Exploring Outdoor Makerspaces to Develop STEM Skills

by

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ABSTRACT

As an urgency has emerged to prepare students to be future-ready, makerspaces have been developed as a technique for teachers to use in classrooms to build science, technology, engineering and math (STEM) skills. Makerspaces expose students to innovation and are powerful tools in training students to use science and engineering practices as they invent, discover and tinker. While indoor makerspaces have been studied in multiple settings, little research has been performed to understand the relevance of makerspaces in outdoor settings.

The goal of this study was to aid 20 elementary teachers in developing their understanding of the usefulness and benefits of outdoor makerspaces. A constructivist approach was used in order for participants to overcome pre-conceived barriers about taking students outside for learning. In this qualitative study, participants took part in a hands-on professional development session to learn how to integrate nature into instruction, then used outdoor spaces to engage their own students in three or more outdoor sessions. Teachers reflected before, during and after the intervention to see if the likelihood of engaging students in outdoor learning changed.

The findings of the study showed that spending time outside with students led to a multitude of benefits for both students and teachers. Benefits included increased student engagement, expanded learning for students and teachers, and STEM skill development. These findings, suggest that outdoor makerspaces introduce a new platform for training students and teachers about science and engineering practices while providing authentic science connections, high engagement, and benefits to social and emotional balance.

DEDICATION

This work is dedicated to Ashley who made it possible for me to pursue my dreams.

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TABLE OF CONTENTS

CHAPTER Page

APPENDIX Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER 1

INTRODUCTION

In the 1960's the United States put the first man on the moon, and since that time many Science Programs were developed to better prepare our students for careers in the fields of science, technology, engineering and math (STEM) (Gunn, 2017). Even though scientific and technological innovation have been on the rise, the United States Department of Education (USDE) says that "few American students pursue expertise in STEM fields—and we have an inadequate pipeline of teachers skilled in those subjects" (Science, Technology, Engineering and Math: Education for Global Leadership, 2017). The contradiction between the high need for students to pursue STEM and low participation of students in STEM pathways, calls attention to a need for change.

National Context

Nationally, attention has been called to preparing students and teachers for STEM (NSTC, 2018). In 2010, the President's Council of Advisors on Science and Technology (2010) identified the importance of equipping both teachers and students with strong STEM career skill sets to assist in preparing a future workforce. The USDE proposed a plan of action through the Committee on STEM Education (CoSTEM) to support this task. CoSTEM set out a framework to help improve student interest in pursuing STEM careers. The framework included "facilitating a cohesive national strategy, with new and repurposed funds, to increase the impact of federal investments in five areas: 1.) improving STEM instruction in preschool through 12th grade; 2.) increasing and sustaining public and youth engagement with STEM; 3.) improving the STEM experience for undergraduate students; 4.) better serving groups historically underrepresented in STEM fields; and 5.) designing graduate education for tomorrow's STEM workforce" (Science, Technology, Engineering and Math: Education for Global Leadership, 2017). The National Science & Technology Council (2018) continues to support this work with their publication *Charting a Course for Success: America's Strategy for STEM Education.* This study supports the need to improve STEM instruction in pre-school through 12th grade, specifically by building capacity for instructors in the elementary years and using the outdoors as a platform to construct learning.

As STEM education seeks to develop critical thinking and problem-solving skills as well as soft skills including collaboration, it is essential that training students in STEM starts in the elementary and secondary years since these are the precursor skills to STEM pathways (NSTC, 2018). As a result of improving STEM instruction in preschool through 12th grade, there has been a shift in local and national standards evolving to develop engineering skills for students in grades K-12 (National Academies of Sciences, Engineering, and Medicine, 2019). One question emerging from this call for educational reform is if teachers are prepared to provide quality STEM experiences for students? Elementary teachers, trained to be generalists, sometimes struggle with the knowledge and confidence to provide quality STEM activities to engage students (Gorena et al., 2015). The importance of teaching STEM, specifically engineering and innovation, at the early grades is integral in inspiring students to pursue STEM pathways (Gorena et al., 2015; Bell et al., 2017).

To support elementary teachers in integrating STEM into their practice, educational leaders have adopted strategies that guide teachers in engaging their students in developing STEM skills. One such strategy is the use of makerspaces (Martin, 2015). These spaces use experiential learning to teach students the engineering design process as they design and prototype solutions to proposed problems. Makerspaces have offered elementary teachers an accessible way to engage students in the engineering design process using a constructivist approach to understanding. In the *Journal of Pre-College Engineering Education Research (J-PEER),* Martin (2015) says "...there is growing interest among educators in bringing making into K-12 education to enhance opportunities for students to engage in design and engineering practices, specifically, in science, technology, engineering, and mathematics (STEM, or STEAM when art is included)" (p. 30). Makerspaces have emerged in both formal and informal settings and have allowed students and adults to use high-tech and low-tech materials to prototype using the iterative process.

These building spaces have leveraged natural skills of elementary teachers to offer students quality experiences to develop STEM skills. Cross (2017) studied makerspaces as constructivist spaces for K-12 students to learn. She found that "educational evolution may be facilitated in Makerspaces, which have also gained curricular validity with the development of the *Framework for K-12 Science Education* as well as the Next Generation Science Standards (National Research Council, 2011)" (p. 3). Makerspaces can empower educators as they build a constructivist platform for students to engage in the engineering design process. Makerspaces allow students to playfully engage in the design process while they face failure in a productive way (Honey & Kanter, 2013).

Although makerspaces have been used to successfully give students practice in communication, reflection, use of tools, technical skills, and practice with the iterative process (Litts, 2015), these spaces may have inadvertently contributed to another problem facing elementary students living in urban spaces; lack of time outside.

This generation has seen a shift from spending time outside to spending more time inside resulting in a disconnection from the natural world (Louv, 2008). The focus on developing STEM skills in students may be a contributing factor to this multifaceted problem. With a primary focus on the use of technology in indoor spaces to develop technology literacy, the requirement for students to spend time inside on digital devices that need to be plugged in, has increased. These students are missing out on the potential benefits natural spaces could provide. Using outdoor spaces could offer students opportunities to develop necessary skills to be future ready while allowing them the benefits of connecting with nature.

Environmental threats are rising and our connection with nature is waning (Lieberman & Hoody, 1998). Lieberman & Hoody (1998) suggest that although students might be aware of the environmental threats, they lack the personal connection to the natural spaces being impacted. Sobel (2008) said “This is what I’m advocating for—an approach to education that simultaneously honors developing a child’s love of the earth and developing a child’s academic and social competence” (p. 3). This suggests that students need to be exposed to more than just indoor STEM activities in which they learn to prototype to solve global challenges. Students need time outside to experience authentic hands-on problem solving while getting to know nature, the very reason they are solving problems.

In response to student's disconnection with nature and the persistent need to develop STEM skills, this study was constructed to explore the use of outdoor makerspaces to develop STEM skills.

Local Context

This study took place in a public elementary school located in the suburbs of Denver, CO. The school is composed of 750 middle to upper middle-class students, kindergarten through sixth grade. The school is separated into two buildings about a mile apart. One building houses students in grades three through six, the intermediate building, and the other building has kindergarten through second grade students, the primary building. The schools are considered two buildings, but one school. Each building has significant spaces that students and teachers can use for outdoor learning. The schools are surrounded by natural spaces within walking distance. Natural features include ponds, a lake, natural open space and a park. Eight percent of the students attending the school are qualified for free and reduced lunch. The school operates like traditional United States elementary schools in which students spend the majority of the day in their homeroom classrooms and make weekly rotations to a specials classroom where they receive instruction in art, music, physical education, technology, and engineering. Science is integrated into regular classroom instruction.

The school is situated down the street from Lockheed Martin, where some parents of the students work. Recently, concerns from administration and the parent community arose about the lack of time and effort put forth to enrich and develop student interest in STEM content and processes during the school day. Parents noticed students were not prepared to engage in STEM classes at the middle and high school levels which put them at a disadvantage in pursuing STEM careers. In addition, students have been scoring below district and state averages on standardized tests in the area of science. In 2017, only 30.1% of fifth grade students scored proficient or advanced on the science portion of the state standardized test, compared to 34.9% in the state and 44.5% in the district (Roxborough Intermediate, 2017).

In 2014, the school pursued International Baccalaureate (IB) certification. The International Baccalaureate Organization (IBO) is an international educational foundation committed to preparing students for a more globally minded future. According to IBO (2019), the IB stands out amongst other curricula because they:

- encourage students of all ages to think critically and challenge assumptions
- develop independently of government and national systems, incorporating quality practice from research and our global community of schools
- encourage students of all ages to consider both local and global contexts
- develop multilingual students.

This instructional change, with an inquiry focus to support critical thinking through global and local contexts, has provided opportunity for professional development to be built around a constructivist approach to learning. Some instructional supports have been created at the building level to promote this change. The librarian at the intermediate building has created a "Tinker Cart" for teachers to check out to use with their classes. The cart, equipped with recyclable materials, serves as a mobile makerspace for teachers to engage students in the engineering design process. The cart is maintained by the librarian. This resource is readily available for teachers but is not frequently used in their instruction. The librarian at the primary building has integrated some makerspace activities into her space to engage students as they are in the library. She sometimes allows students to engage in makerspace activities after they have checked out books. Some teachers have chosen to build a makerspace within their classrooms for students to use regularly. Many teachers have pursued professional development opportunities in makerspaces and design thinking to help them create classroom opportunities for students to engage in the engineering design process. These indoor makerspaces have provided opportunity to support IB instruction as teachers challenge students to think critically about problems that emerge in local contexts. Although teachers are prepared with materials and basic know-how, previous cycles of research give evidence to the fact that continuing professional development is needed.

In addition to regular classroom instruction, all student's kindergarten through sixth grade, take part in an engineering class that employs an indoor/outdoor Tinkerlab.

The structure of this class includes 4-day rotations spread over the course of the year resulting in about 36 sessions of engineering for each class. This engineering class, run by the researcher, employs a constructivist approach to learning. In a 4-day rotation, students spend the first three days learning specific STEM topics using coordinating tools, then on the fourth day are allowed to follow their own curiosities in an open-inquiry opportunity. Students study seven units of investigation a year which incorporate guided inquiry opportunities that require them to use tools and materials to solve local and global challenges. These units have included flight, bridge building, robotics, space exploration, simple machines, water shed investigations, life cycles, brick building, fort building, biodiversity, and wind energy to name several. The open inquiry session on the fourth day is called “Tinker Day” which provides time and space for students to develop questions to investigate on their own. According to one principal, this class has provided unique experience for students and has had a systemwide impact. Since students are better equipped to engage in engineering design challenges in both indoor and outdoor spaces, it has allowed teachers to build on their experiences without having to be experts in STEM.

Adopting an inquiry-based instructional model was not the only change the school focused on while pursuing IB certification. The administration saw a need to focus on the health and wellness of students. This initiative included implementing a 30-minute health and wellness block at the intermediate building on a daily basis and an integrated approach using brain breaks at the primary building. This was in addition to the regular

20-minute recess time after lunch. Teachers were encouraged to take students outside during this wellness block at the intermediate building for structured and unstructured activities. Outdoor backpacks were purchased to encourage teachers to allow students to interact with nature. Outdoor learning resources were provided to guide instruction. Although teachers continue to allow students to engage in free play during their wellness block, according to one principal, few teachers are choosing to provide other outdoor learning experiences to their students.

Teachers at this school are primed for the introduction of an outdoor makerspace. Although many seem comfortable with the idea of inquiry instruction using a makerspace and some are implementing parts in their classrooms, as per conversations with the principals, the lack of teacher’s willingness to take students outside to engage in learning opportunities still persists. The National Academies of Sciences, Engineering and Medicine (2019) have recommended teachers receive ongoing professional development opportunities to build knowledge in developing STEM skills for students in local contexts. This is further supported by the National Research Council: “Elementary student reliance on teachers for the acquisition of accurate STEM content and development of foundational STEM knowledge provides motivation for assuring elementary teachers are provided opportunities to continue their development of STEM understanding” (NRC, 2011). Elementary teachers are the primary source for developing STEM skills in their students, which makes this intervention an important one.

Outdoor learning provides a never-ending source of materials for teachers and students to use as well as provides benefits to students and teachers (Chawla et al., 2014; Banning & Sullivan, 2011). Providing teachers with natural materials to use as manipulatives could reduce the need for pre-packaged science kits that require upkeep and funding. In addition, research shows that being outside provides a myriad of benefits for students. “Makerspaces” and “Outdoor Learning” are terms that need to be defined to fully understand the implications and scope of this study. This will be done in the next chapter.

Study Purpose

The purpose of this study was to explore the potential relevance of an outdoor makerspace professional development intervention to strengthen teachers disposition to engage students in outdoor learning activities to develop STEM skills.

The question that guided my study was:

RQ1: Does an outdoor makerspace professional development intervention affect the likelihood of teachers choosing to engage students in outdoor learning opportunities?

Creating a professional development intervention in an outdoor makerspace required an understanding of what it meant to prepare teachers skilled in STEM process learning, including inquiry-based instruction. This required understanding factors that enhance and detract from teachers’ abilities to teach inquiry-based subjects like science. Loesing (2014) uncovered that teachers ability to teach inquiry-based subjects are influenced by a few different factors including science kit availability, the level to which teachers enjoy what they are teaching, and the engagement of students. In addition, lack of professional development was one factor that detracted from teacher's ability to provide quality experiences for students (Loesing, 2014). The problem of practice this study sought to target was two-fold. First, it addressed the lack of professional development opportunities for elementary teachers to build strategies to develop STEM skills in students. Second, it developed these skills in an outdoor environment in hopes of increasing the likelihood of teachers engaging students in outdoor learning.

CHAPTER 2

THEORETICAL PERSPECTIVES AND RESEARCH GUIDING THE STUDY

This chapter explains theories in order to situate this problem of practice in a relevant place for study. The idea of makerspaces and outdoor learning were introduced in the larger context describing how they employ an experiential, constructivist approach to learning. However, they need to be further developed in order to better understand the basis of this research. This section will first discuss and describe the tenets of makerspaces and outdoor learning, then research will be used to support these concepts with theoretical perspectives and research that guided this study.

Makerspaces

As an urgency in preparing students to be STEM-ready has emerged, makerspaces have developed as a technique to train students to navigate the iterative process to build 21st century skills critical in preparing them for STEM careers. In the Presidential Proclamation on the National Week of Making 2015, President Obama stated:

> Makers and builders and doers -- of all ages and backgrounds -- have pushed our country forward, developing creative solutions to important challenges and proving that ordinary Americans are capable of achieving the extraordinary when they have access to the resources they need. Let us renew our resolve to harness

> the potential of our time -- the technology, opportunity, and talent of our people -- and empower all of today's thinkers, makers, and dreamers.

This statement shows the importance that has been placed on making and building to empower people of all ages to harness the talent of our country.

It is difficult to teach innovation using making without the knowledge of how to engage in inquiry-based learning. Settlage (2007) claims that inquiry education has been widely promoted as the way to approach science instruction. In addition, he identifies inquiry instruction as a complex compilation of skills difficult for teachers to master. Instructional change of this magnitude requires continued professional development opportunities. Nadelson et al. (2013) echoes the importance of continued professional development for elementary teachers. "The lack of understanding about inquiry instruction, the complexity of the approach, and the educational significance to future educators and STEM professionals, provide justification for offering and investigating inquiry-based STEM professional development for elementary education teachers" (Nadelson, 2013, p. 159). Nadelson identifies the importance to develop inquiry-based STEM professional development opportunities for elementary educators.

Multiple definitions have served to define makerspaces. For example, Laura Fleming, an educator and best-selling author says, "A makerspace is a metaphor for a unique learning environment that encourages tinkering, play and open-ended exploration for all" (Fleming, 2016). Fleming provides a concise definition that highlights tinkering and open-ended exploration and play. Cross, another scholar, says, "Makerspaces can be defined as a space where students create self-directed passion projects, prototype inventions, and learn new skills based on their interests through collaboration and tinkering. Makerspaces are dedicated areas where soft-skills can be cultivated." (Cross, 2017, p. 3). Cross identifies the importance of this space incorporating student-directed learning that cultivates skill development. In connection, Doorley explains how "Tinkering is all about process…at its core, tinkering begins with this kind of problem solving and a curiosity about how something works." (2017, p. XII). Throughout these three definitions, there is a sense of student-directed freedom in exploration and collaborative problem-solving. It is through these processes that students develop skills.

In *Timeless Learning (2018),* Socol, Moran, and Ratliff warn against reducing the work done in makerspaces to a small definition which may limit its scope. Instead, they refer to the work in makerspaces and tinkerlabs as "organic learning" (p. 56). The nature of the work in these spaces changes the role of the teacher from being a director of learning to a "kidwatcher." It is a place where "teachers dig deep into not just what kids are supposed to learn but how and why they learn" (p. 57). They refer to makerspaces as "part of an ecosystem of spaces where people are doing work that engages all kids and promotes the flexible use of time" (p. 211). Socol, Moran, and Ratliff introduce the importance of flexibility when engaging students in makerspaces. Time is one factor that needs to be flexible. In the vein of being flexible, I propose the idea of moving these spaces outside to add to the learning ecosystem of spaces available for students to learn.

The idea of organic learning is one of the roadblocks that teachers have in taking students outside to learn. They are conflicted with allowing students freedom to discover because of their tendency to control and constrain activities. With this intervention I seek to lessen this tension for teachers by broadening their understanding of the purpose of makerspaces as places to allow students to engage in loose and unstructured learning. It is in these ways of engagement that students develop an appreciation for nature and learning. “It takes time--loose, unstructured dreamtime -- to experience nature in a meaningful way.” (Louv, 2008, p. 117).

Outdoor Learning

> *Unlike television, nature does not steal time; it amplifies it....Nature inspires creativity in a child by demanding visualization and the full use of the senses.* (Louv, 2008, p.7)

Nature is one aspect of the learning environment that has become underutilized in developing STEM skills in students. The focus on developing high tech skills, requires “clean” spaces for students to use technology. This pull to have students inside, contributes to what Louv calls “Nature-Deficit Disorder” (Louv, 2008). Louv claims that children are stripped of the gift of being outside. They miss out on outdoor experiences the older generation took for granted. This has caused a figurative and literal separation between people and the environment.

Increasing indoor sedentary activities for children has led to problems for our students. Tai et al (2006) say “many [children] find the allure of technological entertainment indoors more appealing than active play outdoors in these manicured, homogenized environments, which further decreases their activity levels... this decline in exercise compounds child health problems" (p. 14). Further, Schilhab (2017a) found that in schools adopting a one-to-one correspondence between students and digital devices, students opt for more sedentary activities during break times. Schilhab et al. (2018) explains how this fixation on digital devices has had an impact on student learning that needs to be counteracted with nature. "We suggest that exposure to a natural environment or natural stimuli, may be seen as a useful and relevant intervention strategy to counteract the effect of exhausted cognitive capacities associated with overuse of smart technology" (Kuo 2018, p. 78).

The benefits of spending time outside with students have been well documented. These benefits range from social and emotional affects to improved learning opportunities. Chawla et al. (2014) highlights benefits of being outside for students including stress reduction, increase in resiliency, and balanced emotional wellbeing. Agostini et al. (2018) echoes this sentiment saying "Teachers planning appropriate and creative use of the outdoors, in fact, support the promotion of children's well-being and mental health" (Kuo 2018, p. 135). In addition to these benefits, studies have also shown that outdoor learning provides opportunities for deep and complex learning (Banning & Sullivan, 2011). Nature provides "the most open-ended experiential universe possible, supporting all of the physical, social, and psychological dimensions of development. It is the source of dynamic perceptions that stimulate thought and build knowledge" (Moore, 1997, pp. 10-11).

Benefits have also been documented for adults. In her article on highlighting benefits of integrating nature into libraries and community spaces, Rodgers says:

> The benefits of exposure to nature are much more than cosmetic: for individuals, research has related it to reduced stress, inflammation, and mortality; improved memory, job satisfaction, and eyesight; and greater social capital. For communities, successful public outdoor spaces not only improve the physical and mental health of residents, they have been shown to aid the environment, create a stronger sense of community, and even boost the economy (2017, p. 26).

Additional research has proven that greater quantity and closer proximity to natural spaces at home and school improves children's cognitive performance (Dadvand et al., 2015) and reduces the occurrence of behavioral issues (Markevych et al., 2014).

The Institute for Outdoor Learning serves as a hub for compiling evidence to support outdoor learning. They provide published articles and evidence briefs to summarize the relationships between the natural environment and a myriad of outcomes. One focus outcome has been on using nature to improve wellness in people of all ages. In an evidence briefing linking being outside to mental health benefits, they highlight studies showing positive outcomes in regards to attention, anger, fatigue and sadness (Bowler et al., 2010, Thompson Coon et al., 2011), greater levels of positive affect and lower levels of negative affect in regards to emotion and mood (McMahan & Estes, 2015), and physiological stress (Haluza et al., 2014). In addition, they report that "there is generally positive evidence relating to the impacts of activities in natural environments on children's mental health and their cognitive, emotional and behavioural functioning"

(Lovell 2016, p. 2). All of these sources of research point to the need to focus on getting kids outside.

The benefits of nature are clear but what about harnessing these benefits to directly target the problems we are seeing in today's society. Kuo and Jordan (2019) compiled a group of research articles to support their argument that nature can be identified as a means for students to learn and develop. They recognize the benefits of nature and advocate using nature to combat the problems we are seeing with our students in today's classrooms. Recent nature studies "raise the tantalizing potential of identifying low-cost ways to address major societal challenges: boosting academic achievement, reducing the achievement gaps between different ethnic and socioeconomic groups, and countering the rise in various mental and physical disorders" (p. 4). This idea changes the perspective that nature simply provides benefits for our students but argues that it can be used as a tool boost achievement and counter mental and physical disorders. This shift in thinking is supported by research that has been done to expand our thinking on how children experience nature. Amicone et al. (2018) discusses how interaction with nature results in cognitive and academic benefits for students, including language development. Other studies have shown further evidence that nature provides high student engagement and reduction in disruptive behavior among students (Szcytko et al., 2018) and may improve standardized test performance (Kuo et al., 2018). Barfod & Daugbjerg (2018) have concluded that green outdoor settings can result in opportunities to support student-led, inquiry-based instruction. These studies show expanded potential benefits when students spend time in or even around nature.

A movement of teachers are capitalizing on the current changing educational culture to take students outside during the school day for learning, exercise and overall wellness. They see benefits in nature igniting wonder in their students. Students can be found outside in natural spaces planting and tending gardens, reading and writing in outdoor classrooms, and doing citizen science projects. The outdoors provides a seemingly unlimited supply of materials for students to discover, question, and create. Being outside exudes a sense of being free and encourages deeper sensory experiences in which students can use take risks and explore. When students can experience learning opportunities with their senses, they are more apt to construct knowledge that will stay with them (Louv, 2008).

