefit to the profession by inspiring the next generation of environmental education instructors, starting with those at MEC, to feel more comfortable talking about, discussing, and teaching about renewable energy. While there is more work to be done in regard to teaching and learning about climate change in education, this is a solid place to start. Staff who spend time teaching at MEC often go on to work at other environmental education programs and could bring the knowledge and resources this project provides with them. I also hope to see the addition of this class at MEC inspire other RELCs and environmental education programs across the state of Alabama to add classes like this to their programming.

Conclusion

This chapter took a reflective look at the major learning I have gained throughout the capstone project process, revisited some of the research I found most helpful from Chapter Two, discussed the implications and limitations of the project, outlined potential future projects, my plans for sharing the project with others, and finally, how I hope this project will benefit the environmental education field.

This capstone project aimed to answer the question, *What are effective methods for teaching middle school students about renewable energy at residential environmental learning centers*, and I believe it has. While this capstone was challenging to complete, the research and subsequent resulting project are something I am proud of and cannot wait to implement into MEC programming in the next year. This curriculum will allow students, teachers, and staff to expand their knowledge about an increasingly important

topic: renewable energy. Learning outside of the traditional classroom is a valuable tool and the use of on-site renewable energy sources will further encourage connection and understanding for students. I still believe, even more so after completing this project, that the environmental education field and RELCs are uniquely positioned to tackle the huge educational undertaking that climate change education requires. Hopefully, through these experiences, students will gain knowledge and critical thinking skills that will set them up for success as we as a society continue to address the climate crisis globally.

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