In *Education and the Environment* (2013), Lieberman makes a connection between the changing educational times with the current environmental problems. He states:

> It is not mere happenstance that we are hearing about these issues simultaneously, for, ultimately, both education and the health of the environment are related to the growth of human societies and many human-driven changes that have taken place across Earth over the past few years. (p. 11)

The challenges we face in both the natural environment and human civilization are interlaced. Lieberman argues that the intersection of these two ideas provide deep and rich opportunities for learning. Outdoor makerspaces provide space for students to interact with both natural and social systems in order to solve real time, relevant problems while developing skills needed to prepare them for future endeavors.

Developmental Psychologist Howard Gardner, known for his work in multiple intelligences, has also identified the importance of providing learning opportunities for students in outdoor environments. In 1983, he developed the theory of multiple intelligences. Believing that traditional IQ tests were limiting when identifying intelligence, his theory identified multiple ways of identifying intelligence. Originally, these were composed of seven intelligences including: linguistic intelligence, logical-mathematical intelligence, spatial intelligence, bodily-kinesthetic intelligence, musical intelligence, interpersonal intelligence, and intra-personal intelligence (Gardner & Ebrary, 1999). Realizing that his original list was incomplete, Gardner later added naturalist intelligence, the eighth intelligence. Since his proclamations of multiple intelligences, educators have been encouraged to create lesson plans to meet the needs of their diverse learners based on intelligence, including learning opportunities for those who connect best with nature.

Outdoor spaces are not only important for those who have a naturalist intelligence. Nature provides fodder for all students to develop skills required for constructing knowledge. They can develop an understanding of cause and effect by observing what happens after snow melts. They can search for evidence of what creatures may live in their area. They learn to ask questions, communicate, collaborate, and critically think to solve mysteries they are faced with in nature. They can build physical strength as they navigate uneven ground in wild spaces. Outdoor spaces ignite wonder in students and give them "an opportunity to develop and apply higher-level thinking and problem-solving skills" (Lieberman, 2013, p. 60).

The nationwide focus on teaching STEM skills and processes provides for opportunities and challenges at elementary grade levels. Opportunities include student's excitement for learning and their strong desire to engage in STEM activities. Challenges include teacher's lack of knowledge and confidence in providing quality STEM activities and the lack of understanding about the benefits of outdoor learning. Meeting the needs of elementary teachers requires ongoing professional development opportunities for teachers to build knowledge in STEM education (Tai et al., 2006).

Experiential Learning

Dewey's *Experience and Education* explains how learning happens through reflecting on personal experiences (1938). Dewey outlined principles of cooperative, democratic environments that focus on an interactive and iterative process where students and teachers learn from experience. Dewey said "Give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking; learning naturally results" (Crookall & Thorngate, 2009, p.11). Dewey understood that to engage students in learning, they needed to be engaged in hands-on activities. "There is an intimate and necessary relation between the processes of actual experience and education" (Dewey, 1938, p. 6). Although I agree with Dewey's assessment that we need freedom and hands-on learning to be brought to the classroom, we need to take this to the next level. Hands-on experiential learning is only the first step, we also need to ensure these experiences are meaningful and relevant creating student-led experiences that are connected to local and global context. Rogers (1969) describes experiential learning in terms of the learner. In his interpretation, Rogers' beliefs about experiential learning identifies the learner as an active initiator, evaluator, and participant in the process (Rogers, 1969). This student-led approach to experiential learning had roots in earlier research done by Maria Montessori.

Montessori (1912), one of the trailblazers of student-led constructivist learning, took experiential learning a step further. Not only did she believe that students learned best by doing, she believed that teachers learn best from students when students are allowed to make their own decisions about learning. Students should not be repressed by assigning them to a desk and observing them like "pinned butterflies," but instead students should be allowed to make choices in their learning. "The school must permit the free, natural manifestations of the child if in the school scientific pedagogy is to be born. This is the essential reform" (Montessori, 1912, p. 15). Montessori was a big proponent of children using tools and materials to build as part of the learning process. The importance of the teacher's role is also reflected in Hoagland's work. Hoagland (2000) states that the critical importance is not the teaching but rather the learning that takes place in this approach. This changes the role of the teacher from being an imparter of knowledge to more of a facilitator of experiences (Hursen, & Soykara, 2012).

As we look at the role of the teacher in providing constructivist, experiential opportunities for students to learn, it is important to look at student learning around science. Agranovich & Assaraf (2013) worked specifically with students in grades 4-6 to determine what makes children enjoy learning science. Overall, student's attitudes toward science were positive, they ranked science as their third favorite behind sports and math. Boys ranked science their second favorite and girls ranked it their third favorite. Student interest in science waned if there was only discussion and reading in text books. More girls than boys enjoyed science experiments. The study concluded that self-efficacy and hands-on experimentation are essential in positively engaging and motivating students in science. Girls specifically, needed hands-on activities and they needed to see a connection to the real-world application in order to be highly engaged (Agranovich & Assaraf, 2013). Other studies showed that when technology and engineering teachers integrated authentic activities for engagement, both males and females were more interested (Mitts & Haynie, 2010; Weber & Custer, 2005). For students to learn more effectively and efficiently, we need to provide students with authentic and purposeful ways for them to engage in the learning process.

To further explore factors that influence elementary teachers in providing experiential or inquiry-based science opportunities for their students, Loesing (2014) highlights the importance of exposing students to science. In her study of "Factors that Affect Elementary Teachers' Ability to Conduct Inquiry-Based Science Instruction," Loesing points out the importance of providing students the time and space to encounter scientific concepts. She says that if students do not spend time on scientific topics during the elementary years, chances are, they will never be able to catch up. Loesing provides evidence that elementary students should especially encounter science using an inquiry approach. It is these early experiences that future scientific understandings are built.

In summary, an experiential, constructivist approach to learning requires a hands-on student-led approach in deploying activities. Using a local context in order to connect learning to real-world application is essential as students form and interpret meaning.

Using a local context seeks to give purpose and meaning to guided and student-led open inquiry opportunities. This intervention provides teachers the opportunity to learn through experiencing an outdoor makerspace in order to better understand how to develop STEM skills in their students and to increase the likelihood they use outdoor spaces, authentic landscapes, with their students.

Constructivist Approach to Research

The constructivist approach was not only used in the creation of this intervention but also in the interpretation of the data. The research supports continued efforts to develop elementary teacher's experience with and understanding of developing STEM skills with their students. New opportunities to do this in outdoor spaces has presented itself and is worthy of study. This study seeks to research the effects of a professional development activity on influencing teacher's likelihood of using outdoor spaces and on teacher's knowledge of developing STEM skills in students.

Since the idea of using outdoor makerspaces as a tool for teachers to develop STEM skills in their students is not well documented, the overarching idea for this study is for me to be a constructivist surrogate to describe experiences for those not able to experience this problem of practice within this situation and containing all the perspectives it affords. In the article, *Naturalistic Generalizations* (1982), Stake and Trumbull describe how educators can use naturalistic generalizations in order to generalize studies to other groups that may not have the benefit of experiencing a change or innovation for themselves. Stake and Trumbull say:

> The vicar is a substitute, performing a service for those not well placed to perform for themselves. The naturalistic researcher observes and records what readers are not placed to observe for themselves, but who, when reading the descriptive account, can experience vicariously the various perplexities. (p. 3)

As a teacher researcher, I am situated in a unique position to glean information from this study. Therefore, this study provides that vicarious experience for other educators looking to learn about how an outdoor makerspace professional development opportunity influences the likelihood that teachers take students outside for learning. In addition, I have interpreted what I experienced for those seeking to study outdoor makerspaces to develop STEM skills in teachers and students.

CHAPTER 3

METHODS

In this chapter, the methods of the study will be described. These methods include the role of the researcher, description of participants, description of the intervention, instruments that were used, the procedures and limitations of this study.

Role of the Researcher

As the researcher of this study and teacher to all students at the school, I had unique positioning to support and train both teachers and students before and during the intervention. All students had prior experience using the Outdoor Makerspace during engineering class, so they were familiar with the landscape as well as the expectations of being outside for instruction. This familiarity with tools and processes of being outside, supported teachers as they took students outside for learning. I was available for teachers in order to support by answering questions and to co-teach during the times they took students outside. This availability was scheduled 12 mornings August through October. In addition, I sent weekly email correspondence that included ideas for participants to engage students in outdoor learning (see Appendix E for these resources).

As the researcher, I recruited participants to take part in the study by having conversations about what the process entailed and what it offered them as instructors. The recruitment process happened during the time of the hands-on outdoor makerspace activity. After participants were recruited, I collected pre-intervention data using google forms (see Appendix A). Directly after, the hands-on portion of the intervention was implemented (see Appendix D). During the intervention, I made some observations of participants and collaborated with them to tweak the intervention to make changes on the fly. These observations were kept in a journal that was used in data analysis. Finally, I collected post-intervention data using google forms and by performing a semi-structured group interview (see Appendix C). As a teacher at the school, I had a chance to support teacher learning along the way by answering questions and providing resources.

Participants

Participants for this study were recruited from a pool of teachers working at a public elementary school located in the suburbs of Denver, CO. I ensured I had good representation from all grade levels, a mix of new and experienced teachers, both male and female educators, and teachers that are quick to adopt innovation and those that may be reluctant. Participation in this intervention was voluntary.

Intervention

The Outdoor Makerspace intervention included a professional development module that gave elementary teachers hands-on experience using an outdoor makerspace (see Appendix D). This experience was provided in hopes of increasing their knowledge of building STEM skills in students and to increase the likelihood of using outdoor spaces for learning. In preparing this intervention for teachers, I used instructional requirements to support the IB, national recommendations as well as prescribed attributes of STEM education (Morrison, 2006).

The IB requires an inquiry-based instructional model to support student learning. This intervention included task cards to provide both a guided and open inquiry activity to model two different ways of providing opportunities for students. The task cards were created so that teachers could take them and have at least two activities to use with their own students. Recommendations from the National Academies of Science (2019), say that "professional development leaders should provide teachers with the opportunity to learn in the manner in which they are expected to teach, by using *Framework*-aligned methods during professional learning experiences" (p. 7). The *Framework for K-12 Science Education*, created by the National Research Council in 2011, suggests that teachers situate their lessons in local context that are meaningful for students in order to develop critical thinking skills, increase the ability to ask deep questions, and to practice refining ideas collaboratively (p. 10). This intervention was created with these points in mind. Teachers experienced an outdoor makerspace activity as students would and were then given opportunity to collectively refine ideas through reflection. Reflection was done collectively during the outdoor makerspace activity in a verbal format and then required after each of the outdoor learning sessions in which teachers took students outside (see Appendix B). A final reflection was done during the post-intervention assessment and then collectively during the semi-structured group interview (see Appendix C).

In addition, STEM education attributes were followed to ensure that necessary structures align with STEM best practice. Morrison (2006) recommends multiple structures to ensure quality instruction. Among his recommendations are:

- Innovation and invention highly prized in all student engagement
- A culture of questioning, creativity and possibility
- Active and student-centered
- Equipped to support spontaneous questioning as well as planned investigation
- Center for innovation and invention
- Equipped with small hand tools or makerspace
- Supportive of teaching in multiple modalities
- Serves students with a variety of learning styles and disabilities

These characteristics guided the development of task cards for this intervention. By providing two different task cards, this intervention allowed for choice, teacher-centered learning opportunities, and a focus on multiple modalities of learning. One task card focuses on a guided inquiry approach and the other focused on an open inquiry approach. Multiple task cards provided opportunity for smaller group work experiences that encouraged more opportunity to reflect and allow for spontaneous questioning. Providing tools and materials in a makerspace promoted an environment for innovation and invention in which a variety of learning styles could be accommodated.

A free time to tinker was also an option that teachers could choose which helped them to understand an open inquiry approach to learning. In Advancing Engineering Education in P-12 Classrooms, Brophy et al. (2008) states that "Learning engineering requires identifying opportunities to conceive of something new, comprehending how something works, and researching and applying knowledge to construct something novel and appropriate for others" (p. 384). Free tinker time was constructed to do just that.

Allowing time and space to discover interests, discover new and interesting phenomena, and practice using skills to construct with tools gave participants the practice they needed to move toward mastery learning. In their recommendations for future study, Weber & Custer (2005) also recommend providing time and space for students to practice STEM skills. They point out gender-based preferences that need to be accounted for when developing activities. Females specifically flourish engaging in “design activities [that] include a focus on problem solving or socially relevant issues” (p. 60). This intervention was pursued to provide experiential learning to encourage teachers to explore how to engage students by allowing them to direct their own learning in an outdoor space.

The intervention included:

Part 1: A pre-intervention assessment followed by 45 minutes of directed hands-on time working with tools in the outdoor makerspace (the hands-on portion is detailed below).

Part 2: At least three, participant directed outdoor learning sessions with their students, followed by a reflection of their experience (see Appendix B).

Part 3: A post-intervention assessment followed by a 30-minute semi-structured group interview to reflect on outdoor learning experiences and to dictate next steps (see Appendix C).

This exploratory intervention, although seemingly limited and small in its ability to influence long lasting change, is merely the first step in engaging teachers in an outdoor makerspace activity. The results of this inquiry are valuable in understanding how to construct ongoing professional development opportunities to develop STEM skills in outdoor spaces. Mertler and Charles (2011) “suggest that we usually consult sources for answers that are most convenient to us and with which we are most comfortable; however, these sources have the potential to be fraught with problems" (p. 5). Since the development of the outdoor makerspace intervention have been primarily composed of my own ideas with resources convenient and most comfortable to me, I need other perspectives to give feedback to vet the strategies and activities I am offering. By gathering teacher feedback on this professional development opportunity, I can inform future professional development as well as reflect on my own practice in order to make improvements.

The story of the intervention.

Intervention part one. The first part of the intervention, giving teachers time in guided and open inquiry experiences working with tools in the outdoor makerspace, took place during a regularly scheduled staff meeting. Before the session, participants used a google document to reflect on their perceptions of taking students outside for learning (see Appendix A). The google document was used as a reflection tool before, during and after the intervention.

The participants were then shown a google presentation (see Appendix D). The slide presentation explains the purpose for taking students outside to develop STEM skills, shows the Design Thinking process, and explains the Nature Scene Investigator protocol from the Lawrence Hall of Science program called Better Environmental Education, Teaching, Learning & Expertise Sharing (BEETLES, 2019).

Participants were asked to get in small groups of 2-3 and given a biodiversity scavenger hunt (see slide five of the presentation). Participants were taken outside and given four minutes to check off as many of the boxes on the scavenger hunt as possible. This activity was meant to better acquaint participants to the outdoor space and to trigger background knowledge of scientific topics of study. After four minutes, participants were asked to form a circle and asked “in this activity, what did you notice?” Participants were given time to discuss how they reacted to the scavenger hunt, how they saw themselves using the activity with their own students, and to identify what changes they would make. Photos in Figure 1 show participants engaged in the scavenger hunt activity.

Figure 1

Scavenger Hunt

Photos show participants interacting with nature and each other during the scavenger hunt.

After the scavenger hunt, participants took part in the Nature Scene Investigator Protocol (Lawrence Hall of Science, 2019). For this protocol, participants were asked to form two concentric circles, with the inner circle sitting around a bucket and the other circle standing behind them. The participants were given roles during the protocol. The participants in the inner circle were asked to make observations of what was under the bucket and the participants in the outer circle were prompted to ask questions. When participants were in place, the bucket was removed to reveal a bird's nest and a paper wasp's nest. After a few minutes of listening to participants questions and observations, the roles were switched so that the inner circle asked questions and the outer circle made observations. When there was a lull in discussion, participants were asked what they noticed about participating in the protocol. Figure 2 shows participants engaging in the protocol.

Figure 2

Nature Scene Investigator Protocol

Photo shows two concentric circles of participants asking questions and making comments about the two mystery objects in the center of the circle.

Next, teachers chose from two different task cards to direct their learning in the outdoor makerspace. The task cards were comprised of a guided inquiry activity and an open inquiry activity that detailed instructions and tools to interact with the space. The purpose of the pre-determined task cards was two-fold. First, the cards offered structure to teachers who felt overwhelmed or uncomfortable about engaging in learning tasks in an outdoor space. Second, the task cards were created to model how outdoor makerspace tasks can be presented to students. During this outdoor task, all participants were able to use materials provided on rolling carts in the outdoor makerspace. Materials included: squirt bottles, shovels, hammer, nails, buckets, PVC pipes, tires, tubes, outdoor backpacks (i-Pad, magnifying glass, binoculars, gloves, tweezers, and specimen jars), and recyclable building materials.

Tasks included:

1) How can you use natural materials to construct a bird's nest?

2) Free time to tinker

Task Card #1: Guided Inquiry

How can you use natural materials to construct a bird's nest?

Participants choosing task #1 received these instructions: "First, examine the bird nests to understand how birds construct from natural and found materials. Discuss with a partner/team what materials you want to build a nest with, then gather your materials from nature. Finally, use the collected materials to construct a nest. Reflect on the process."

Task Card #2: Open Inquiry

Free time to tinker

Participants choosing task #2 had access to all tools, outdoor makerspace carts, materials in nature, and nature journals. Instructions included: "Use this time and space as an opportunity to tinker in nature and explore new and interesting phenomena. Reflect on your learning and record questions you have."

All participants chose the guided inquiry activity of building a bird's nest out of natural materials. Photos of the nest prototypes are pictured in Figure 3.

Figure 3

Nest Prototypes

These nests were built by participants using natural materials found on campus.

After participants completed their assigned task, they were gathered in a circle to discuss their thinking about the activity. They were asked "what did you notice?" and "What could you change?" After a brief discussion, participants were taken back inside to finish watching the rest of the google slide presentation. This portion of the presentation gave participants examples of how outdoor learning has been used to develop STEM skills in elementary students. After the presentation, participants were asked to reflect on how they could use outdoor makerspaces in their own context. They used sticky notes to write ideas, then posted them on a chart paper that was shared with the group.

Intervention part two. The second part of the intervention took place after the hands-on portion. Participants were asked to commit to take students for up to three outdoor learning sessions. They used an online google form to record what they did in each session and reflect on their perceptions of the experience (see Appendix B). Participants were encouraged to take photos of their activity in order to better reflect on their experience. The researcher was available to support participants during some of this time by co-teaching, answering questions, and providing resources. The researcher scheduled twelve days, 9:00 am – 1:00 pm, to support participants during the intervention cycle. Participants were able to sign up to discuss or co-teach outdoor learning activities, watch a modeled lesson, or ask questions about outdoor learning opportunities. In addition, participants received weekly emailed Outdoor Learning Ideas to use with their students (see Appendix E). These resources were stored in the google classroom and accessible to participants throughout the study.

Intervention part three. The third part of the intervention, a post-intervention assessment followed by a 30-minute group interview to reflect on experiences and to dictate next steps, took place after participants had completed their outdoor student sessions (see Appendix C). Although I provided two opportunities for the participants to attend a group interview, all but one participant attended the same session. One participant was unable to attend.

Instruments

The research plan integrated multiple approaches to understanding how the professional development intervention influenced teacher preparation in developing STEM skills in students and the likelihood that they would use outdoor spaces for learning opportunities in the future. This influence was assessed by comparing teacher reflections before, during and after the intervention. I used journaling, a semi-structured group interview, and photos as a means to collect and evaluate data.

Journals. Teacher journals were used to evaluate teacher perceptions of Outdoor Learning and STEM skill development using outdoor spaces. Journals were provided in a google form, in order to allow participants to reflect after each of their outdoor experiences. Journals included prompts, but also served as a free space for teachers to reflect on their learning experiences before, during and after their Outdoor Makerspace activities. In addition to teacher journaling, I kept a reflective journal, as the researcher, to document my thinking and observations along the way. This reflective journal provided a place to reflect on the process and to have another perspective as I analyzed data.

The use of journaling is used in social research for various reasons. There are multiple types of journals that can be used to collect data in social research including: observation journals, methodological journals, theoretical journals, analytical journals and personal journals (Allen, 2017). For this research project, I used an observation journal, or field notes, to observe and record detailed notes of the participants during the intervention. The participants used a google document as a personal journal to reflect on their personal experiences.

Observational journals. Observation journals, or field notes, played an important role in the data collection process by offering opportunity to triangulate findings. I used a recording device to collect my real-time observations as they happened. Since we were outside and I needed to be available for teacher questions during the time of my observations, this tool ensured that I could still make observations during this busy time. These recorded observations were transcribed and marked as a Real Time Observation (RTO) before any additional coding occurred. In addition, to recording my RTOs, I allowed for time immediately after the intervention to record my observations while they were still fresh in my mind. To increase the validity of my field notes I strove to achieve the rule of thumb amount of 10 double-spaced pages for every hour of observation (Allen 2017, p.2) and record observations using all of my five senses knowing that no detail is too small or insignificant. I paid specific attention to impressions of the situation including the mood and limiting factors.

Reflective journals. Since reflective journaling is often used in the field of education as a means of development (Coghlan & Brydon-Miller, 2014), I used it as a means for participants to reflect on their experience in order to further professional knowledge of using outdoor spaces as a tool to develop STEM skills in students. Researchers find that "the value of journaling in action research lies in the reflective process that encourages a deeper self-awareness and confidence in oneself through extending personal and professional insights. Ideas can be 'debated' and new approaches trialed on the page" (Coghlan & Brydon-Miller 2014, p. 3). Taking students outside carries with it feelings of apprehension for teachers. Journaling and the reflective process may give participants time and space to work through these feelings of apprehension in order to construct a more positive understanding of outdoor learning. In this intervention, journaling was used as a tool to increase the likelihood that teachers will want to take their students outside to develop STEM skills in the future.

The participant reflective journals were a space for participants to openly reflect on their feelings, thoughts, apprehensions, and celebrations. Participants were able to journal, post photos, and reflect on their experiences in order to construct an understanding of using an outdoor makerspace. There were no restrictions around what could be recorded in these journals except that they needed to answer the prompts both before and after the intervention (see Appendix A, B, & C).

Semi-structured group interviews. I offered two semi-structured group interviews to allow participants time to reflect on their experiences. My goal for conducting these interviews was to gain deeper insight into participant perceptions toward taking students outside for learning opportunities and to dig deeper into their understanding of the connection between nature and developing STEM skills. Although I offered two group interviews, all but one participant attended the same interview. One participant was not able to attend. Questions for the semi-structured interview can be found in Appendix C.

Kvale and Brinkmann (2015) say that the “qualitative research interview attempts to understand the world from the subjects’ point of view, to unfold the meaning of their experiences, to uncover their lived world prior to scientific explanations” (p. 3). Uncovering and understanding the perspective of the participants was critical in understanding why they chose to or choose not to do something. This is a relevant point as I sought to find out if participants were more likely to take students outside based on participation in this intervention. Likelihood is a complex concept that incorporates beliefs and feelings used in decision making. The qualitative interview was the tool I used to better understand these beliefs and feelings in order to know how to proceed in encouraging participants to use outdoor spaces in instruction.

Semi-structured group interviews are interviews conducted with multiple participants that follow a flexible structure in order to obtain information. The flexible structure allows the researcher to have a plan in order to start asking questions, but then allows for deviation from the plan in order to pursue unexpected lines of information that may arise. A group dynamic, as opposed to a one-on-one format, allows for a ‘dialogic spiral’ where participants can build on one another’s thoughts and ideas (Paris & Winn 2013, p. 31). This group technique can be valuable when participants may need support in building understanding around a certain concept that may be new like outdoor makerspaces. As in most group interview settings, the focus of the interview was to “bring forth different viewpoints on an issue” (Kvale & Brinkmann 2015, p. 175).

Photos. Photos were used to capture the learning of teacher participants during part 1 and part 2 of the intervention. During part 1, the researcher took photos of the participants engaging in the 45-minute session of directed hands-on time working with tools in the outdoor makerspace. The photos were taken to capture a visual representation of how teachers interact with the environment and to show the products that were created. In part 2 of the intervention, where teachers took their students outside for learning, photos were encouraged to be taken by the participants to help in the reflective process. These photos were not used by the researcher, but by participants to communicate classroom activities with parents, as reflective tools in the classroom for students, and some were sent to the researcher to give a visual voice to outdoor activities. In addition, photos were used to analyze the amount of nature present on the two campuses. Research has shown that the amount of natural space students are exposed to can impact the amount of benefit that results. Landscape photos were analyzed for this purpose.

Qualitative inquiry allows a researcher to use unique ways of gathering data to understand participants lived experiences. Photos are one way to do this. Fischman (2001) believes that educational research may have created a "blind spot" in understanding by neglecting to use visual culture in its inquiries. He explains:

> In the matrix of the visual are also inscribed what is there that cannot be seen, through what lenses the visible and invisible become intelligible, and the spatial and temporal location of the observable and the observer, all of which constrain what is possible to see and not to see. (p. 29)

It is the researchers goal to uncover the unseen in order to better understand participants lived experience.

Photos were used as a visual inquiry into how teachers experience the intervention. When working outside, it is important to capture photos that clearly depict the relationship between participants and nature. A photo can tell the viewer about the comfort level of the participant, the emotional state of the participant or how the participant is interacting with their surroundings. Photos were used to glean information about the interaction between the participant and nature that might be difficult to capture in a narration.

> Working with photos is often conflated with only looking at images; looking is very important though often done poorly. However, the scholarly value of photos is heightened when researchers work with them in more diverse ways: to generate questions; to stimulate memory; engaging with sensory and affective experiences of, and responses to, photos ('feeling your way'); playing with images. (Tinkler 2014, p. 15)

Researcher generated photos were analyzed to look specifically for emotions of participants when taking part in the hands-on portion of the intervention as well as participants comfort levels with nature identified by proximity to natural spaces.

Procedure

The procedure for this dissertation cycle of research entailed getting permission from my district, recruiting participants, collecting pre-intervention assessment data, implementing the intervention, and collecting post-intervention assessment data. Before I started recruiting participants for this cycle, I received permission from my building principal and district personnel. I did this via face-to-face and email conversations explaining the scope of the research. I obtained signatures from the necessary people to approve the process.

Recruiting participants occurred via face-to-face interactions with staff. I spoke with them about the process and offered permission forms to be signed in order to participate. After permissions were collected, I sent out the pre-intervention assessment. Google forms were used and pushed out to teachers to ensure anonymity during the process. After pre-intervention assessment data was collected, I implemented the intervention. Teachers took part in the intervention during a regularly scheduled staff meeting. Pictures were taken throughout the intervention in order to capture the process and to document final products. Participants then had three months to engage their students in three outdoor learning opportunities and to reflect on their experiences using a during-intervention reflective form. This form was also provided through a google platform. Finally, post-intervention data was collected through two data gathering techniques, a post-intervention assessment and a semi-structured group interview. The interview was recorded using an audio recording device. Data was collected and analyzed using HyperResearch. Table 1 delineates the timeline that was used for the intervention.

Table 1

Timeline and procedures for the study

Time Frame	Procedure	Notes
April 2, 2019	Dissertation proposal defended	Chapter 1-3 was presented to gain approval for this cycle of research.
April	Gained permission from building and district leadership.	This was done via face-to-face and email conversations. Necessary signatures were obtained.
August	Recruited participants and collect appropriate forms for research	Introduced teachers to the opportunity and collected permission papers from all interested.
August	Collected pre-intervention data for dissertation research	Pre-intervention data was collected via google forms.
August 2	Implemented intervention	Intervention was implemented during a regularly scheduled staff meeting.
August 2-October 29	Participants took their students outside for at least 3 lessons in the outdoor makerspace	Researcher supported participants with weekly email ideas, time to meet and collaborate, and modeled lessons.
November 11	Collected post-intervention data	Post-intervention data was collected via google forms as well as through a group interview.
November-December	Analyzed data	HyperResearch was used to analyze data.

Limitations

A responsible researcher must consider the limitations of doing an action research project with such a distinctive group of educators in order to inform her practice. Since the researcher was a classroom practitioner during this investigation, there were limits to the accessibility of participants. Only the teachers working at the two buildings, where the researcher worked, were invited to take part in the intervention. This limited both the number of participants and the diversity. Although this limited the number of participants, it represents a practical number, under the circumstances, in order to gain a basic understanding of how the professional development opportunity changes the likelihood of teachers taking students outside.

Another limitation that may exist is the veracity of the data collected. The researcher, having built relationships with participants over a five-year period, may have implications when asking participants to share honest thoughts and perceptions of their own learning. Some participants may feel because of the relationship with the researcher, that negative reflections should be down-played to preserve the friendship. The opposite is also possible. Positive responses may be exaggerated to show support.

CHAPTER 4

DATA ANALYSIS AND RESULTS

The purpose of this study was to explore the potential relevance of an outdoor makerspace professional development intervention to strengthen teachers disposition to engage students in outdoor learning activities to develop STEM skills. This chapter provides the findings of this investigation. A description of data analysis will be discussed then results will be described. Results are presented in two sections. First, results from the pre-intervention and post-intervention assessments are compared, then claims are presented and supported using data.

Data Analysis

This study integrated multiple approaches to understanding how the professional development intervention influenced teacher preparation in developing STEM skills in students using outdoor spaces and, in the likelihood, that teachers use outdoor spaces for learning opportunities in the future. The likelihood was assessed by evaluating pre-intervention and post-intervention assessments. Participant reflective journals, or during-intervention assessments, were used to gather information during the intervention. The reflective journals asked participants to record what activity they did with their students as well as to reflect on their time outside, specifically what surprised them and what they learned. Researcher fieldnotes, a semi-structured group interview and researcher generated photos were also used to explore the research question. The pre-intervention and post-intervention assessment were directly compared to glean information about the tendency for the intervention to influence the likelihood of teachers taking students outside. In addition, participant comfort levels for teaching STEM using outdoor spaces were compared pre-intervention to post-intervention in order to determine if there was a change.

There were originally 30 participants signed up to complete the intervention. Out of the 30 original participants, 20 completed all three parts of the intervention including the hands-on portion (including a pre-intervention assessment), taking students outside for learning at least three times (and reflecting on their experiences in a during-intervention assessment), and participation in a group interview (including a post-intervention assessment).

The data collected was analyzed using methods recommended for qualitative research projects (Mertler, 2017; Saldana, 2016). In the initial phase of coding, directly after each assessment was given, the open responses collected via the pre-intervention, during-intervention, and post-intervention assessments were uploaded into HyperResearch. Using In Vivo coding, an initial code book was formed using participant's own words. This first cycle coding method sought out elements that emerged from the data that established relevant ideas for a closer look (code books can be seen in Appendix B).

Once the first-round coding was done for each of the phases of data collection, a second round of coding was performed to identify the central/core categories (Saldana 2016, p. 56). Focused coding was used in order to restructure the first cycle data, to develop "smaller and more select list of broader categories, themes, concepts, and/or assertions" (Saldana, 2016). From these groupings, central/core categories were formed. To do this, all codes from the code book were written separately on sticky notes and then sorted into groups with similar ideas. These groups were then given labels to best identify them. The first three themes that emerged were: benefits of taking students outside for learning, reservations in taking students outside for learning, and perceptions of student response when they are taken outside for learning. This list expanded after during-intervention assessment data was analyzed to include: Teacher learned something new. It was again expanded after post-intervention assessment data was collected to include: Needs of teachers to continue outdoor learning. Focused coding was used again under the benefits, perceptions and reservations categories in order to establish a more select list of themes.

Data from the semi-structured group interview were analyzed in a series of steps. First, notes were taken of participants' responses during the interview in order to glean initial information from their responses. These notes were then expanded as the researcher listened to the interview multiple times in order to add details to the notes. Each of the interview questions served as a theme or category which was used to triangulate the data that emerged from the pre-intervention, during-intervention and post-intervention data analysis in HyperResearch. Interview transcripts were also coded using the established code book from HyperResearch.

Researcher fieldnotes were collected during the entire intervention. The analysis of fieldnotes followed a different protocol. A recording device was used to collect real-time observations during the hands-on portion of the intervention. Since the intervention took place outside and the researcher needed to be available for participant questions during the time of observations, this tool ensured I could make observations and be available to participants as needed. These recorded observations were transcribed and marked as a Real Time Observation (RTO) before any additional coding occurred. Researcher fieldnotes were gathered throughout the rest of the study in written form.

There were some unforeseen changes made during the implementation of the intervention. The participant recruitment did not go as planned. I was expecting to offer the professional development opportunity as a choice to the 42 certified teachers on my staff who chose to be part of the outdoor cohort. Out of the 42 certified teachers, I was hoping to recruit ten to fifteen participants to complete the intervention. Instead, the leaders in my building wanted to offer the outdoor makerspace intervention to all certified staff at a whole school staff development meeting. This meant that instead of holding just one 60-minute session for ten to fifteen participants, I held three 45-minute sessions with nine to eighteen participants. Because of this change, I recruited participants after I offered part one of the intervention, the outdoor makerspace hands-on portion. As a result, instead of the ten to fifteen participants I expected, I recruited 30 participants, of which 20 completed the entire intervention.

In addition to recruitment changes, there was also a change in the time I was given to do the hands-on portion of the intervention. The time for the intervention was cut from 60 minutes to 45 minutes. This cut in timeframe did not allow me to complete the entire professional development intervention that was proposed. Because of the shortened timeframe, teachers did not see the entire google presentation that was originally planned for. They missed out on seeing the slides that showed examples of how students have been engaged in outdoor makerspaces and they missed out on filling out a sticky note on how they could use outdoor makerspaces in their own context. The google presentation was shared with all participants after the hands-on portion, via a google classroom, so they could have access to all examples and resources that were not presented.

Results

Results from this study are presented in two sections. First, results from the pre-intervention and post-intervention assessments were compared to glean information specific to participant comfort levels around using outdoor spaces and developing STEM skills in students. After these results are compared and discussed, claims will be presented and supported using data from during-intervention reflective participant journaling, transcripts from the semi-structured group interview, researcher field notes, and photos.

Pre-intervention & post-intervention assessment comparison. In the analysis of the pre-intervention and post-intervention assessments, information about participants was gathered about teaching experience and perceptions about taking students outside for learning. First, information about subject taught and years of experience was compiled. This data showed that participants in the study represented kindergarten through sixth grade classroom teachers as well as a counselor and an art teacher. Among participants, years of teaching experience ranged from one year to more than sixteen years (see Figure 4).

Figure 4

Years of Teaching Experience

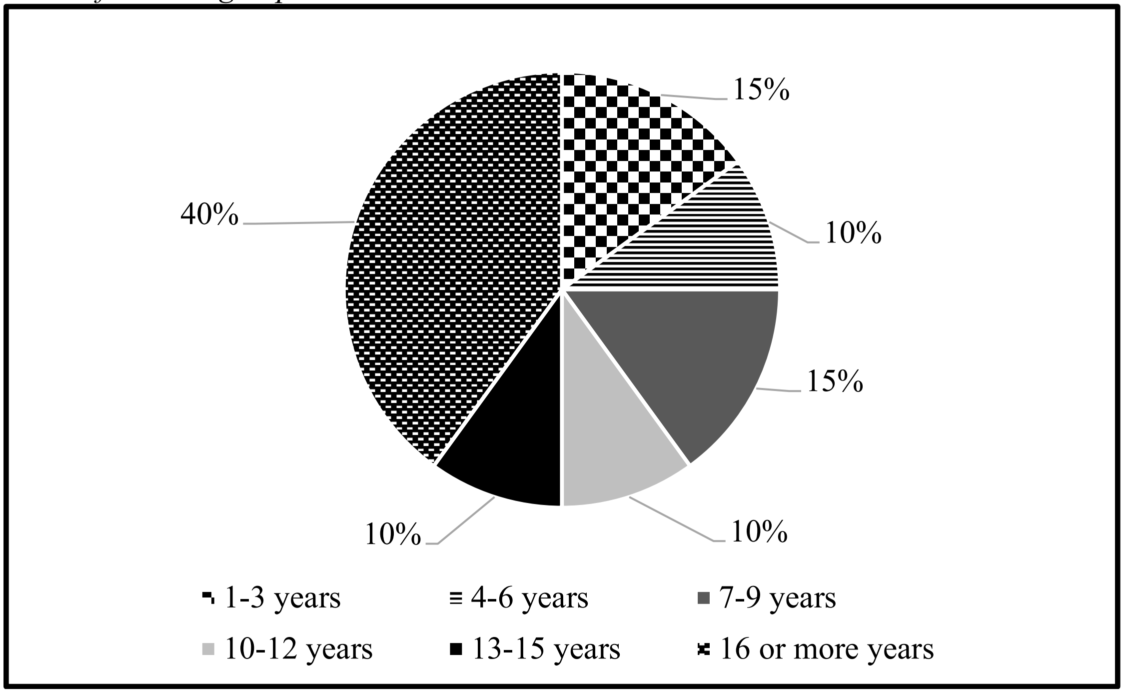
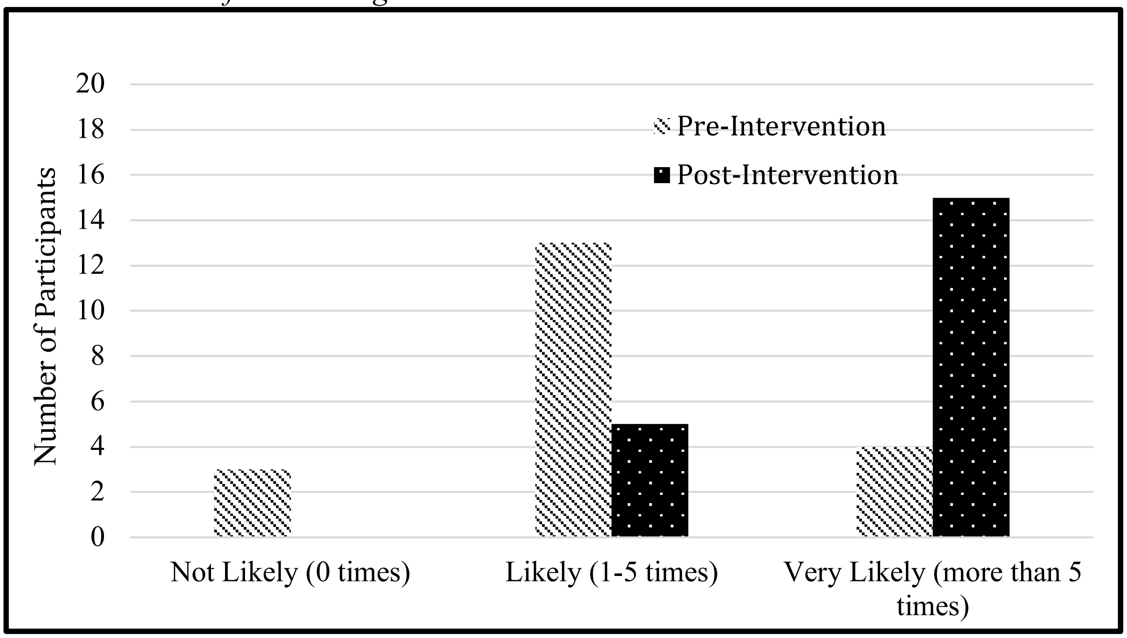


Figure 4 shows that twelve participants have ten or more years of experience and three participants are in their first three years of teaching. This data suggests that the majority of participants are experienced teachers with ten or more years' experience in teaching.

Next, the pre-intervention and post-intervention assessments employed a Likert-type scale to allow participants to rate their beliefs about their likelihood of taking students outside for learning. In the pre-intervention assessment, participants were asked: In the past, how likely were you to take students outside for learning? Participants indicated whether they were *not likely (0 times), likely (1-5 times),* or *very likely (more than 5 times)* to take students outside over a one-year period. In the post-intervention assessment, participants were asked: In the future, how likely are you to take students outside for learning? Again, participants indicated whether they were *not likely (0 times),* *likely (1-5 times),* or *very likely (more than 5 times)* to take students outside over a one-year period. Comparative responses for pre-intervention and post-intervention assessments are captured in Figure 5.

Figure 5

Pre-Intervention/Post-Intervention Assessment Comparison: Likelihood of Taking Students Outside for Learning



In the pre-intervention survey, the majority, 17 participants, responded that they were either *likely* or *very likely* to take students outside for learning in the past. Three participants responded that they were *not likely* to take students outside for learning in the past. In the post-intervention portion of the survey, these numbers jumped to 100% of participants reporting that they would either be *likely* or *very likely* to take students outside for learning. In the post-intervention assessment, none of the participants reported that they would intentionally keep students indoors for learning. Of the teachers who reported either *not likely* or *likely* during the pre-intervention, 93% moved up one category in the post-intervention to either *likely* or *very likely*. This data was further supported by comments made by participants in the post-intervention assessment. When asked what expectations participants had about using an outdoor makerspace in the future, participant 1 stated "I'm excited to finish the activity we started and follow through the seasons and connecting that to the temperature patterns. I'm excited about doing other lessons outside as well." Participant 16 responds by sharing how she plans to integrate outdoor makerspaces into a specific unit:

> I'm already planning on setting a time to have the kids go outside to gather materials for a project later this year. In the past, we have specified that the kids use recycled materials or this project. I'm excited to introduce natural resources from outside. It ties perfectly into the project. I can't believe I didn't think to do it in the past!

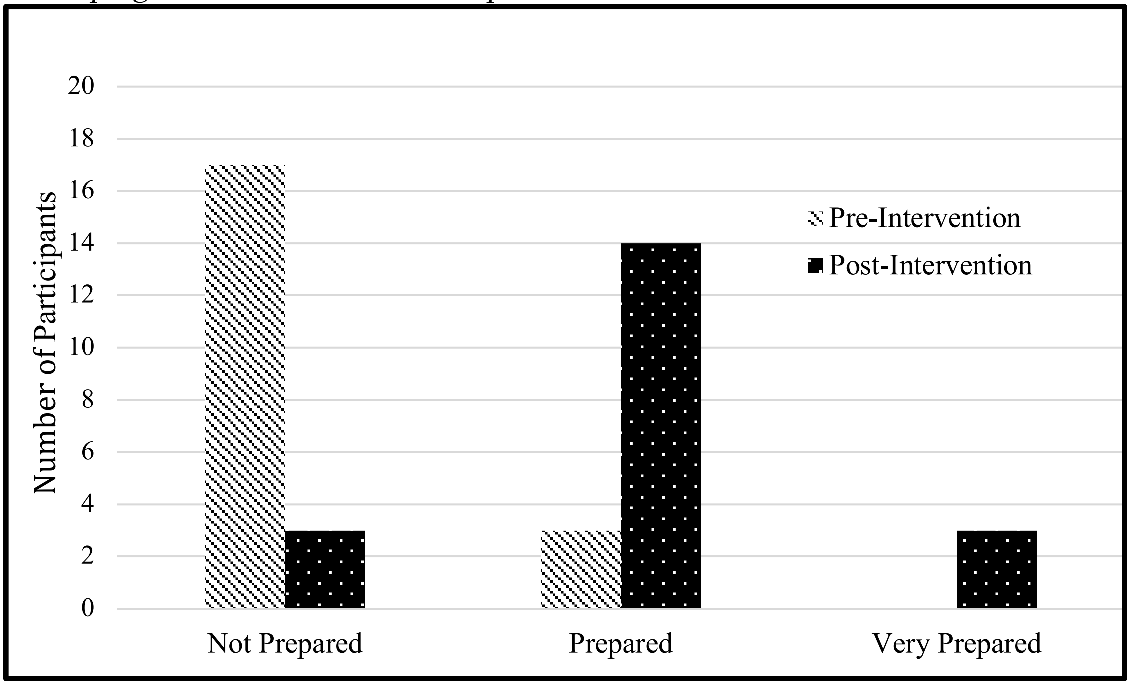
This information tells me that most teachers who took part in the intervention increased in their likelihood to take students outside for learning and some are already planning how this integration will take place.

There was one rating that was outside of the majority trend. Participant 15 reported that she would be *likely* to go outside on her post-intervention assessment after reporting she was *very likely* on the pre-intervention assessment. After asking her the reason for her change in rating from the pre-intervention to the post-intervention assessment, she reported that it was probably due to the inclement weather that was being experienced at that time. Weather seemed to play a role in the comfort levels of teachers taking students outside for learning. During the final week of data collection specifically, researcher fieldnotes identified three days of that week to be highly impacted by snow storms. One day of school was cancelled, one day was designated a late start in which students came 90 minutes late to school, and another day temperatures did not reach the district acceptable temperatures to take students outside. This snow storm caused at least three participants to abandon planned outdoor lessons with their students. Another perspective participant was not able to complete her outdoor activities and as a result was forced to drop out of the study. This will be discussed later in this chapter. Overall, the majority of participants increased in their likelihood of taking students outside for learning. This leads me to believe that the intervention had an effect on teacher disposition when it came to changing the likelihood of taking students outside for learning.

In the pre-intervention and post-intervention assessments, participants were also asked to rate their level of preparation in developing STEM skills for students in outdoor spaces. A Likert-type scale was used to rate preparation levels in which participants indicated whether they were *not prepared, prepared,* or *very prepared*. Responses for the pre-intervention and post-intervention assessments are captured in Figure 6 below.

Figure 6

Pre-Intervention/Post-Intervention Assessment Comparison: Level of Preparation in Developing STEM Skills in Outdoor Spaces



In the pre-intervention assessment, the majority of participants, 17, responded that they were *not prepared* to develop STEM skills in their students using outdoor spaces. Only three said they were *prepared* and none of the participants responded that they were *very prepared* to use outdoor spaces to develop STEM skills in their students. In contrast, the post-intervention assessment showed that 17 of the participants reported that they were *prepared* or *very prepared* to develop STEM skills for students in outdoor spaces. Only three participants reported that they were still *not prepared.* This data suggests that teachers feel more prepared to develop STEM skills using outdoor spaces after the intervention than they were before the intervention. It also reveals that a few teachers still feel ill-prepared to develop STEM skills for students in outdoor spaces. This trend of feeling more prepared to teach STEM using outdoor spaces was evident in other data that was collected as well. In the post-intervention semi-structured group interview, Participant 12 said that because of the intervention, she gained a deeper understanding of STEM. Previously, she believed that when teaching STEM, all topics needed to be represented and integrated into each lesson taught. This experience allowed her to understand that it is OK to separate the content when needed. By going outside to focus on one of the threads of STEM, then taking the information inside to integrate it into another STEM thread, she found teaching STEM more manageable. This information helped her to feel more comfortable and able to develop STEM skills in her students. This data suggests that the intervention may have a positive influence in preparing teachers to develop STEM skills for students in outdoor spaces.

Comparing pre-intervention and post-intervention assessment data clearly showed that participants increased in likelihood of taking students outside for learning after taking part in the intervention and many increased in their level of preparation of developing STEM skills in students using outdoor spaces. In examining this data and comparing it to other compiled data from post-intervention semi-structured interview, researcher fieldnotes, and photos, I was lead to make some claims about outdoor learning integration, teacher growth around outdoor learning, and developing STEM skills using outdoor spaces. These claims come from themes that emerged from the data and are set forth in Table 1. Themes and claims will be presented and then supported throughout the rest of the chapter.

Emergent themes.

When analyzing the open-ended responses in pre-intervention, during-intervention, and post-intervention assessments as well as semi-structured group interview transcripts, 136 codes were identified. These codes were then grouped together in three categories that emerged organically from their grouping. These categories included: benefits of taking students outside for learning, reservations in taking students outside for learning, and perceptions of student response when they are taken outside for learning. In second cycle data analysis, two more categories emerged from the data including: Teacher learned something new and needs of teachers to continue outdoor learning. These codes were then further grouped into major themes including outdoor learning integration, Teacher growth through outdoor learning, and developing STEM skills using outdoor spaces. This data will be used to support the claims made in this chapter and the next.

Table 2

Themes, Theme-related Components and Claims

Themes	Theme-Related Components	Claims
Outdoor learning integration	Using an outdoor makerspace hands-on professional development experience increases comfort levels for teachers when taking students outside for learning. Weather influences teacher comfort levels, both positively and negatively, when taking students outside for learning.	Integrating outdoor learning requires developing teacher comfort levels and overcoming negative factors.

	Teacher’s lack of time and lack of knowledge in planning for outdoor learning activities present a barrier in engaging students in outdoor learning.	
Teacher growth through outdoor learning	Using outdoor spaces for instruction expands learning for students and teachers. Students exhibit high levels of engagement when taking part in outdoor learning experiences.	Teachers are able to understand and support their students and their practice by integrating outdoor learning.
Developing STEM skills using outdoor spaces	Science and engineering practices are naturally integrated when engaging students in an outdoor makerspace platform. Allowing students to connect with nature during instruction develops an authentic experience for students as they develop a connection with their environment. Teacher’s learning expands in STEM by using outdoor learning as a platform for instruction.	Outdoor makerspaces naturally serve as a platform to develop STEM skills as teachers and students make meaning through connecting with the environment.

Outdoor learning integration. Claim 1- *Integrating outdoor learning requires developing teacher comfort levels and overcoming negative factors.* The following components were found to substantiate this claim: (a) outdoor makerspace hands-on professional development experience, (b) weather influences teacher comfort, and (c) lack of time and knowledge.

Outdoor makerspace hands-on professional development intervention. The hands-on professional development intervention included three parts: (1) a hands-on direct instruction portion in which teachers took part in an outdoor makerspace session as their students would, (2) taking students outside for learning at least three times and reflecting on the experience using the during-intervention assessment and, (3) reflecting on the experience as a whole through participation in a semi-structured group interview and completing the post-intervention assessment. Some portions of the intervention were found to increase comfort levels for teachers in taking students outside for learning.

Pre-assessment data showed that even before they took part in the intervention, participants believed there were benefits to outdoor learning. In the pre-intervention assessment, participants were asked what benefits, if any, were there in using outdoor spaces for learning. The highest frequency of responses included providing a change of environment, excitement to learn, and physical and mental benefits. When asked how they thought students would respond to learning outside, all participants reported that students would react in a positive way, although two participants thought some students may be distracted or dislike extreme temperatures. Even though participants recognized benefits for their students and believed students would respond positively, only 21.1% reported that they were *very likely* to take their students outside five or more times during a school year for structured learning. Participants reported concerns with behavior management, lack of experience and knowledge of taking students outside, and concerns about materials needed. As I mentioned in my conceptual framework, I believe that by allowing teachers time and space to construct different beliefs about taking students outside to develop STEM skills, comfort levels would rise increasing the likelihood that they would take students outside for learning. This belief was supported by data.

The study began with participants taking part in a hands-on professional development experience in an outdoor makerspace. This portion of the intervention allowed participants to experience outdoor learning as they would provide it to their students. Data showed that this experience coupled with the experience of taking their own students outside multiple times for outdoor learning opportunities, helped participants construct positive beliefs about taking students outside to develop STEM skills. In the post-intervention assessment, participants were asked to choose which intervention supports were most beneficial during the study (checking all that apply). The supports they had to choose from were: *the initial hands-on professional development session, time and space to take students outside to learn on your own, weekly emailed outdoor learning ideas, collaborating with others doing outdoor learning, reflecting on your outdoor learning experiences,* and *other*. Response rates showed that 90% of participants selected both the *hands-on portion of the professional development* and *time and space to take students outside to learn on your own* as the most helpful in supporting their efforts in taking students outside for learning. These supports were closely followed by *weekly emailed outdoor learning ideas* which 80% of participants chose as most helpful. This data leads me to believe that just as we need to give students time to explore before they work with tools, we also need to give teachers the same opportunities. Giving teachers time to experience outdoor spaces as a tool to engage students in learning, gives them time to build their comfort levels in order to increase the likelihood that they will repeat the practice. When teachers were able to experience being outside with their students, they were able to experience first-hand the benefits of taking their students outside. This experience allowed them to persevere through doubts they had in order to integrate outdoor learning into their practice.

As reported earlier, comparing pre-intervention assessment data to post-intervention assessment data, there were changes in how participants reported their likelihood in taking students outside for learning. Assessment scores before the study, showed that 84.3% of participants were either *likely* or *very likely* to take their students outside for learning before taking part in the intervention. Post-intervention scores showed that 100% of participants reported being either *likely* or *very likely* to take their students outside for learning. This change in likelihood came after participants experienced the hands-on portion of the study and after being outside with their students' multiple times. Therefore, the increase was attributed to increased comfort levels in taking students outside.

Participant comments from during-intervention reflections and post-intervention reflections, further support the claim that teachers will continue to build their comfort levels in order to take their students outside for learning. Participant 13 said:

> I would like to try to continue to push myself to find creative ways to get the kids outside. I loved the walk and talk protocol and want to utilize that more often. I am excited about the potential and for getting outside as often as possible!

Another participant echoed the idea of getting students outside for learning saying: "I'm already planning on setting a time to have the kids go outside to gather materials for a project later this year" (Participant 16). I attribute this increase in the likelihood of taking students outside for learning to an increase in comfort levels for participants.

There were other supports that also seemed to increase teacher comfort levels in taking students outside. When reporting which outdoor makerspace supports were most beneficial in the post-intervention assessment, half of the participants reported that reflecting on their outdoor learning experiences were beneficial and nine of the participants said that collaborating with others doing outdoor learning was also helpful. These scores lead me to believe that reflecting on the outdoor experiences and collaborating with others can take the mystery out of outdoor makerspace teaching practice and can lead to increased comfort levels.

Just as there are supports that increase the likelihood of outdoor learning integration, there were also factors that negatively influenced the likelihood of participants taking students outside for learning. The two most highly reported negative influences were adverse weather and lack of time.

Weather influences teacher comfort levels. Weather was a factor that influenced teacher comfort levels, both positively and negatively, for taking students outside for learning. There were comments made specifically about how weather influenced student learning and behaviors. When weather was a pleasant temperature and the wind was not blowing, participants tended to remark positively on their experience outside. One participant included student comments as she took them outside for learning. The student said: "I like to be outside because it's a nice day" (student comment reported by Participant 5). Another participant commented on how the nice weather had a calming effect on her students: “I was so surprised at how attentive they were to the speaker. It was a calm day, so there was no wind. The outdoor atmosphere seemed to actually calm them” (Participant 10). Another participant reported how the nice day could have an influence on where students chose to do their work, “they were the only group that opted to debrief outside, perhaps because the conditions were best for it (cool, shady area, not windy)” (Participant 19). Researcher fieldnotes also supported the idea that teachers were more comfortable taking students outside when conditions were agreeable to the majority of their students. This typically happened when it was a warm day with calm winds. Here is an excerpt from researcher fieldnotes on October 9, 2019 that support this thinking.

> I notice most participants are going outside when the weather is nice. Today, the temperature is in the 70s and I noticed three classes outside. Last week when it dipped into colder temperatures, I didn’t notice any classes outside. Maybe it’s because students are not prepared for cold and windy weather. Maybe it’s because teachers do not feel comfortable in colder weather. It is difficult to use paper and pencil outside when it’s so windy!

There were comments made in during-intervention assessments that supported the idea that students and possibly teachers did not want to go outside when weather was not considered optimal. One participant shared, “Every time we went outside they loved it and didn't want to go back inside (except one day that was pretty hot)” (Participant 13). When the weather was more adverse including snowy, too hot, too cold and/or windy conditions, participants tended to respond negatively. During the post-intervention group interview, a participant mentioned how the weather foiled her plans to take students outside, “I had a couple of times where I had planned something for out there and there was no way it was going to happen because of the crazy wind, so you have to be flexible…” she goes onto say, “…I never did get to write in the snow with food coloring and water because by the time it got nice enough to do it, there was no snow left” (Participant 10). This comment by the participant forms another layer of how weather can impact comfort levels in taking students outside. She mentioned, when planning activities outside, you have to be flexible in case plans need to change due to weather. Flexibility could be a factor to look into when considering what contributes to teacher comfort levels when taking students outside.

Concerns for adverse weather also came up in post-intervention assessment comments. In this assessment, participants were prompted to mention continued reservations they had about taking students outside for learning. In this context, adverse weather was mentioned eight times. One participant mentioned, “Weather in Colorado can be difficult sometimes!” (Participant 20). As mentioned previously, during the final week of data collection, there was a winter storm that came through our area closing the school one day and causing a late start another. It was because of this adverse weather that one potential participant was not able to complete all of her required outdoor lessons and had to drop out of the study. Another participant commented that the adverse weather influenced her to change the likelihood of taking students outside from her pre-intervention assessment rating of *very likely* to a post-intervention assessment rating of *likely*.

Although during-intervention comments did not reflect much data for adverse weather, it could be because most days had agreeable weather or that participants opted not to go outside during adverse weather. Since this study was performed between the months of August and October in a suburb of Denver, Colorado, average temperatures ranged from 64 degrees F to 83 degrees F. This range of temperatures was most likely considered pleasant by the participants and could possibly play a role in how they construct understandings about outdoor learning. Understanding how weather plays a role in constructing understandings about outdoor learning could be the topic of future studies.

Lack of time and knowledge. Lack of time and knowledge were both factors that were reported to negatively impact the likelihood of taking students outside for learning. This factor emerged from the data in two ways: lack of time to plan and lack of knowledge to plan integrated outdoor activities.

The post-intervention assessment showed that participants continue to struggle with having an adequate amount of time and knowledge to prepare for and conduct outdoor learning. In this assessment, when asked to comment on what barriers still exist in using outdoor makerspaces with students, lack of time for planning was reported five times and lack of knowledge on how to plan for integration was reported seven times. This combination of lack of time to plan and lack of knowledge to plan integrated outdoor activities go hand in hand.

Participant comments support the idea that lack of time and knowledge are both negative factors in taking students outside for learning. When asked what barriers still exist, one participant comments: “Time for planning, typically I end up making an impromptu trip outside with the class changing the setting of the lesson instead of directly planning for it” (Participant 2). Another participant commented that it is not only planning that creates a strain on time, but also the academic expectations that take up valuable instructional time: “Time, current academic expectations take up more time than I have already, how to blend it with other things” (Participant 4). Comments like this among the participants show that lack of time and knowledge on how to integrate outdoor learning continues to be a factor that negatively impacts the likelihood that participants take students outside for learning.

One participant made an interesting comment about how her length of time teaching may make it more time consuming or more difficult to plan for outdoor learning. When commenting on barriers that still exist for her in taking students outside for learning, she says:

> I think just reminders/change of mindset to utilize the outdoors. I have taught so long and so much inside that I need to make it part of planning lessons. I appreciate new ideas and resources that I have not thought of using. I really appreciate the focus on this, it is so important during the times we live in. (Participant 8)

This comment brings up an interesting possible connection between the lack of time/knowledge factor with the number of years of teaching experience. Could teachers who have been teaching longer and have more experience planning activities inside, be more prone to barriers of time and knowledge planning for outdoor learning integration?

Since the majority of participants in this study have at least ten years of teaching experience, I wonder if lack of time and knowledge would be more of a factor for them as they plan for outdoor learning integration. This question could be a topic for future study.

Integrating outdoor learning requires developing teacher comfort levels and overcoming negative factors. Different components influence these comfort levels. Implementing the outdoor makerspace hands-on professional development experience, has shown to increase comfort levels in taking students outside for learning. Weather was found to influence teacher comfort both positively and negatively. Finally, lack of time and knowledge are barriers that continue to exist for teachers in taking students outside for learning.

Teacher growth through outdoor learning. Claim 2- *Teachers are able to understand and support their students and their practice by integrating outdoor learning.* The following components were found to substantiate this claim: (a) 'learning is expanded' and (b) high student engagement.

Learning is expanded. One unexpected theme that emerged from the data was how outdoor learning acted as a tool to expand learning by developing teacher understanding of their practice and their students. Being outside proved to change things up for teachers and students in a way that allowed new learning to emerge. This was evident for both teachers and students. This major recurring theme was identified in data analysis and given the title 'learning is expanded.' The theme was separated into teacher learning and student learning. In during-intervention and post-intervention data collection, this theme was identified 32 times for student learning and 21 times for teacher learning. The categories under this theme for students included ‘learning is expanded’ and ‘21st century skills.’ The categories under this theme for teacher learning included ‘teacher learned something new’ and ‘social emotional learning’(SEL).

Being outside proved to expand learning for students in multiple ways. Participants reported that student’s excitement to learn was piqued by being outside. One participant mentioned that her students were designing blueprints for an unused space on campus “they are incredibly creative and do a much better job thinking outside of the box than I can. They did complete some very detailed blueprints and everyone participated and was excited.” (Participant 17). Participants reported that this excitement led to student’s willingness to do more work and as a result students produced more. One participant talked about taking her students outside for writing “they were all engaged and writing was effortless. (I have two reluctant writers and they had no problem putting their thoughts on paper in this setting)” (Participant 5). The same participant commented on how another struggling student gained confidence by being outside for learning, “she read her favorite book so loud outside and with great expression to the class. I loved how being outside made her more confident.” This idea of increased willingness for students to do more work was echoed by eight other participants. During the post-intervention group interview one participant reported that students’ thinking changes while outside. She states “They think more outside than they do inside. So, they don’t ask ‘how do you do this?’ They just do it. But [when they are] inside they’re like ‘but I don’t have a pencil!’” (Laughter) (Participant 17). Excitement to learn acted as an incentive that increased student engagement outside and expanded their learning.

The outdoor environment offered a change in surroundings that boasted hands-on opportunities and authentic connections that were not available in an indoor setting. In the pre-intervention assessment, ‘change in environment’ was one of the most highly reported benefits of using outdoor spaces for learning at a frequency of 12 times. Participants used outdoor spaces for many hands-on experiences for students. These experiences included opportunities to connect their learning using their 5 senses and the integration of community service opportunities. When identifying the frequency of topics that were covered in outdoor learning, lessons on integrating the 5 senses were the most frequently reported topic of study at a frequency of 15 times followed by topics in science (frequency of 12) and math (frequency of 10). Experiencing these lesson topics through a hands-on, whole-body approach, expanded learning for students by magnifying the experience as they used all 5 senses. During-intervention assessments highlight this focus on whole body learning. One participant commented on how when taking students outside students used their 5 senses without being prompted: “I heard one student say to another student ‘You touched sap. Nice!’” (Participant 5). This student not only learned about trees, but was able to experience them through seeing, touching and smelling. Another participant commented on how students were able to expand learning by using their sense of sight, smell and hearing: “They saw and heard more than I did! Many of them even wrote down smells!” (Participant 13). By taking students outside for learning, they were able to take part in phenomena that naturally engaged all of their senses.

In addition to using 5 senses in outdoor lessons, teachers also used community service projects in order to expand learning for students. One participant took students outside to identify problems on our campus: “We saw a good amount of litter and noticed that there are no garbage cans on the north side of the building which may be the reason for the litter” (Participant 9). Identifying problems on campus allowed students to engage in authentic problem-solving opportunities. Another participant had students identify community issues and propose solutions to these issues: “They came up with some community issues I didn’t think about and had thought-out solutions for some of them. For example, a few students saw the crosswalk on R street as a hazard and suggested a traffic light instead of a flashing yellow pedestrian light” (Participant 10). Student’s eagerness to work to make improvements during these community service projects was evident: “I was surprised at how eager the students were to get their hands dirty with challenging manual labor” (Participant 18). This participant went on to say of the community service project, “These kids took every stage of their project very seriously. I hope we can find other outdoor activities as fulfilling as this one was!” Giving students authentic problems to solve and allowing them opportunity to solve them, served to expand their learning. Student learning was also expanded by developing 21st century skills. In during-intervention assessments and post-intervention assessments, participants reported that outdoor learning promoted creativity, curiosity, confidence, and developed observation skills, all contributing to 21st century skill development.

In addition to expanding learning for students, participants also reported extended learning for themselves. The time outside served as a co-learning model for teachers and students to better understand what worked and what didn’t work. This learning resulted in a better understanding of instructional practice, of students, and of the resources that outdoor spaces offer. In the post-intervention assessment, participants were asked to report their reservations and excitement about using outdoor makerspaces in the future with students. One participant reported specifically about being excited about their own extended learning: “Excitement- the kids enjoy the outdoors, more exposure to our unique environment, and extended learning for me” (Participant 12). This trend of expanding instructional techniques was appreciated by the participants who took part in the study.

One specific way teachers expanded their learning was an understanding of how being outside influenced student behavior. Originally, in pre-intervention assessment, participants were asked what reservations they had about taking students outside for learning. Data shows that ‘behavior management’ was the highest reported reservation teachers had about taking students outside being reported 15 times. So, this change in their thinking was an important step in increasing comfort levels and in turn in increasing the likelihood that they take students outside for learning. As participants were able to take students outside, their reflections about the experience serve as evidence for this expanded learning. During the post-intervention group interview one participant spoke about her kindergarten class saying:

> I thought they were going to be all over the place, they are going to run around, they are not going to do what we are asking them to focus on, and they totally did not, they were fine. They were more engaged in being outside… (Participant 3)

This sentiment was repeated by many participants in their time outside with students. Some participants reported a couple students in class that may be off-task, acting silly or distracted, but as a whole, most participants found students to be engaged and on-task. During-intervention data show 31 reports of high engagement for students and 7 reports of being on-task. Although there are continued reservations about behavior when taking students outside, the frequency is much less in post-intervention assessment where participants reported ‘behavior management’ only twice as a reservation for taking students outside for learning, compared to pre-intervention reports of 15 times.

Learning for participants was also expanded as they observed how being outside positively impacted student’s academic achievement. Out of the 76 lesson reflections collected during the intervention, participants reported that they performed a writing lesson outside nine times with students. It was in this context that this positive academic impact was seen. As participants reflected on these outdoor lessons, their learning was expanded. In the post-intervention group interview, one participant mentioned how being outside opened up writing for a struggling student:

> It opened up writing for a couple of my kids um, so I have some kids who are dyslexic and so they don’t want to write because they’re embarrassed but being outside and then having that pique of interest like OK you can draw what you see and you can, and it was a good segue like it built this trust with having the pencil in their hand and I noticed I got more writing out of them. (Participant 16)

In the post-intervention assessment, participant comments revealed how writing for their students was different when they were outside, specifically students who normally struggle. One participant reflected about how nature provided exciting and novel fodder for students to write about: “We found a toad on the playground to write about. Students were all super excited to write about that toad (even kids who normally struggle with writing)" (Participant 6). Another commented, "They were all engaged and writing was effortless. (I have two reluctant writers and they had no problem putting their thoughts on paper in this setting)" (Participant 5). Other observations by participants included how students thinking opened up outside allowing them to ask more questions and to work more independently on task completion. One participant commented that after a week of keeping students inside for learning, she noticed that she saw more negative student behaviors than when they spent more time in an outdoor learning environment (Participant 16). The physicality of outdoor learning served as a calming influence for her students even after they returned inside.

Outdoor learning gave teachers a unique opportunity to connect with their students in a way that they could not in an indoor environment. One participant comments that engaging students in an outdoor environment gave a unique perspective to student learning. She mentioned "It was a nice way to kick off a new unit. They were engaged. This shared experience led to quality conversations between peers when we returned to the classroom" (Participant 14). Another participant mentions how she was able to gain unique insight into her students: "I loved the discussion I had with the kids. It was an opportunity to learn about them and how they operate" (Participant 16). During a math lesson outside in which students were drawing arrays on the sidewalk, a teacher comments "I was able to see which kids understood the arrays and which didn't. They were much more engaged than if we were writing them on paper" (Participant 11). Another mentioned an incidental encounter with a student that was prompted by being outside: “I learned that one of my students knows a bit about birds, which was cool” (Participant 16). These encounters participants had with their students, served to expand their learning.

Another theme that emerged when thinking about expanding learning for teachers’ is how outdoor learning supports students’ social and emotional needs. Social and emotional needs of students range from the need to practice positive peer interactions to practicing strategies for calming anxiousness. Participants found that students were able to practice these strategies while engaging in outdoor learning. This was evident when analyzing during-intervention and post-intervention data, where a recurring theme, ‘calm learning,’ was identified. The idea of calm learning was somewhat surprising to some participants who expected student behavior to be the exact opposite of calm when they were outside. Participant reflections on their time outside provides evidence of this calm learning: “It was nice as students could listen to nature and read at the same time. Students seemed calm and focused during our time outside” (Participant 15), “They all enjoyed choosing their own prompt and finding a space outside they could relax and write in” (Participant 17), “The students were really into it. Most were very quiet as they took time to observe things around them” (Participant 4). This trend of calm learning was also felt by students. A participant quoted a student who said, “I like being outside because then I get my own peace and quiet to write down what I see and what I hear” (Participant 5). Post-intervention interview data further supports the trend of calm learning. In interviews, one participant was surprised at how being outside actually calmed the students who needed more movement inside. She said:

> I was surprised that um, I, I thought that when I took my kids out, especially the kids that are always needing to move around and not stay in one place for too long that it was going to make them want to do that more and instead it calmed them. They, they settled in and they were doing what we were doing. It seemed easier. (Participant 2)

In addition, during post-intervention interviews, a participant mentioned how taking students outside allowed her students the opportunity to practice what 'balance' looks like:

> I think it's a good opportunity for kids to learn balance because um, because my class had just finished playing a game outside and then we walked over, laid down in the grass and looked up at the clouds and they used their imagination. So, we talked about there are times for loud and moving around and then there's times where you need to be calm and ready for learning and ready to focus. And then when we got back inside we talked about how that looks in the classroom and balancing you know sometimes we are up and around and talking to each other and other times we're, we need to be focused on whatever we are doing and being quiet. And so just for kids to see 'oh that can happen outside and inside' is a good thing. (Participant 15)

Calm learning was a theme that emerged from the data and proved to support students social and emotional learning by providing a calm environment in which to learn. It was reported nine times in during-intervention and post-intervention assessments. Since participants did not report this in pre-intervention assessment, it supports the idea that they did not know this was a benefit of outdoor learning. Physical and mental health benefits were cited by participants before, during and after the intervention. In all, physical and mental health benefits were reported a total of 56 times. Supporting these trends in data collection were reports of students having ‘fun’ and being ‘happy,’ reported nine times in during-intervention and post-intervention data collection. Another finding that may have supported social and emotional learning for students was the fact that they liked being outside. This was reported 22 times for during-intervention and post-intervention data collection.

Participant learning was also expanded as spending time outside allowed teachers time and space to get acquainted with their environment. They learned that the outdoors provides free and available materials to use in classroom projects. One participant learned that the majority of her students preferred choosing natural materials to build with as opposed to purchased materials. She recorded her students quotes: “The things outside are fresher than the things inside,” “Outside had all the fun things I needed: pine needles for hair, tiny rocks for eyes, and a stick for a mouth.” She goes on to reflect on what she learned from her students: “I learned that all the pretty ribbon, shiny sequins, glitter, etc. in our classroom maker space was not as exciting to twenty of my twenty-four students. They preferred outside treasures” (Participant 5). Another teacher reported how learning outside has benefits as materials are provided: “Most of the supplies are provided. The kids are more engaged and there seems to be more independent learning and follow through” (Participant 12). Another participant said:

> I like to go outside for all different reasons. It doesn't always need to be a makers-space per say. The nice part is that often the space doesn't require things to be brought in, you can just use the things found there. I appreciate the new resources and ideas to learn outside with. (Participant 17)

The idea of having materials to integrate into building projects came up in interview data as well. One participant mentioned "…these items are free and in nature. I was just um, that was just kind of a moment where I'm like wow outdoor makerspace is much needed besides the other many reasons. Cheaper on the budget too" (Participant 5). This realization of free and available materials being right outside the door, opens up so many possibilities for teachers who struggle with having sufficient funding and materials to do hands-on learning projects with students. This can sometimes be a deterrent for teaching STEM. Engaging students in outdoor learning provides natural materials for students to build and work with. Participants found these materials to be helpful.

High student engagement. Teacher growth through outdoor learning is also supported by looking at the data around high student engagement. High reports of student engagement were recorded before, during and after the intervention. Even before the intervention, participants believed that their students would enjoy being outside for learning. In pre-assessment data, when asked about the benefits of taking students outside for learning, there were 23 reports that students would *enjoy the change in environment*, 21 that students would be *excited to learn outside*, and 17 that *student engagement would be high*. Even so, participants seemed to be surprised at the level of engagement for their students as well as the benefits that high engagement afforded. During the intervention, as they reflected on outdoor lessons, participants said “Again, consistently the student’s engagement is so much higher outside” (Participant 1), “They are still very engaged and excited to be outside and many of the kids continued looking for items to add to the collections later in the day” (Participant 2), “All student engagement was up, but I noticed that specifically the students who have the most difficult time staying on task were the ones who had the highest engagement outside” (Participant 1), “I was surprised how engaged and on task they were” (Participant 11). One teacher compared the same activity she did with students inside to their reactions doing it outside:

> I first had the kindies do this lesson inside-and asked them to look around the classroom for things they could count. The next day we went outside. All of the kindies were much more engaged in the lesson, turning over their recording sheet and wanting to record more things they could count! (Participant 1)

During interviews participants echoed and supported this data: “Kids who struggle in a classroom environment seem to excel outside” (Participant 1), “I saw that as well…students who had a hard time being in my office and sitting and getting, their horizons were expanded when we went outside” (Participant 19).

Even though teachers believed outdoor learning would be engaging for their students before the intervention, taking part in the intervention allowed them to construct a deeper understanding of what this meant. When asked ‘what are the benefits of using outdoor spaces for learning?’ pre-intervention comments included: *they will love it* and *they will be engaged*. Post-intervention reports show how thinking has grown as a result of taking students outside. Participant 9 reports that being outside:

> engages students on another level, their attention and buy-in increase whenever I talk about going outside and they are able to fully immerse themselves in some of the activities we do outside; the fresh air is great for all of us!

Another participant reports: “Kids come alive in a way outside that's nearly impossible to replicate in the classroom. The level of engagement is off the charts” (Participant 14). One teacher reports how student learning is supported outside:

> Boy does it increase engagement BIG time! It instantly helps kids who need to move focus, and it helps everyone’s mood improve due to getting exposed to sunlight (vitamin D). I feel it’s also important due to the fact that many of these kids go home and sit in front of technology so for those kids it’s the only opportunity to get outside. And if they are learning at the same time? Talk about a win-win!! (Participant 13)

Another participant mentions how outdoor learning not only engages students but positively supports behavior and thinking as it connects learning in a real-world application:

> My kiddos are more engaged outside. I love having them really notice what is around them. I’ve noticed that when I don’t get the kiddos out regularly, some of my ‘high-flyers’ fly a little higher. I also think bringing activities outside helps kids think outside the box and brings ideas into the real world (Participant 16).

The time teachers spent outside with students served as a means to expand learning as teachers connected with their students in a different way and the time allowed them opportunity to construct a deeper understanding of the benefits of taking students outside for learning. High student engagement, connection to the real-world, and development of 21st century skills are all academic benefits that expand student learning in an outdoor environment. Student's social and emotional needs are met through a calm learning environment, fresh air, space, sunshine and a fun environment in which to learn.

Another variable that could have been a factor in the high levels of reported engagement, could be the dose-response of nature students were exposed to. In Kuo et al. (2019) the researchers spoke about the 'nature advantage' in regards to how nature exposure benefits students. One question that still persists is "how 'natural' does a landscape need to be to boost classroom engagement?" (p. 37). Kuo et al. (2019) highlights how Tennessen and Cimprich (1995) identified how the amount of nature could have an impact on student performance:

> In schools with considerably greener surrounds, lessons in nature might have even larger impacts on classroom engagement; in one of the few studies including a wide of levels of nearby nature, the more natural a students' dormitory view, the better their cognitive performance. (p. 35)

When analyzing the landscape photos, I took of the spaces where outdoor learning took place on our campus, I found high levels of nature present. All areas were surrounded by or included untouched and manicured natural space. On campus 1, outdoor spaces were in sight of rolling hills, neighboring farm land and natural space. In addition, campus 1 has been identified as a Certified Schoolyard Habitat Site by the National Wildlife Federation. This designation confirms that the site provides local wildlife food, water, cover, places to raise young, and provides evidence of sustainable, environmentally friendly practices. Campus 2 is surrounded by manicured green space and adjacent to two ponds. A tree fort has also been created between two pine trees for students to enjoy. In addition, wildlife is often present on both campuses. This level of nature may have been a factor that influenced the high levels of student engagement that were reported. Figures 7 through 11 show landscape photos that give a visual representation of nature levels on campus 1 and campus 2.

Figure 7

Campus 1: Certified Schoolyard Habitat

Campus 1 was deemed a Certified Schoolyard Habitat by the National Wildlife Federation. The sign is posted on the edge of the property which shows how the school campus is situated next to farm land.

Figure 8

Campus 1: Level of Nature in Unmanicured Space

Photo taken during the Outdoor Makerspace professional development hands-on portion of the intervention. Three participants searching for natural materials to use in nest making activity. The photo shows part of the campus that has natural space that is not manicured in addition to the rolling hills that are in sight during most outdoor learning activities on this campus.

Figure 9

Campus 1: Level of Nature from Blacktop

This photo shows that even when outdoor activities happened on hard top surfaces away from nature, nature was in sight for participants.

Figure 10

Campus 2: Level of Nature

This aerial photo shows the natural green space that surrounds building 2. The two ponds are shown at the top of the photo. Natural manicured grass space is evident surrounding the building. The turf field is shown at the bottom. (Academy Sports Turf, 2020).

Figure 11

Campus 2: Tree Fort

This photo shows the tree fort that was built on campus 2 to engage students in nature.

Developing STEM skills using outdoor spaces. Claim 3- *Outdoor makerspaces naturally serve as a platform to develop STEM skills as teachers and students make* *meaning through connecting with the environment.* The following components were found to substantiate this claim: (a) science and engineering practices, (b) connection with nature, (c) teacher's learning expands in STEM and outdoor learning.

Science and engineering practices. When identifying STEM skills that need to be developed, the Next Generation Science Standards (NGSS) have been nationally recognized as a tool to guide educational work in the area of science learning. These standards approach scientific learning through a three-dimensional lens, including: practices, core ideas, and crosscutting concepts (NGSS Lead States, 2013). This approach sets forth the expectations of what students should know and be able to do. Although teachers have worked with science standards in the past, the NGSS introduces the importance of integrating science and engineering practices into instruction. The NGSS includes an explicit list of these science and engineering practices. The skills include:

- asking questions and defining problems,
- developing and using models,
- planning and carrying out investigations,
- analyzing and interpreting data,
- using mathematics and computational thinking,
- constructing explanations and designing solutions,
- engaging in argument from evidence,
- obtaining, evaluating and communicating information

(NGSS Lead States, Appendix F, 2013)

Even though participants were not expressly directed to do lessons focused on science and engineering in the outdoor makerspace, reviewing topics that were covered, data shows that many of the science and engineering practices were naturally integrated into student learning.

When categorizing the activities/lessons teachers performed in the outdoor makerspace with students, a total of 76 activity/lessons were reported. The breakdown of activity/lesson topics are shown in Table 3 below.

Table 3

Activity/Lesson Topics Reported for Outdoor Makerspace

Topic	Frequency
Other	52
Science	12
Math	10
Technology	1
Engineering	1

The twenty-four lessons that were categorized as STEM topics included science content and process learning, math and computational thinking, using technology as a tool in learning, and prototyping. These lessons highlighted the use of many of the science and engineering process skills listed above. Investigations were planned and carried out as students learned how pollution travels as a result of the water shed process. Students identified a problem with leaves accumulating on campus, then built and tested prototypes to solve the problem. Students were asked to make claims about living, nonliving, and once living things in nature then supported their ideas by using evidence. Data was collected and analyzed as students measured, sorted, and counted objects in nature as part of a math lesson. Each of the reported STEM lessons integrated at least one of the science and engineering practices. What was surprising is that the lessons/activities that were reported under ‘other’ also had a high rate of integrating the science and engineering practices recommended by NGSS.

The ‘other’ category included lessons focused on: the five senses, nature/scavenger hunts, drawing, reading/writing, physical activity, and service learning. The five senses were reported in fifteen of these lessons. These lessons were comprised mostly of a question posed by a teacher and required students to obtain, evaluate and communicate information of some kind. Students used their senses to create sound maps, identify objects in nature for future writing topics, and to determine which sense helped them to feel most calm. Many of the 5 senses lessons reported writing down and verbally communicating information supporting the skill of obtaining, evaluating and communicating information. In addition, these activities allowed students to practice engaging in argument from evidence as they made claims and supported these claims by using evidence. One participant reported that she would use the information gathered with their senses to further scientific work in the classroom. “We are working on the senses. We went out focused on listening, then wrote down what we heard. We will use this work as scientists, writers, historians, etc.” (Participant 16). This comment provides evidence that the information gathered in her 5 senses lesson will be used to further science learning.

Reading and writing was mentioned in thirteen of the lessons reported. Although I was not able to identify if what students were reading and writing included scientific topics, the process of reading and writing supports the skills of obtaining, evaluating and communicating information. Many of the writing lessons included writing about natural phenomena students found on campus. Topics included creatures or natural materials.

Nature Walks and Scavenger Hunts were reported in six of the lessons. Many of the activities did not expressly report a connection to STEM content, but science and engineering practices were evident. One participant explained what he did with his students:

> We took a nature hike around the outside fence perimeter and ended up at the outdoor classroom. During the walk, the students were told to observe the wildlife around them, and that the expectation will be to sketch something that's alive, then draw its connections [to the natural and social system]. (Participant 18)

This lesson provides evidence that students were engaged in developing and using models by drawing a diagram of something that was living and then drawing its connections to living and non-living items around it. It also provides an example of engaging students in obtaining, evaluating and communicating information. Other nature walks and scavenger hunts required students to record items found in nature, to collect objects to use as manipulatives for math, picking up trash, and comparing natural items found in different seasons.

Service Learning was a topic that was reported in eight of the lessons. One participant reported:

> We walked around the outside of the building with clipboards, observing the possible needs and opportunities of our school. We are working on our third line

> of inquiry [which was] making positive change in local policies… [we] took the school community approach in this activity. (Participant 9)

Students engaged in defining problems on campus and constructed plans to solve them. This was also evident in a garden restoration project, a trash collection movement, and a future improvement project of an unused playground.

Drawing was specifically reported in three of the lessons. The purpose of these three lessons was to engage students in artistic drawing in an outdoor environment. It was performed as part of a before school art club. By taking part in this activity, students were able to develop and use models by practicing their drawing skills. Although this may be a tenuous connection to developing STEM skills, it does allow students time and space to practice drawing.

Overall, of the 52 lessons reported by participants in the 'other' category, 87.5% were found to have ties to supporting science and engineering practices. This is especially important since participants were not expressly asked to integrate the science and engineering practices into their outdoor makerspace lessons and activities. This will be discussed more in chapter 5.

Connection with nature. Another factor that was found to support the idea that outdoor makerspaces naturally serve as a means to develop STEM skills, was providing teachers and students time and space to connect with the environment. This claim goes back to the idea that understandings are constructed based on experiences. If experiences with the environment are only read about and learned about from afar, students and teachers will construct an understanding that is surface level and inauthentic. When time is spent in nature learning about nature, an intimate relationship is formed with the environment. Teachers are able to understand how to use the environment as fodder to bolster a deeper scientific understanding with their students and students build an appreciation for nature that can turn into a passion to protect it.

A hands-on approach to learning, has long been called for in science instruction in order to boost student engagement and authenticate learning experiences, yet much of the learning students do about the environment is done inside. This outdoor makerspace study showed how being outside can boost student engagement in learning. In post-intervention data collection, participants were asked to list the benefits of outdoor learning. The top three answers were *high student engagement,* at a frequency of 39, *learning is expanded,* frequency of 21, and *promotes positive connection with the environment,* 20 responses. These responses serve as evidence that hands-on learning works in the outdoor environment as well as the indoor environment. The hands-on approach used outside, revealed some unexpected results in teacher learning. In during-intervention reflection, one participant mentioned that a student misconception was uncovered by being outside: "I was surprised that students watched a grasshopper hop and thought it had turned into a butterfly!" (Participant 3). She mentioned that because this misconception was uncovered, she was able to address it in class discussion. It is unlikely that this misconception would have been uncovered if students were not able to interact with this creature in the outdoor environment. Other participants commented on the power of building a shared experience with their students. The shared outdoor hands-on experiences have proven to expand learning when brought back into the classroom.

One participant remarks on an outdoor learning experience saying “It was a nice way to kick off a new unit. They were very engaged. This shared experience led to quality conversations between peers when we returned to the classroom” (Participant 14). In the post-intervention assessment, another participant wrote:

> The students loved it and every single student was engaged. We have drawn upon that experience in order to relate to work done in the classroom. It helps to have a common experience rather than assuming children have had similar experiences in their lifetime. (Participant 9)

During the post-intervention interview, a participant mentioned how she is using shared lived experiences to ground her instruction:

> I found myself drawing on like our shared [experiences], because I live here too…And I find myself doing that more now than I did even last year, like ‘Hey you know when you go by the ponds and you see blah, blah, blah,’ or ‘Hey you know when you are on the Highline, do you guys know where that is, that’s where you cross the street and there’s that old shack?’ I am able to draw sort of a shared experience…I think that’s kind of cool. (Participant 16)

These examples provide evidence that participants are grounding instruction based on shared and lived experience.

Something else that came up in the study that supports developing STEM skills in teachers is the idea that teachers do not have to know everything in order to teach STEM. One participant shared in the post-intervention interview that getting kids to ask ‘why’ is his goal and that it is alright if he doesn’t know all the answers. He said:

> When your outside, come up with a why question…I won't know a lot of those answers so that's where tech comes in, right and we can take notes outside as we are doing our walk…then we can go in and research a little more. Then if it's something we can test out that would be cool too or make theories. (Participant 18)

Some participants embraced the freedom that came from being in an outdoor environment. Topics that arose from this perspective were the idea that outdoor environments provide space for students to self-differentiate, time and space for organic, and student-directed learning.

Differentiation is a strategy teachers use to engage all students at their own levels. Outdoor learning was found to provide a means for students to self-differentiate. Differentiation was achieved by allowing students choice in how they wanted to engage with nature, for example: sitting, standing, laying down while writing or choosing what activity they wanted to engage in. One participant noticed this differentiation with her students: "I love how the kiddos differentiated for themselves. Some really wanted to continue with the physical game, and others needed a quieter activity" (Participant 16).

Participants stretched themselves outside the walls of their classrooms in order to engage in outdoor learning. This act of being a risk-taker, helped teachers to construct a different understanding of how instruction could look. During post-intervention group interviews, a participant shared how his initial beliefs of outdoor being intimidating waned as he spent more time outside. He said that although classroom management is hard anyway, most of us would say, but when you take [students] outside, you are leaving the classroom and it's harder to hear each other and suddenly they are further away from me, and um so it's kind of intimidating but it definitely got less intimidating the more I went out. (Participant 14)

Another participant mentioned how the logistics of using an outdoor makerspace also needed to be considered and gotten used to. She said:

> Things I didn't think about like if we are going outside with our notebooks and pencils and then we go from enrichment, which is when I often did outside time, to recess, what do we do with all that stuff. I mean just little things, or like the first few times forgetting to get a walkie, you know and then remembering OK I need to do that, you know those things and I got more and more comfortable. The kids got used to a routine, you know ok we put our things in this certain spot and pick them up on our way in from recess. But that was at first kind of off putting, like oh, oh I didn't think this through, but we are getting used to it. (Participant 16)

One participant found delight in taking her students outside realizing that there is a time and place for students to direct explorations guided by their own curiosity. She states, "It was delightful...I learned (and am still learning) that learning does not always have to be planned, prepared, and preorganized. It's amazing the organic learning that occurs when outdoors and allowed to explore freely" (Participant 9). This organic or student-directed approach was mentioned three times as participants reflected on outdoor learning.

Participants also made discoveries about themselves. One teacher discovered why she may have previously been reluctant to engage students outside. She writes:

> I think it's just me (maybe with my fear of snakes, etc.) that I have limited them in the past. I know you have discussed this with us and how you overcame your fears so they don't limit the students. I will make more of an effort with this fear and become more of a risk-taker. (Participant 5)

Teachers learning expands in STEM and outdoor learning. Teachers learning was found to expand in their understanding of delivering STEM instruction and in how to manage outdoor learning.

First, teachers' thinking was found to change during their time outside with students. One participant summed it up succinctly when asked about barriers that still exist in using outdoor makerspaces with students:

> I think I just need reminders/change of mindset to utilize the outdoors. I have taught so long and so much inside that I need to make it part of planning lessons. I appreciate new ideas and resources that I have not thought of using. I really appreciate the focus on this, it is so important during the times we are living in. (Participant 8)

This comment was profound when understanding teacher perspective on outdoor learning. In deconstructing this comment, I found two points to be relevant as we think about implications for practice.

First, the participant identifies the need for a change of mindset in order to understand how to utilize the outdoors for learning. As an experienced teacher, this participant believed that her experience helped her construct an indoor mentality when it came to purposeful planning. Not having time and space to construct an understanding of how to use outdoor makerspaces, created a barrier in taking students outside for learning. In an existing culture of time constraints, this lack of understanding may be the one thing that keeps her inside.

Second, the participant uses the word ‘appreciates’ in a couple different contexts. She mentioned that she appreciates new ideas and resources that she had not thought of using. She goes on to say that she also appreciates the focus on outdoor learning and identifies that it is important specifically ‘during the times we are living in.’ This participant understands the benefits of outdoor learning and wants to engage students but lacks the know how to purposefully plan for its integration. Her feeling of being appreciative tells me that she is open and willing to try new things but may lack the time to research new ideas on her own. She values the idea of outdoor learning and is confident in knowing it is a valuable endeavor for her students, even if she may lack confidence in her abilities. This is a salient point since there was evidence that at least one participant was not confident in knowing the value of outdoor learning for her students. In the post-intervention assessment, participant 7 mentioned that one of her reservations in continuing outdoor learning with her students is that “I wouldn't want others to view it as ‘not a real lesson.’” This leads me to think that to increase the likelihood of teachers taking students outside for learning, educational leaders need to embrace outdoor learning as a valid and valuable teaching strategy.

Other participants showed evidence of expanding their learning in multiple ways. One participant identified the need to balance the learning students engage in by providing other options besides technology. “Thinking about it in a different way is definitely needed and great for these kids who are surrounded by technology in one way or another. To think about things differently” (Participant 9). Another participant identified how her learning expanded as she explained how her instruction had changed over the time she took seven groups outside for learning. She mentioned that “it was definitely a learning experience for me I think as much as it was for them.” She was asked if she was more confident now because of her time outside with students. She said:

> I am and I think that I trust my um, my ability to appropriately structure it for them, like I feel like I gave myself permission to say if it’s going to help them better learn, then it’s OK to put some of those structures in place. (Participant 19)

Another participant identified the benefits of using outdoor materials for students to build. She spoke about a prototyping activity she did with her students in the outdoor makerspace saying that “and it wasn’t expensive which sometimes you think STEM is going to be expensive” (Participant 17). Another participant identifies how her mindset was changed in taking students outside, she said:

> Teaching kindergarten, I thought that [going outside] was going to be a chaotic disaster, (laughs) … and they were fine. They were more engaged in being outside…their observations were really deep and their conversations were really deep and they followed directions, no one got hit by a car (group laughs and someone else says ‘that’s a win!’). It was a really good experience and it made me

feel like the kids can learn, you know for us, those basic skills and colors, like and it is way more fun to learn colors going outside and finding things that are colors than it is to sing the color song. So, yeah it was good. (Participant 3)

Expanding teacher learning to stretch mindset is necessary when thinking about developing skills to teach STEM. Outdoor learning has played an important role in providing a platform in which to do this.

In analyzing data, I found a tendency for a dichotomy of teacher beliefs to emerge that included providing a structured approach versus providing an unstructured approach to learning when in the outdoor makerspace. Some participants believed that their lessons were not successful if they were not in control of student learning and others embraced and found benefit in the opportunity to provide a more organic, student autonomous approach to learning. Some participants focused on providing structure for students, “I understand that I need to front load my students with my expectations and enforce them consistently if I want the learning experience to be successful” (Participant 14), “I realized that the time spent like this outside should be well-planned and purposeful- and frequent!” (Participant 18). Other participants highlighted the benefit of providing more of an unstructured environment for students to learn in, “I learned (and am still learning) that learning does not always have to be planned, prepared, and preorganized. It's amazing the organic learning that occurs when outdoors and allowed to explore freely” (Participant 9). Other participants are continuing to struggle with finding a balance between structured and unstructured instruction, “A reservation I have is ensuring there is appropriate structure (enough that we're productive but not so much that it feels constricting or limiting)” (Participant 19). This tension between structure and lessons focused on student autonomy, suggests the need for more study and conversation about best practice in an outdoor makerspace. This topic will be further discussed in the next chapter.

Identifying science and engineering practices in activities/lessons and showing how outdoor learning provides a hands-on, authentic connection with nature are two ways that support the claim that outdoor makerspaces naturally serve as a means to develop STEM skills in teachers and students. By taking students outside for learning, teachers have grown to learn about themselves and are learning to stretch their mindset to change instructional practice to account for student-directed learning.

Closing Thoughts

In analyzing the data in this qualitative study, themes emerged about using outdoor spaces as a platform for learning. Participants reported that they were more likely to take students outside for learning after taking part in the study. They also reported higher rates of competence in teaching STEM to students using outdoor spaces. Themes that emerged included outdoor learning integration, teacher growth through outdoor learning, and developing STEM skills using outdoor spaces. Themes served as a basis to develop claims that were substantiated using evidence from the data. These claims could have implications to instructional practice and will be further discussed in the next chapter.

CHAPTER 5

DISCUSSION

The purpose of this study was to explore the potential relevance of an outdoor makerspace professional development intervention to strengthen teachers disposition to engage students in outdoor learning activities to develop STEM skills. The outdoor makerspace intervention allowed elementary teachers to first experience an outdoor makerspace activity to develop STEM skills, gave them opportunity to try it with their students, then provided time to reflect on their experience. This section will provide information about results of the intervention in relation to the extant literature, lessons learned, implications for future research and a conclusion which will include implications for teaching practice.

Results in Relation to the Extant Literature

Comparing the findings of this study to previous research, consistencies in results were discovered. As mentioned in previous chapters, outdoor learning has been identified as a source of benefit for students in a myriad of ways. Evidence of positive mental health and cognition (Lovell, 2016), reduction in occurrence of behavioral issues (Markevych et al., 2014), stress reduction, increase in resiliency, balanced emotional wellbeing (Chawla et al., 2014) and opportunities for deep and complex learning opportunities (Banning & Sullivan, 2011) have all been documented and substantiated by previous studies. Many of the participant perceptions in this study were consistent with these findings. Pre-assessment data showed that participants believed there were multiple benefits in taking students outside for learning. Cited benefits included change in environment, excitement to learn, physical and mental benefits, high engagement, authentic hands-on experiences, promotion of 21st century skills, and supporting academic skill development. What was discrepant, was a misalignment between participants thinking there were benefits in taking students outside and actually using outdoor spaces to engage students on a regular basis. This study showed teachers were not using outdoor spaces to yield maximum benefit to their students. Because of this misalignment, I chose to offer teachers time and space to construct and develop their understanding of the benefits of outdoor learning by experiencing it first-hand. This constructivist approach to building their understanding served as well to increase their comfort levels in using outdoor spaces to develop STEM skills in their students. Comparing pre-intervention and post-intervention assessments, participants reported higher scores in STEM preparation after the study than they did before. This study confirms that there are multiple benefits to taking students outside for learning, but also that to increase the likelihood for these participants to take students outside, knowing these benefits was not enough. It was through the experience of taking students outside that participants were able to understand the "deep and complex learning opportunities" (Banning & Sullivan, 2011) that the space offered. In post-intervention assessments, participants expanded their perceptions of benefits for students to include 'learning is expanded' and 'promotes positive connection with the environment.' Post-assessment data supports the claim that participant mindsets were expanded through experiencing time outside with students.

When considering research that has been performed most recently on the benefits of nature, there were some surprising similarities to the results of this study. In a compilation of studies focused on using the natural world as a resource, *Frontiers in Psychology* (October, 2019), published a collection of studies highlighting the benefits of outdoor learning for student learners. One study in particular, showed 'surprising benefits of teaching a class outside' (Kuo et al., 2018). The study "show[ed] that learning outdoors is not just a fun, novel experience for kids, but also helps them focus once they return to the classroom." These sentiments were echoed by participants in the current study. Multiple participants stated that after taking students outside, they returned to the classroom ready to learn. Another similarity that was evident was that participants from both studies had pre-intervention reservations about taking students outside, thinking they would be out of control and that they would be unable to focus. These pre-conceived reservations were put to rest when participants found the opposite to be true. Participants were surprised by the high level of engagement for their students, particularly the students who typically lacked focus, as well as the continued focus on learning when they returned to the classroom.

In the section highlighting priorities for future research, Kuo et al. (2018) states that studies need to be done with "students from less urban, less disadvantaged contexts, as well" (p. 37). The thinking is that urban, less advantaged students may have less contact with nature and therefore may have a heightened reaction to outdoor learning. In addition, they advise future studies integrate lessons focused on content other than biology in order to better establish the generality of the results. The current study begins to investigate outdoor learning incorporating suburban populations and lessons that are not biology specific. The results of this study, although not generalizable due to the size and the qualitative approach, give a glimpse that even these stipulations do not change the positive benefits of outdoor learning for student learners.

Lessons learned

Upon completion of this study, I found that I have learned lessons along the way. I discovered that my understanding of the power of outdoor makerspaces was limited and narrow before doing this study. I knew that hands-on experiential learning was a powerful tool to use with students, but I did not understand how outdoor spaces supported learning for teachers as well. Outdoor learning proved to lend an authentic context to stretch mindsets in order to construct new instructional thinking. One unexpected theme that arose from the data was how teacher learning was expanded during the implementation of the intervention. The theme ‘learning is expanded,’ was identified in during-intervention and post-intervention data collection 21 times for teacher learning. The categories under this theme for teacher learning included ‘teacher learned something new’ and ‘social emotional learning’(SEL). Although this was what I was hoping for, I did not anticipate such a strong showing for teacher learning to be expanded.

One lesson I learned during data collection was how difficult using photos was to capture useful information. Originally, I wanted to use photos to identify emotions of participants as they used outdoor spaces. I thought that I could triangulate data to highlight how outdoor learning supported emotional wellness. I realized as I was taking photos, that I have permission to take photos of participants and their prototypes, but not their faces. This changed how I used photos in the study. Instead of the participants, I took photos of the spaces where outdoor learning happened. Although, this changed the direction of my thinking, it still proved to be a valuable venture in thinking. This change in direction opened up new questions to be studied.

Implications for Professional Development

This action research study explored the potential relevance of an outdoor makerspace professional development intervention to strengthen teachers disposition to engage students in outdoor learning activities to develop STEM skills. The results of the study have implications for future professional development opportunities being constructed for educators. The results suggest that participants taking part in this hands-on opportunity, were more likely to take students outside for learning. Giving teachers time and space to engage students in outdoor learning allowed them to construct their own beliefs about the benefits of outdoor learning opportunities for students and as a result, built confidence in their ability to meaningfully engage students outside to develop STEM skills. My first recommendation would be to provide hands-on professional development sessions to model for teachers how to use outdoor spaces as a platform to integrate their science standards. Then challenge them to take students outside for learning using their new-found knowledge.

Lack of time and knowledge continues to be a challenge when working with teachers to develop quality STEM practices. In this study, teachers appreciated support in the form of ideas that integrated their science standards and used outdoor settings. This helped them to reduce time searching for outdoor learning ideas and also helped them to know the activity was a quality one that had been vetted by experts in the field. My recommendation would be to support teachers by providing ongoing resources in the form of vetted outdoor lessons that connect to national science standards.

Another surprising finding, that has an impact on STEM professional development, was that STEM learning happens naturally outside. In the initial stages of this study, I believed that to cover STEM content and process learning, participants needed to explicitly plan for STEM lessons. This was proved to be a narrow understanding of how outdoor makerspaces supported the science and engineering practices set forth by the NGSS. During data analysis, when categorizing the activities/lessons teachers performed in the outdoor makerspace with students, a total of 76 were reported. Out of these, only 24 were categorized as covering STEM specific content. The other 52 activity/lessons did not intentionally cover STEM specific content. It is these 52 activity/lessons that were analyzed in order to determine if they covered any of the science and engineering practices. It was surprising to learn that the majority of these non-STEM lessons covered one or more of the science and engineering practices. To compliment this finding, participants reported growth in STEM understanding over the course of the study. Comparing pre-intervention and post-intervention scores for ‘level of preparation in developing STEM skills for students in outdoor spaces,’ participant scores changed. The pre-intervention scores showed 17 participants reported being unprepared. The post-intervention scores showed 17 participants being prepared or very prepared. Understanding that outdoor learning naturally provides time and space to cover science and engineering practices is an important finding. This finding is powerful when thinking about filling known gaps in instructor support for teaching STEM. Earlier cycles of research showed gaps to include lack of materials to build, prototype, and conduct experiments and lack of knowledge on how to engage students in the engineering design process. If we can teach educators about the connection between outdoor learning and science and engineering practices, we can better support STEM learning.

Implications for Research

The results of this study support previous research that has been performed highlighting benefits of outdoor learning. These benefits include evidence that outdoor learning promotes balanced emotional wellbeing (Chawla et al., 2014), opportunities for deep and complex learning (Banning & Sullivan, 2011), high student engagement and reduction in disruptive behavior among students (Szcytko et al., 2018). The results of this study further the understanding of how outdoor learning impacts teacher practice and substantiates the idea of future study.

This study showed that a tension still exists for teachers with providing structured and unstructured learning for students in outdoor spaces. Participants struggled balancing controlling learning for students with a more organic approach giving students freedom to explore when taking them outside. Some participants felt that their lessons were unsuccessful when they did not feel in control of student learning. Others embraced the opportunity to give students freedom in learning and exploring. This tension suggests an opportunity for future study using outdoor makerspaces as a tool to train teachers how to provide a balance of structure and student autonomy. Reeve (2016) shows that when educators provide a balance of structure and student autonomy, high engagement is achieved. Since teachers are practiced at how they provide student support in the classroom, outdoor makerspaces can be a new platform in which to retrain teachers and students about the balance of structure and student autonomy.

One of the major findings in this study showed that taking students outside resulted in high student engagement. The high student engagement produced by this study could be tested in other age brackets to test the validity of using outdoor makerspaces with older students. McREL International published a white paper entitled *Student Engagement: Evidence-based Strategies to Boost Academic and Social-Emotional Results* (Abla & Fraumeni, 2019). This paper states the need for teachers, specifically with older students, to focus on building student engagement to boost academic and social-emotional results. “People change, and students, by and large, feel less connected with school the longer they’re there” (p. 3). One strategy identified to boost this engagement, is to connect to the “real” world through internships or service projects (p. 10). Since outdoor learning has been shown to provide both authentic learning contexts and service project opportunities, further study could test how older students respond to a class based on providing student learning in outdoor makerspaces in order to determine its effect on engagement.

Adverse weather was a factor impacting the reservations participants had about taking students outside for learning. In fact, weather prohibited one potential participant from completing the study and influenced another to decrease in her rating for likelihood of taking students outside. Further research could include how weather impacts the likelihood that teachers take students outside for learning. It would be interesting to see how weather in different areas around the world impact benefits, reservations, and perceptions of taking students outside for learning.

Conclusion

The results of this contextualized applied project are supported by prior research and provide limited evidence about the potential relevance of using an outdoor makerspace professional development opportunity as a tool to increase the likelihood that teachers take students outside for learning. In analyzing data, three themes emerged: 1) Integrating outdoor learning requires developing teacher comfort levels and overcoming negative factors, 2) Teachers are able to understand and support their students and their practice by integrating outdoor learning, 3) Outdoor makerspaces naturally serve as a platform to develop STEM skills as teachers and students make meaning through connecting with the environment. Each of these themes have implications for instructional practice.

The purpose of this study was to gather a baseline of data in order to inform the creation of future professional development opportunities incorporating outdoor spaces to develop STEM skills in students and teachers. This study revealed some important information about how outdoor spaces change learning for students but also how outdoor learning changes teacher's understanding of their students and their practice.

It was clear that the participants in this study needed to develop comfort levels and required support in overcoming negative factors in order to integrate outdoor learning into their practice. In the beginning, participants believed there were benefits in taking students outside for learning, but participants were not maximizing benefits by going outside on a regular basis. At the end of the study, there was consensus among participants that engaging students in outdoor learning had a multitude of benefits. Reported benefits included: high engagement, expanded learning, promotion of physical and mental health, provided a change of setting, created novel experiences for students, and provided fodder to develop 21st century skills. In addition, participants reported that they would all be more likely to use outdoor spaces for learning in the future. Using outdoor makerspaces, for these 20 participants, has proven to be a platform that benefits learning for both teachers and students. I am not certain that this understanding would have been realized without the explicit requirement for them to take students outside for learning. Allowing teachers to engage in outdoor makerspaces by providing hands-on exploration and reflection, allows them to construct a meaningful understanding of outdoor learning spaces. They can experience how these spaces can be used and are able to develop a first-hand account of the benefits of using outdoor spaces with students. In addition, teachers need to be supported with resources that give them ideas for content connection and integration. The ability to connect with others doing the same thing tended to increase quality and quantity of lessons/activities provided in the outdoor platform. This finding suggests that to increase the likelihood that teachers take students outside for learning, we need to get teachers outside. This could be done in pre-service teacher training or in ongoing training for in-service teachers.

Lack of time and lack of knowledge continues to be a concern for elementary teachers when it comes to engaging students in outdoor makerspaces to develop STEM skills. This study shed light on how lack of experience outside may create barriers for teachers when planning for outdoor learning lessons. This data calls for specific changes when we think about teaching practice. It suggests that while teachers may understand the benefits of taking students outside for learning, they may lack the time and know how to purposefully plan for its integration. We need to provide professional development opportunities in order to give teachers time and space to experience outdoor makerspaces in order for them to know what it looks like and how to integrate it into daily practice. Mindsets of teachers need to be expanded. This study shows that this can be done by providing hands-on professional development opportunities for teachers in outdoor spaces. This professional development needs to be followed by teachers dedicated to taking students outside for learning opportunities and further support on ideas for integration.

For the participants in this study, the outdoor makerspace proved to be a valuable addition to the known confines of the indoor classroom space. It offers a hands-on, everchanging, ever-present environment to engage students. This untapped resource could provide an alternate platform for training teachers to engage students. To do this, we must first better understand outdoor makerspaces.

When I began this study, my understanding of outdoor makerspaces was developed from my own work with students in outdoor spaces. I used the term "outdoor makerspace" as a way to describe the learning I provided students. This learning engaged them in loose and unstructured time to interact in nature. Time outside served to construct or 'make' knowledge as they used natural and man-made materials to design and build. As discussed earlier, multiple definitions have served to define makerspaces. For example, Laura Fleming, an educator and best-selling author says, "A makerspace is a metaphor for a unique learning environment that encourages tinkering, play and open-ended exploration for all" (Fleming, 2016). "Makerspaces can be defined as a space where students create self-directed passion projects, prototype inventions, and learn new skills based on their interests through collaboration and tinkering. Makerspaces are dedicated areas where soft-skills can be cultivated" (Cross, 2017, p. 3). If these definitions serve to describe makerspaces, what sets an outdoor makerspace apart? Is it just the fact that these things are being done in an outdoor space? Do outdoor makerspaces require the need to engage in using natural material to construct meaning and build prototypes? This distinction is one I continue to struggle with. If we define outdoor makerspaces simply as students being outside tinkering with manmade materials, how can we ensure a quality interaction with nature? If we want to use outdoor makerspaces as a tool for teachers to engage students, we need to develop a definition that describes its function.

Another implication for teaching practice comes from the fact that science and engineering practices were found to be a natural occurrence in outdoor learning. Even when teachers did not plan for STEM instruction in outdoor spaces, 87.5% of the lessons/activities were found to support science and engineering practices. This was not an aspect that was anticipated. This is a powerful finding that can provide another avenue when preparing instructors to teach STEM. In a time when teachers are required to develop STEM skills in their students but may lack the resources or knowledge to do so, outdoor makerspaces can provide opportunity for teachers and students to develop these skills in a co-learning model. Outdoor spaces provide engaging, authentic, real-world projects. The results of this study suggest the importance of studying outdoor makerspaces with older students in order to boost engagement and to address the tension for teachers between structured and organic learning. Using outdoor makerspaces as a platform to boost student and teacher learning may provide opportunity to change the landscape of education.

This research contributes to the literature by helping to suggest what outdoor makerspaces encompass. By offering a working definition and research to support the use of an outdoor makerspace professional development with elementary school teachers, others may find relevance in their work. Congruously, professional development providers may discover the importance of offering similar experiences to inspire and empower teachers to take students outside for learning.

In conclusion, the outdoor makerspace was used to construct prototypes as well as to construct knowledge, as it stretched the mindset of participants to develop a deeper understanding of the benefits of using outdoor spaces with students. It offered some known and some unforeseen benefits for both students and teachers. The knowledge and understanding gained in this study lead to a deeper and broader understanding of the power of outdoor makerspaces and the benefits to teachers and their students. Albert Einstein sums it up well: “Look deep into **nature**, and then you will understand everything better.” Simply allow teachers and students time outside and begin to empower positive instructional change.

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APPENDIX A

OUTDOOR MAKERSPACE PRE-INTERVENTION ASSESSMENT

(Appendix A)

Pre-Intervention Assessment

Prompt 1: Name

Prompt 2: Grade you teach: K, 1, 2, 3, 4, 5, 6, other

Prompt 3: Years of teaching experience: 1-3, 4-6, 7-9, 10-12, 13-15, 16 or more.

Prompt 4: In the past, how likely were you to take students outside for learning? (Estimate how many times in 1 year). Not likely (0 times), Likely (1-5 times), Very Likely (more than 5 times).

Prompt 5: Rate your level of preparation in developing STEM skills for students in outdoor spaces. Not prepared, prepared, very prepared.

Prompt 6: What are the benefits of using outdoor spaces for learning?

Prompt 7: What expectations do you have about using an Outdoor Makerspace? Reservations or excitement?

Prompt 8: How do you think students will respond to learning outside?

APPENDIX B

OUTDOOR MAKERSPACE DURING-INTERVENTION ASSESSMENT

(Appendix B)

During-Intervention Assessment

Prompt 1: Name

Prompt 2: Date of Outdoor Learning

Prompt 3: How much time spent outside

Prompt 4: What grade do you teach: K, 1, 2, 3, 4, 5, 6, other

Prompt 5: How many times have you taken students outside for learning this year? 0, 1, 2, 3, 4, 5, more than 5.

Prompt 6: What activity did you do with your students?

Prompt 7: Reflect on your time outside with students. What surprised you? What did you learn?

APPENDIX C

OUTDOOR MAKERSPACE POST-INTERVENTION ASSESSMENT

(Appendix C)

Post-Intervention Assessment

Prompt 1: Name

Prompt 2: Grade you teach: K, 1, 2, 3, 4, 5, 6, other

Prompt 3: In the future, how likely are you to take students outside for learning? (Estimate how many times in 1 year) Not likely (0 times), Likely (1-5 times), Very Likely (more than 5 times).

Prompt 4: Rate your level of preparation in developing STEM skills for students in outdoor spaces. Not prepared, prepared, very prepared.

Prompt 5: What are the benefits of using outdoor spaces for learning?

Prompt 6: What expectations do you have about using an Outdoor Makerspace in the future? Reservations or excitement?

Prompt 7: How did students respond to learning outside?

Prompt 8: What barriers still exist for you in using outdoor makerspaces with students?

Prompt 9: What support do you need in using outdoor makerspaces to develop STEM skills in students?

Semi-Structured Group Interview Questions

Questions:

- What was most surprising in taking part in Outdoor Makerspace activities?
- What benefits do you notice in taking students outside for learning?

- How has your understanding of developing STEM skills in students changed?
- How has your confidence changed in taking students outside for learning activities?
- Will you use outdoor activities to develop student STEM skills? If so, what activities will you use?
- What continued support do you need to develop student learning in STEM or the environment?

APPENDIX D

OUTDOOR MAKERSPACE GOOGLE SLIDE PRESENTATION

(Appendix D)

Google Slide Presentation for

Outdoor Makerspace Professional Development Session

SLIDE 1- VERBAL INSTRUCTIONS: Welcome to Outdoor Makerspaces: Using Outdoor Spaces to Develop STEM Skills.

Sign into Google Classroom to do the Pre-Assessment

Class Code: 5p1v0zz

Prompt 1: Name

Prompt 2: Grade you teach

Prompt 3: Years of teaching experience: 1-3, 4-6, 7-9, 10-12, 13-16, 16 or more.

Prompt 4: In the past, how likely were you to take students outside for learning? (Estimate how many times in 1 year). Not likely (0 times), Likely (1-5 times), Very Likely (more than 5 times).

Prompt 5: Rate your level of preparation in developing STEM skills for students in outdoor spaces. Not prepared, prepared, very prepared.

Prompt 6: What are the benefits of using outdoor spaces for learning?

Prompt 7: What expectations do you have about using an Outdoor Makerspace? Reservations or excitement?

Prompt 8: How do you think students will respond to learning outside?

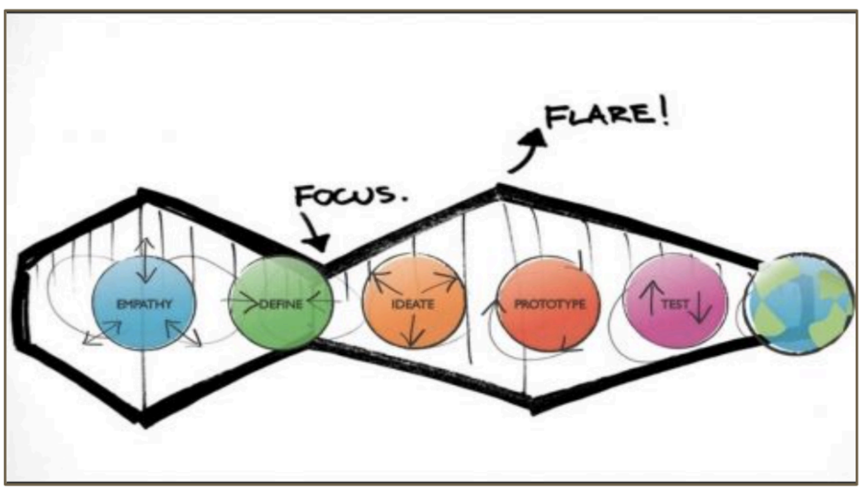
SLIDE 2- VERBAL INSTRUCTIONS: Log into the Google classroom and take the pre-assessment survey.

SLIDE 3- VERBAL INSTRUCTIONS: Why use Outdoor Makerspaces? Yes, we have to develop STEM skills in students. Most teachers do this with screens. Although this is a must...we need to balance screen time with screen free STEM options. Nature is one of those opportunities to engage students in STEM while working on social and emotional skills.

When we think about student engagement there are relevant contexts to consider. 1) The top context is students' lived experience. As teachers, it is difficult for all of our students to have just 1 shared lived experience. Developing shared lived experiences with students is crucial in knowing their background knowledge and knowing how to move them forward in the iterative process. 2) Using the local context is essential in engaging students in meaningful contexts that they can construct their own meaning that will last. This means using the community, local geography, and tying into local history. 3) Allowing students to understand how their work may impact and create change beyond school. I do this by using the UN Sustainable Development Goals.

Finally, Kids have the right to be outside! Research shows that spending time outside reduces stress and anxiety, improves mental health, creativity and imagination grow, self-reliance flourishes, learning is heightened, physical fitness improves, immune systems get stronger, ADHD symptoms are reduced. In addition, when teaching science on a limited budget and with few supplies, the outdoors offers opportunities to use free supplies. As we transition into using the NGSS, outdoor spaces allow us to give students opportunities to connect with authentic landscapes.

Design Thinking

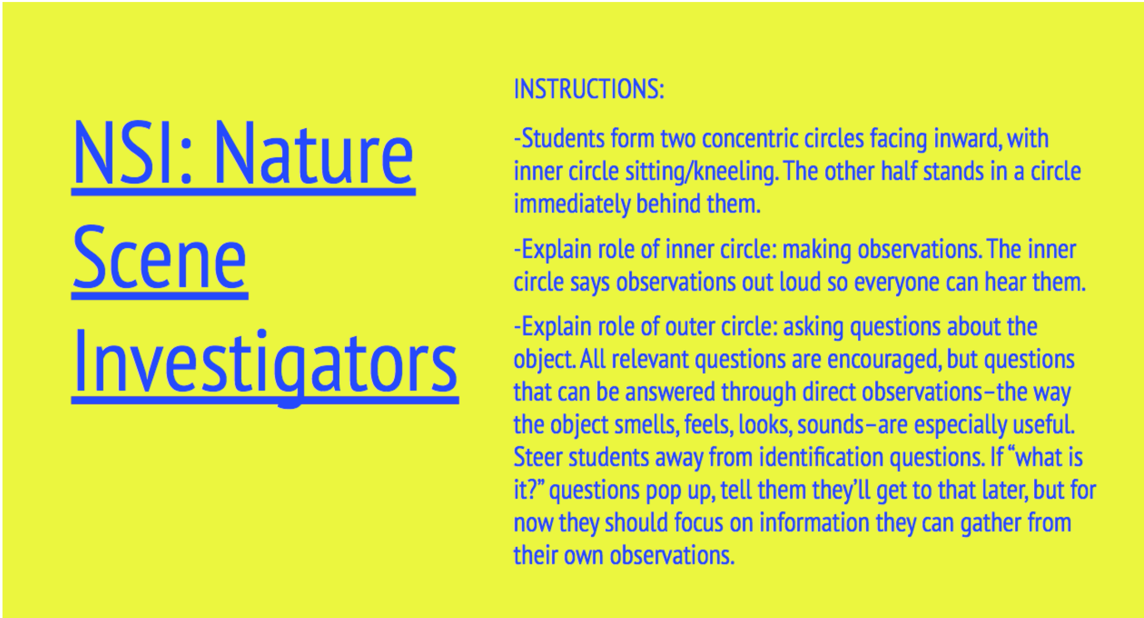


SLIDE 4- VERBAL INSTRUCTIONS: Design thinking is one way we can teach students the engineering design process. We need to give students time and space to empathize and connect with nature so that they are passionate about solving the problems the world is facing.

Scavenger Hunts: Use tools, review vocabulary, ignite curiosity, connect with your local habitats.

SLIDE 5- VERBAL INSTRUCTIONS: Scavenger Hunts are a quick and easy way to get to know your area and to notice things you haven't before. There are multiple forms of scavenger hunts that review vocabulary, allow students to use tools, ignite students' curiosity, and to authentically connect with your local habitats. These two forms were found online. The first is great to use with younger students and the other can be used with older students. We are going to use the biodiversity scavenger hunt to get to know our outdoor space. Each of the boxes you and your team check off are worth one point. If you complete the food chain, it is worth 2 points. Look over the scavenger hunt and let me know if there are vocabulary words you are unfamiliar with so we can clear those up before we start. You and your team will have 4 minutes to get as many boxes marked off as you can.

After the scavenger hunt, ask this question: What did you notice?



SLIDE 6- VERBAL INSTRUCTIONS: Nature Scene Investigator is a protocol that allows participants to learn how to ask questions and make observations with objects in nature. The topic of discussion will be 2 types of nests, one a bird's nest the other a paper wasp nest. Participants follow the instructions below to ask questions and make observations.

INSTRUCTIONS:

-Students form two concentric circles facing inward, with inner circle sitting/kneeling. The other half stands in a circle immediately behind them.

-Explain role of inner circle: making observations. The inner circle says observations out loud so everyone can hear them.

-Explain role of outer circle: asking questions about the object. All relevant questions are encouraged, but questions that can be answered through direct observations–the way the object smells, feels, looks, sounds–are especially useful. Steer students away from identification questions. If "what is it?" questions pop up, tell them they'll get to that later, but for now they should focus on information they can gather from their own observations.

-After a lull happens in talking, have participants switch roles.

Discussion after: what did you notice? Did you see how the trajectory of the questions and observations went from simplistic to richer and deeper? How can you use this protocol to engage students in your own contexts? This can assist in developing SEPs for students.

Task Cards

Task Card #1: Guided Inquiry

How can you use natural materials to construct a bird's nest?

First, examine the bird nests to understand how birds construct from natural and found materials. Discuss with a partner/team what materials you want to build a nest with, then gather your materials from nature. Finally, use the collected materials to construct a nest. Reflect in your journal about the process.

Task Card #2: Open Inquiry

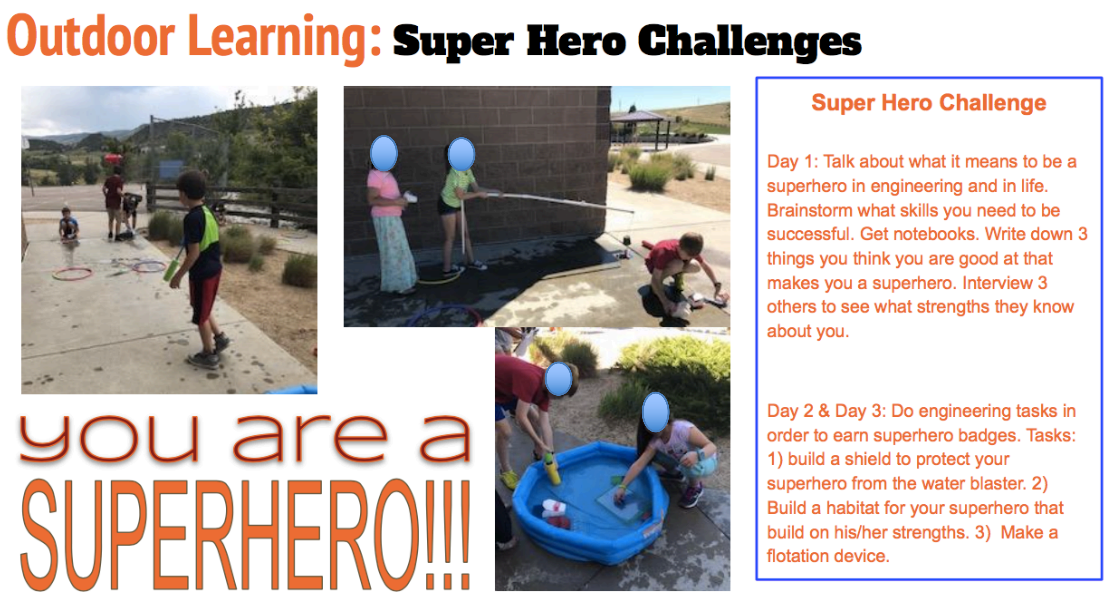
Free time to tinker

Participants choosing task #2 will have access to all tools, outdoor makerspace carts, materials in nature, and nature journals. Use this time and space as an opportunity to tinker in nature and explore new and interesting phenomena. Use your journal to reflect on your learning and record questions you have.

SLIDE 7- VERBAL INSTRUCTIONS: Task cards for engaging in nature.

Task Card #1: Guided Inquiry
How can you use natural materials to construct a bird's nest?
First, examine the bird nests to understand how birds construct from natural and found materials using the NSI Protocol. Discuss with a partner/team what materials you want to build a nest with, then gather your materials from nature. Finally, use the collected materials to construct a nest. Reflect aloud about the process. What did you notice about the process? What could you change?

SLIDE 8- VERBAL INSTRUCTIONS: For me, I started outdoor makerspaces in an enclosed area. When taking kids outside, tailor it to start at your comfort level. As you spend more time outside, you will feel more comfortable and know your boundaries. This example is one of learning about infrastructure. I took a play space and broke it up into plots. Groups of students needed to first build a structure, then transport water from the water source to their structure. This task allowed me to see how students interacted with each other in an outdoor space doing STEM tasks.



SLIDE 9- VERBAL INSTRUCTIONS: This example of STEM tasks in the outdoor makerspace supports social emotional learning. Instructions for what I did is included in the slide: Day 1: Talk about what it means to be a superhero in engineering and in life. Brainstorm what skills you need to be successful. Get notebooks. Write down 3 things you think you are good at that makes you a superhero. Interview 3 others to see what strengths they know about you. Day 2 & Day 3: Do engineering tasks in order to earn superhero badges. Tasks: 1) build a shield to protect your superhero from the water blaster. 2) Build a habitat for your superhero that build on his/her strengths. 3) Make a flotation device.

SLIDE 10- VERBAL INSTRUCTIONS: This outdoor learning example shows how you can use a scientific investigation to feed into an engineering design task. Using the design thinking protocol (see slide 4), you need to first empathize to find out about worms before building a habitat for them. First experiment with worms to find if they like light or dark. Place the worm in between a light and dark patch to see where they are drawn. Record the results on a class chart. Repeat the experiment 5 times and record results. Next, see if worms like wet or dry places. Place a worm in between a wet and dry patch to see where they are drawn. Record the results on a class chart. Repeat the experiment 5 times and record results. Look at the results to determine what worms need. Design and build a worm habitat to meet the needs of your worm.

SLIDE 11- VERBAL INSTRUCTIONS: Nature walks are a great way to look for human impact in surrounding areas. The first picture shows how students found tadpoles in a big puddle that formed by the school. As the puddle dried up, they were concerned with the health of the tadpoles, so they brought a hose and filled the puddle as the water evaporated. One student even made a filtration system to run the water through to ensure it was clean. The next picture shows how a group of 6th graders taught a younger group about students about the ecosystem they live in. They took them on a scavenger hunt to look for creatures. The third picture shows how students are tinkering in nature. They are calm and focused. Outdoor learning gives them a sense of peace. The red circle in the picture shows a “bush.” We thought this was just a normal bush until we went for a walk and discovered it was actually barbed wire. The discovery prompted a discussion of why the pile of wire was there. What was here before our school was built and what will be here after the school is gone. It brought up discussions of responsibility and human impact. The other pictures show teachers using outdoor spaces for class meetings, reading, instructional blocks. The pond fieldtrip allowed students to see the human impact of fishing on their beloved pond.

SLIDE 12- VERBAL INSTRUCTIONS: Allowing students time and space to tinker in nature gives them freedom to discover what they are curious about. Allows them to ask questions and have fun engaging with nature. The pictures show how students build, find new living things, use biomimicry to build nests, find treasures, build forts, use tools to discover what animals live near us….

Reflection:
How can I use Outdoor MakerSpaces in my context?

On a sticky note
post one outdoor learning
activity you would like to
try with your students.

SLIDE 13- VERBAL INSTRUCTIONS: Every outdoor context is different. How can you use outdoor makerspaces in your own area? On a sticky note post an idea that you are going to try with your students.

Materials

-carts on wheels
-squirt bottles
-small shovels
-buckets
-funnels
-PVC pipe
-hose
-blow up pool
-binoculars
-tweezers
-small containers

SLIDE 14- VERBAL INSTRUCTIONS: Here is a starter list of materials that are helpful in an outdoor makerspace.

Resources:

20 STEM Outdoor Learning Activities
Last Child in the Woods, Richard Louv
The Nature Connection, Clare Walker Leslie. Outdoor learning activities for all 12 months.
BEETLES, (Better Environmental Education, Teaching, Learning & Expertise Sharing) Free resources to engage students outside, Lawrence Hall of Science
Generation Wild: 100 things to do before you are 12, S'more solar oven, book ideas.

Citizen Science: *Citizen Science is collaborative scientific research, managed by scientists and conducted by amateur or non-professional scientists in the field.* Its goal is to further science itself---and the understanding of both science and the scientific process.

GLOBE (Global Learning and Observations to Benefit the Environment)
CoCoRaHs Community Collaborative Rain, Hail, and Snow Network
Project Noah is a tool to explore and document wildlife, a platform to harness the power of citizen scientists everywhere.
Eco-Schools USA Green projects to engage students

SLIDE 15- VERBAL INSTRUCTIONS: Resources are helpful when you are just getting started with taking students outside. I have linked 20 STEM outdoor learning activities, Generation wild that has the reasons for going outside and activities to do with your students, BEETLES which give protocols for engaging students outside with nature. If you are interested in doing citizen science with your students, there are some resources that show you how to engage students in collecting scientific data to inform scientists around the globe in their work. Sustainability work is also a great way to engage students in authentic work in which they can create a positive change.

Looking for a few adventurous teachers?

-Sign a consent form and receive a copy of the CO Kids Outdoor Bill of Rights.

-Take students outside for learning opportunities at least 3 times between now and Oct. 31. Take at least 3 photos of each time in order to reflect on your experience. Reflect after each experience via google form.

-Take the post-assessment survey.

-Take part in a group interview in November to reflect on your experience.

SLIDE 16- VERBAL INSTRUCTIONS: I am taking volunteers who would like to try outdoor makerspace learning with their students. If you would like to take part in this study, please fill out the consent form. When you return it to me, you will receive the CO Kids Outdoor Bill of Rights to post in your classroom. You will be committing to taking your students outside for at least 3 opportunities for learning between now, Aug 2., and Oct 31. You will take at least 3 photos when you are outside with your students in order to reflect on your experience. Reflect after each experience via google forms. In Nov., you will take the post-assessment survey and take part in a group interview to reflect on your experience.

APPENDIX E

WEEKLY EMAILS

(Appendix E)

Weekly Emails with Outdoor Learning Ideas

Aug 11, 2019, 9:50 AM
Hey Outdoor Makerspace Cohort!

First I wanted to say thank you for signing up to be part of my research! All of your feedback, positive and negative, will help me to think through how to better support teachers. It has been fun to see how teachers are already getting kids outside for learning.

To support our group with outdoor learning, I will send weekly emails with ideas for you to integrate with students. These are just ideas...do not feel like you have to use them, they are just here to support you.

Remember to reflect on your outdoor learning experiences on the form that I shared with you in our google classroom.

OUTDOOR LEARNING IDEA #1: Walk and Talk
Students will:

- Discuss various topics and questions with peers.
- Improve listening skills
- Use scientific language to exchange ideas.
- Become more comfortable sharing ideas with the group.

Before going outside for an outdoor walk/hike, line students up in sets of two. This will keep students closer to you as you walk/hike and provide students a talking partner during the walk. Pose questions along the walk/hike to engage students in topics of your choice. State question twice, then say, “walk & talk!”
The walk-talk PDF is attached for more information.

Please let me know if you have any questions or would like me to demo with your class (I have time Monday and Tuesday this week 9:15-1:30).

Thanks so much for your willingness to stretch yourselves!

beetles

Science and Teaching for Field Instructors

Student Activity Guide

Walk & Talk

Many field instructors have found this simple routine to be transformative for their field experiences with students, because it kicks off discourse so well. It's easy to lead, and easy to participate in, because it's primarily one-on-one discussion. While walking from one spot to the next, students discuss prompts and questions in rotating pairs. It helps establish a learning community and a "culture of talk" for your group, in which ideas and observations are discussed and valued by all members. It's particularly useful at the beginning of a field experience as an invitation to the theme, and then provides a way to reflect back at the end of the experience.

Students will:

- **Discuss various topics and questions with peers.**
- **Improve listening skills**
- **Use scientific language to exchange ideas.**
- **Become more comfortable sharing ideas with the group.**

Grade Level:
Any grade

Timing:
Flexible timing: 5–20 minutes

Related Activities:
Walk & Talk can be used in the invitation or reflection stage of any activity.

Materials:
Prepared questions

Tips:
To ensure a successful experience, review the teaching tips found on page 2 and throughout this guide.

Setting:
Choose a path wide enough so partners can walk two abreast. It's great to do at the beginning and end of a hike.

NEXT GENERATION SCIENCE STANDARDS

Walk & Talk **is a discussion routine that can be used throughout an activity or sequence of activities to support the type of learning called for by the** ***NGSS (and Common Core)*** **by providing students the opportunity to talk about science ideas, and creating a culture of discourse within a group of students. For additional information about connections to** ***NGSS*****, go to page 9 of this guide.**

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Sun, Aug 18, 2019, 9:01 AM
Hey Outdoor Makerspace Cohort,

It has been fun and exciting to see how teachers are using the outdoors to expand student thinking. Don't forget to fill out the google form to reflect after each of your outdoor activities.
OUTDOOR LEARNING IDEA #2: Outdoor Math Learning
Here are some ideas to include math in your outdoor learning adventures:

Penny Hike- use an object like a penny. Have students find 10 things from the natural/social system bigger/smaller than a penny.
Measuring- use appropriate tools to find items in nature that are 1 inch, 12 inches long, etc.
Shape Hunt- students find and record shapes found in nature.
Measure our campus and create scaled maps.
Measure weather data points to see how they change over time. RXP has a weather station that can be tracked at Wunderground.

Have fun this week!

Mon, Aug 26, 2019, 6:26 AM
Hey Outdoor Makerspace Cohort,

It has been a beautiful week in engineering learning about biodiversity at RXI and how to make square bubbles at RXP. Here are some ideas for this week brought to you by Generation Wild. Don't forget to fill out the google form to reflect after each of your outdoor activities.

OUTDOOR LEARNING IDEA #3: 100 things to do outside before you are 12.

Did you know that on average, kids spend only 7 minutes a day playing outside?

Generation Wild is a great resource to inspire outdoor activities for kids. I have attached a PDF of 100 things to do outside before you are 12. You can use this with your class or give one to each student.

Have fun exploring!

GOCO

GENERATION WILD

Kids grow better outside.

100 things to do before you're 12.

- NO. 1 Skip rocks.
- NO. 2 Spot a shooting star.
- NO. 3 Dig to China.
- NO. 4 Create a sidewalk mural.
- NO. 5 Roll down a hill.
- NO. 6 Go on a picnic.
- NO. 7 Build a fort.
- NO. 8 See what's hiding under a rock.
- NO. 9 Tightrope walk on a log.
- NO. 10 Blow dandelions into the wind.
- NO. 11 Imitate a bird's call.
- NO. 12 Dance in the rain.
- NO. 13 Dig up worms.
- NO. 14 Make a flower necklace.
- NO. 15 Climb a tree.
- NO. 16 Sleep under the stars.
- NO. 17 Fly a kite.
- NO. 18 Explore a state park.
- NO. 19 Roast marshmallows.
- NO. 20 Find the Big Dipper.
- NO. 21 Jump into a pile of leaves.
- NO. 22 Build a snowman.
- NO. 23 Splash in puddles.
- NO. 24 Go fishing and eat what you catch.
- NO. 25 Make a walkie talkie out of tin cans and string.
- NO. 26 Go on a hayride.
- NO. 27 Eat an apple straight from a tree.
- NO. 28 Catch a crawdad.
- NO. 29 Wade in a stream.
- NO. 30 Cook over a campfire.
- NO. 31 Find a walking stick.
- NO. 32 Pick wild raspberries.
- NO. 33 Hike a 14er.
- NO. 34 Read a book under a tree.
- NO. 35 Start a water balloon fight.
- NO. 36 Grow something from a seed.
- NO. 37 Catch snowflakes on your tongue.
- NO. 38 Run through a sprinkler.
- NO. 39 Try to catch your shadow.
- NO. 40 Make a musical instrument with stuff from nature.
- NO. 41 Learn how to do a cartwheel.
- NO. 42 Make a crayon leaf rubbing.
- NO. 43 Bury a time capsule.
- NO. 44 Whittle a stick.
- NO. 45 Collect six different kinds of rocks.
- NO. 46 Tell ghost stories around the campfire.
- NO. 47 Pick up pennies from the deep end of the pool.
- NO. 48 Hear your own echo.
- NO. 49 Find shapes in the clouds.
- NO. 50 Find your way home using only a compass and map.
- NO. 51 Chase a butterfly.
- NO. 52 Find a four-leaf clover.
- NO. 53 Swing on a rope swing.
- NO. 54 Build a snow cave.
- NO. 55 Play hopscotch.
- NO. 56 Tube down a creek.
- NO. 57 Make a fairy garden.
- NO. 58 Play capture the flag.
- NO. 59 Make mud pies.
- NO. 60 Go cardboard box sledding.
- NO. 61 Hear an elk bugle in the wild.
- NO. 62 Pop a wheelie.
- NO. 63 Race toy boats down a stream.
- NO. 64 Find a secret hiding place.
- NO. 65 Go bird watching.
- NO. 66 Brew sun tea.
- NO. 67 Play Double Dutch jump rope.
- NO. 68 Collect bugs.
- NO. 69 Go ice skating on a pond.
- NO. 70 See who can jump the farthest.
- NO. 71 Play freeze tag in the moonlight.
- NO. 72 Walk on stilts.
- NO. 73 Paddle a canoe.
- NO. 74 Have a wheelbarrow race.
- NO. 75 Spin in circles and try to walk a straight line.
- NO. 76 Mark your trail with cairns.
- NO. 77 Jump off a diving board.
- NO. 78 Walk on your hands.
- NO. 79 Get your own pumpkin from a pumpkin patch.
- NO. 80 Run a mile.
- NO. 81 Make a bow and arrow with branches and string.
- NO. 82 Visit a glacier.
- NO. 83 Make a pinecone bird feeder.
- NO. 84 Go rock climbing.
- NO. 85 Find a columbine in the wild.
- NO. 86 Make a tiny boat using a leaf.
- NO. 87 Pitch a tent.
- NO. 88 Identify animals by their tracks.
- NO. 89 Make snow ice cream.
- NO. 90 Play in a treehouse.
- NO. 91 Watch the sunrise.
- NO. 92 Eat something you grew.
- NO. 93 Build a bike jump.
- NO. 94 Set up a lemonade stand.
- NO. 95 Press flowers in a book.
- NO. 96 Watch a caterpillar turn into a butterfly.
- NO. 97 Go horseback riding.
- NO. 98 Stay out for a lunar eclipse.
- NO. 99 Make a snow angel.
- NO. 100 Soak in a natural hot spring.

MORE INFO
GenerationWild.com

FACEBOOK
Generation Wild Colorado

INSTAGRAM
@GenerationWildColorado

TAG US
#100ThingsToDo

Sun, Sep 1, 2019, 6:06 PM

Hey Outdoor Makerspace Cohort!

I hope your time outside is proving to be valuable for you and your students! Here is another resource to support you as you take students outside.
Remember to reflect on your outdoor learning experiences on the form that I shared with you in our google classroom. Reflection after Outdoor Learning

OUTDOOR LEARNING IDEA #4:
Did you know that when outside: Learning is heightened
Kids have been shown to perform better on concentration tests after being exposed to the outdoors. This exposure to the outdoors is also linked with the delay of gratification and lower ratings of hyperactivity in children. In fact, kids learn better outdoors. Studies have shown that kids are significantly more engaged in schoolwork in an outdoor setting, which allows teachers to teach uninterrupted for nearly twice as long as they can in classes indoors.

20 Outdoor Learning activities to develop STEM skills

Mon, Sep 9, 2019, 9:55 AM

Hey Outdoor Makerspace Cohort!
Did you know that when outside: Creativity and imagination grow
Being outdoors in natural surroundings stimulates a child's imagination. When kids play outside, they interact meaningfully with their surroundings. They have room to think and explore, design their own activities, and approach the world in inventive ways.

Here is another resource to support you as you take students outside. Remember to reflect on your outdoor learning experiences on the form that I shared with you in our google classroom. Reflection after Outdoor Learning

OUTDOOR LEARNING IDEA #5: Outdoor Classroom Day: Challenge: spend an entire day outside for learning.

This site has many great ideas that include:
-Sound mapping: Mapping skills can be tricky to learn. Have students sit in one place, draw a map of their surroundings in sounds.

-Journey Stick: Engage students in nature art. Have students find a stick and pick up nature treasures along a nature hike to preserve memories and knowledge of the journey they made.

-Texture Walk: Have students experience their surroundings through touch. How does this perspective change their understanding of nature?
-Hungry Birds: Our campus is home to a variety of birds. During the cold season, these birds may struggle to find food. Make bird feeders that will ensure a healthy population of birds.

Sat, Sep 14, 2019, 2:04 PM

Hey Outdoor Makerspace Cohort!
Did you know that being outside: Stress and anxiety decrease
There's a correlation between exposure to nature and lower levels of stress. In fact, children's stress levels fall within minutes of seeing green spaces. Studies confirm that spending time in a forest can help reduce concentrations of the stress hormone cortisol, lower pulse rate and blood pressure, and decrease anxiety. So next time life gets overwhelming, grab your kids and go camping.

OUTDOOR LEARNING IDEA #6: Citizen Science: *Citizen Science is collaborative scientific research, managed by scientists and conducted by amateur or non-professional scientists in the field.* Its goal is to further science itself---and the understanding of both science and the scientific process.

GLOBE (Global Learning and Observations to Benefit the Environment) Protocols to engage students in authentic science data collection.

CoCoRaHs Community Collaborative Rain, Hail, and Snow Network

Project Noah is a tool to explore and document wildlife, a platform to harness the power of citizen scientists everywhere.

Eco-Schools USA Green projects to engage students in creating positive change in 10 pathways to sustainability.

Sat, Sep 21, 2019, 10:34 PM

Hey Outdoor Makerspace Cohort,
Did you know that ADHD symptoms are reduced when time is spent outside.
Research shows that children with attention deficit disorder are better able to concentrate and follow directions after playing in an outdoor setting than they were after playing indoors.
In 2009, a study revealed that children who were professionally diagnosed with ADHD were able to concentrate better after just 20 minutes of walking in a park. Those 20 minutes in a natural environment were enough to elevate attention performance, which led the researchers to conclude that doses of nature serve as a safe, inexpensive, widely accessible tool for managing ADHD symptoms.

OUTDOOR LEARNING IDEA #7: Taking Nature Photos

Give students i-pads and send them outside to take photos. Have them look for:

- evidence of: change of season, rain, plants/animals that live on campus, types of rocks, plants changing over time.
- prompts for writing
- patterns in nature, shapes, colors, textures
- phases of the moon, how shadows change throughout the day
- take a photo a day from the same perspective to show change over time
- artistic vision of nature, abstract vision

Here are some photos our students took on our Bio Blitz this year (aren't they amazing!)



Sep 29, 2019, 9:44 AM

Hey Outdoor Makerspace Cohort,

Three and a half more weeks to complete your 3 visits outside with your class. I hope your time outside is proving to be valuable for you and your students! Here is another resource to support you as you take students outside. Remember to reflect on your outdoor learning experiences on the form I shared with you: Reflection after Outdoor Learning

Did you know: Immune systems get stronger and healthier when kids go outside. Outdoor light stimulates the pineal gland, the part of the brain that is vital to keeping our immune systems strong. Sunshine improves vitamin D levels in your child's body, which can provide protection from osteoporosis and health conditions such as heart disease and diabetes.

OUTDOOR LEARNING IDEA #8: Create a Mission

John Muir created "Mission: Explore" books that included ideas for people to get excited to interact with their environment (attached below). Here is an excerpt:

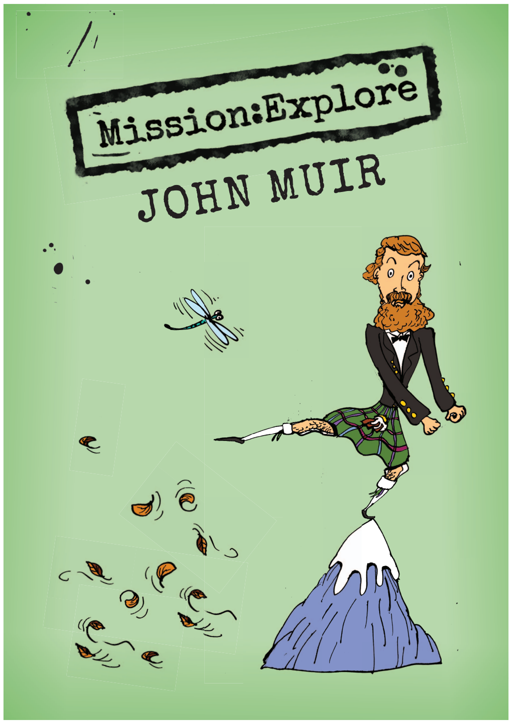
Dear Explorer,

These missions will help you follow in the footsteps of nature conservation's father figure - John Muir. They are for everyone who dares to explore the world with Muir's spirit of adventure and curiosity.

Inside 'Mission: Explore John Muir' you'll find 20 Muir- related missions, and some of Muir's words from over 100 years ago. Your challenge is to complete and record as many missions as you can. You can find plenty of other missions to do on the Mission: Explore website.

By the time you have completed your copy of this e-book you will have tracked, watched, listened, walked, imagined, immersed and even danced your way through wild nature on your doorstep and further.

Before you accept any missions in this book complete our Explorer Basic Training (from page 24) and make sure you have permission to carry out your plans.
It's time to explore.



The Geography Collective with The John Muir Trust

Sat, Oct 5, 2019, 2:54 PM

Hey Outdoor Makerspace Cohort,

It is exciting to see everything you guys are doing to engage students outside! I will be introducing RXP students to our new RXP Tree Fort this week. Today, I have included 2 things. First, a recent article that explains the benefits of teaching outside. Next, a copy of the NGSS Science and Engineering Practices. Please remember to reflect on your outdoor learning experiences on the form I shared with you: Reflection after Outdoor Learning

When outside Self-reliance flourishes

Kids learn a lot playing in nature. Playing on rocks and climbing in trees teaches them valuable lessons about risk-taking and improves their self-confidence. When children play without adult intervention, they develop independence by having control and learning how to assert it. They learn how to make their own decisions, solve their own problems, create and abide by rules, and get along with others.

OUTDOOR LEARNING IDEA #9: Focus on Science and Engineering Practices

EDUCATION | Articles & More

The Surprising Benefits of Teaching a Class Outside

A new study finds that a class in nature helps kids be more attentive and focused once they return indoors.

BY JILL SUTTIE | MAY 14, 2018

As any teacher knows, students need to be engaged with learning to absorb lessons in any meaningful way. Otherwise they can become distracted, disrupting everyone in the classroom and taking time away from instruction.

There are many ways to foster engagement, of course. But one may surprise you: holding classes outside. Findings from a new study show that learning outdoors is not just a fun, novel experience for kids, but also helps them focus once they return to the classroom.

Students at the Millennium School in San Francisco gather outside.

In this study, third-grade students from two classrooms were assigned to conduct about half of their biology lessons outside (on a nearby patch of grass) and half inside the classroom during an academic year. The lessons involved things like identifying leaves and understanding the process of decomposition, and were closely matched: The indoor lessons had natural elements (like leaves and soil), while the outdoor lessons were conducted like a regular classroom (without student interaction or free play).

Oct 20, 2019, 11:08 AM

Hey Outdoor Makerspace Cohort,

Hope your break is going great! 9 more days to complete your 3 visits outside with your class and reflect on them. If you know you will not be able to complete this task, please just email me to let me know, I can remove you from the study. Here is another resource to support you as you take students outside. Remember to reflect on your outdoor learning experiences on the form I shared with you: Reflection after Outdoor Learning

OUTDOOR LEARNING IDEA #10: Let's go (build and) Fly a Kite
Have students observe wind patterns and decide what type of kite design would work best in RXPI wind conditions.
Kite Designs

7 Benefits of Outdoor Learning

Experts say that outdoor learning is quite beneficial to students because it makes them healthier and happier, and they do better academically. The various benefits include:

1. Students who get to experience an outdoor learning environment tend to be more attentive and, therefore, have a better recollection of the information that was shared.

2. Consistent exposure to nature decreases stress and anxiety, helps elevate mood, and helps with emotion.

3. Children often have too much exposure to digital screens via televisions, computers, and cell phones. This can result in a "nature deficit disorder," which may lead to obesity and possible psychological and academic issues. Outdoor learning allows students to put their focus back on nature.

4. Outdoor environments naturally inspire children to be more physically active.

5. Exposure to bright sunlight found in nature is also healthy for vision. Bright sunlight is necessary for the eyes to develop properly, lowering the risk of nearsightedness.

6. In outdoor settings, children are more motivated to work together in groups, which can improve their social skills. They learn to manage conflicts, communicate, and cooperate with their peers in a more effective manner.

7. Outdoor learning provides children with hands-on experiences in nature. Most children learn better by using their senses. Outdoor environments provide the perfect place to do this. Instead of viewing different types of plants or wildlife on a computer or TV screen, they can see, smell, hear, and touch them in nature. Students can even start a garden and grow fruits and vegetables, which may have them wanting to sample their harvest. These hands-on experiences cultivate a love of nature and get them interested in our natural resources.

Sun, Oct 27, 2019, 3:25 PM

Hey Outdoor Makerspace Cohort,

Only 4 more school days to complete outdoor learning activities with your students and complete your reflections. Some might think that when there is snow outside, you must stay in. I have learned that there is no bad weather, just bad clothing. Bundle up and head outside with your kids.

OUTDOOR LEARNING IDEA #11: Snow STEM

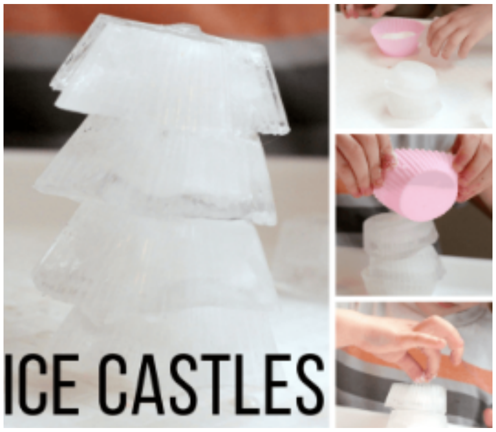
WINTER STEM ACTIVITIES – SCIENCE

Simple Snow Science – If you fill jars with equal amounts of ice, snow and water, do they really have the same amount of H2O? Find out in this simple science project that often surprises kids with the results!

Build Ice Castles - Connect ice cubes by melting them with salt to make ice castles.

1. Students freeze water in different molds including ice trays, silicon muffin trays, etc.

2. After they have all their ice blocks, show them how salt reduces the freezing point of water and allows the ice to melt. This will allow the blocks to connect.



Make Snow Paint - Mix food coloring and water to make snow paint. This mixture can be put in squirt bottles, ketchup bottles, or students can use pipettes (I have these) to squirt colorful pictures on snow.

Have fun!!!

APPENDIX F

PARTICIPANT DESCRIPTIONS

(Appendix F)

Participant Descriptions

Participant 1: Kindergarten teacher, has 16 + years' experience teaching, completed 3 lessons outside (2 science, 1 math). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *very prepared* to develop STEM skills for students in outdoor spaces.

Participant 2: Kindergarten teacher, has 7-9 years' experience teaching, completed 3 lessons outside (1 science, 2 math). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 3: Kindergarten teacher, has 16 + years' experience teaching, completed 3 lessons outside (1 math, 2 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 4: First grade teacher, has 13-15 years' experience teaching, completed 3 lessons outside (1 math, 2 other). Pre-intervention assessment: *not likely* to take students outside (0 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *likely* to take students outside (1-5 times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 5: First grade teacher, has 16 + years' experience teaching, completed 3 lessons outside (3 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 6: Second grade teacher, has 16 + years' experience teaching, completed 4 lessons outside (4 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *very prepared* to develop STEM skills for students in outdoor spaces.

Participant 7: Second grade teacher, has 1-3 years' experience teaching, completed 3 lessons outside (1 math, 2 other). Pre-intervention assessment: *not likely* to take students outside (0 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *likely* to take students outside (1-5 times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 8: Second grade teacher, has 10-12 years' experience teaching, completed 3 lessons outside (1 math, 2 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *not prepared* to develop STEM skills for students in outdoor spaces.

Participant 9: Third grade teacher, has 7-9 years' experience teaching, completed 5 lessons outside (2 science, 1 math, 2 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 10: Third grade teacher, has 13-15 years' experience teaching, completed 3 lessons outside (1 math, 2 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *likely* to take students outside (1-5 times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 11: Third grade teacher, has 4-6 years' experience teaching, completed 3 lessons outside (2 math, 1 other). Pre-intervention assessment: *very likely* to take students outside (5+ times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 12: Fourth grade teacher, has 16 + years' experience teaching, completed 3 lessons outside (2 science, 1 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 13: Fourth grade teacher, has 16 + years' experience teaching, completed 3 lessons outside (1 science, 1 tech, 1 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 14: Fourth grade teacher, has 16 + years' experience teaching, completed 3 lessons outside (2 science, 1 other). Pre-intervention assessment: *not likely* to take students outside (0 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *likely* to take students outside (1-5 times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 15: Fourth grade teacher, has 4-6 years' experience teaching, completed 4 lessons outside (2 science, 2 other). Pre-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *likely* to take students outside (1-5 times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 16: Fifth grade teacher, has 7-9 years' experience teaching, completed 6 lessons outside (6 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 17: Fifth grade teacher, has 10-12 years' experience teaching, completed 5 lessons outside (1 engineering, 4 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 18: Sixth grade teacher, has 1-3 years' experience teaching, completed 5 lessons outside (5 other). Pre-intervention assessment: *likely* to take students outside (1-5 times) and *prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *very prepared* to develop STEM skills for students in outdoor spaces.

Participant 19: Counselor, has 1-3 years' experience working with children, completed 7 lessons outside (7 other). Pre-intervention assessment: *very likely* to take students outside (5+ times) and *not prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces.

Participant 20: Art teacher, has 16 + years' experience teaching, completed 3 lessons outside (3 other). Pre-intervention assessment: *very likely* to take students outside (5+ times) and *prepared* to develop STEM skills for students in outdoor spaces. Post-intervention assessment: *very likely* to take students outside (5+ times) and *very prepared* to develop STEM skills for students in outdoor spaces.

APPENDIX G

CODE BOOK USED IN DATA ANALYSIS

(Appendix G)

Code Book used in Data Analysis

Pre-Intervention Assessment Benefits: In Vivo Code Book

Code for Benefits of Outdoor Learning	Frequency of Code
Authentic Experiences	8
Change in Environment	12
Collaboration	1
Connect with Nature	7
Excited to Learn	18
Fun	2
Global Understanding	1
Great for Kids	1
Hands-On	5
Health Benefits	12
High Engagement	17
Language Development	1
Learning Expands	5
Mental Health Boost	1
More Space	4
Physical Movement	8
Promotes Creativity	5
Promotes Problem Solving	1
Retention of Skills	1
Student Enjoyment	1
High Self Efficacy	1
Longing for More	1

Pre-Intervention Assessment Perceptions of Student Response: In Vivo Code Book

Code for Perceptions of Student Response to Outdoor Learning	Frequency of Code
Dislike outdoors	1
Lack responsibility	1
Love it	33

Pre-Intervention Assessment Reservations: In Vivo Code Book

Code for Reservations of Outdoor Learning	Frequency of Code
Behavior management	11
Lack of Experience	4
Lack of focus	3

Lack of knowledge	8
Trouble letting go	1
Materials	5
Too much sensory stimulation	1

During-Intervention Assessment Benefits: In Vivo Code Book

Code for Benefits of Outdoor Learning	Frequency of Code
Calm Learning	8
Connect with nature	14
Excited to Learn	3
Freedom	1
Fresh air	3
Fun	4
Hands-on	3
Happy	1
High engagement	31
Increase observation skills	4
Learning expands	12
Liked Modeled Lessons	1
More space	1
On task	7
Organic learning	3
Physical movement	3
Promote mental health balance	1
Promotes confidence	1
Promotes creativity	3
Promotes curiosity	2
Relationship building	3
Reluctant to return inside	3
Revealed student misconceptions	3
Students followed rules	1
Students like being outside	13
Students love service learning	2
Self-differentiating	1
Shared experience	2
Teacher changed lesson structure	3
Tech was used	1
Warm weather	1
Willingness to learn/work more	1

Post-Intervention Assessment Benefits: In Vivo Code Book

Code for Benefits of Outdoor Learning	Frequency of Code
Excited to be outside	9
Excited to try something new	1
Existing resources	1
Extended learning for the teacher	1
Appreciation for nature	3
Authentic experiences	13
Away from tech	2
Calming environment	1
Can be messy	1
Change in environment	17
Collaboration	1
Connect with nature	10
Excited to learn	18
Freedom	1
Fun	4
Global understanding	2
Great for kids	1
Hands-on	7
Health benefits	18
High engagement	31
Language development	1
Learning expands	6
Mental health boost	2
More space	5
Physical movement	11
Promotes creativity	6
Promotes problem solving	2
Retention of skills	1
Student enjoyment	2
Successful	1
Willing to learn more	1
High self-efficacy	1
Longing for more	1

Post-Intervention Assessment Perceptions of Student Response: In Vivo Code Book

Code for Perceptions of Student Response to Outdoor Learning	Frequency of Code
Enjoy change in environment	1
Excited	1
Fun	1
Happy	1
High Engagement	4
Love it	11
Request outdoor learning	1

Post-Intervention Assessment Reservations: In Vivo Code Book

Code for Reservations of Outdoor Learning	Frequency of Code
Adverse weather	8
Behavior management	2
Lack of time	3
Lack of knowledge	2
Materials	3

Post-Intervention Assessment Needs: In Vivo Code Book

Code for Needs to Integrate Outdoor Learning	Frequency of Code
Change of mindset	1
Ideas for outdoor learning	2
Integration ideas	4
Lack of time	5
Outdoor teaching space	1
Purposeful activities	4
Resources	1
Structure	1

APPENDIX H

IRB EXEMPTION

(Appendix H)

IRB Exemption

EXEMPTION GRANTED

Gustavo Fischman
Division of Educational Leadership and Innovation - Tempe
480/965-5225
fischman@asu.edu

Dear Gustavo Fischman:

On 5/30/2019 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Outdoor Makerspaces: Using Outdoor Spaces to Develop STEM Skills
Investigator:	Gustavo Fischman
IRB ID:	STUDY00010216
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Intervention Notes.pdf, Category: Participant materials (specific directions for them); • Estes IRB Social-Behavioral-Protocol.docx, Category: IRB Protocol; • Estes Recruitment.pdf, Category: Recruitment Materials; • Teacher Journal Prompts.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Consent Form Estes.pdf, Category: Consent Form; • Semi-structured interview questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (1) Educational settings, (2) Tests, surveys, interviews, or observation on 5/30/2019.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Patricia Estes
Patricia Estes