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Developing A Garden-Based Curriculum For Middle School Content Enrichment

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DEVELOPING A GARDEN-BASED CURRICULUM FOR MIDDLE SCHOOL CONTENT ENRICHMENT

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Abstract

Garden-based education has been around for more than a century. It is one of the many outdoor learning strategies used by modern teachers. Gardens provide an engaging, safe, and interesting place to learn. However, teachers face a number of challenges when teaching in an outdoor setting. In order to decide if those efforts are justified a study of the research relating to outdoor education was conducted. The literature review revealed that outdoor learning offers benefits to student learning, physical and mental health, and overall development. This literature review informed the creation of a cross-content curriculum project. The lessons that make up the curriculum project address language arts, math, science and social studies topics and utilize a school garden to access the advantages of outdoor learning.

Table of Contents

Chapter One

Introduction

"Why try to explain miracles to your kids when you can just have them plant a garden."

- Robert Brault

As the quote by Robert Brault suggested, gardens offer amazing learning opportunities. School districts invest time and money to create these flexible learning spaces because they offer opportunities to teach using real-world examples (Graham, Beall, Lussier, McLaughlin, & Zidenberg-Cherr, 2005). Science has the most obvious connection to outdoor learning, but almost any subject can take advantage of the resources it provides; however, many teachers still choose not to use them. In most cases that is because they are not aware of the benefits, do not have the curriculum to support the lessons, or are uncomfortable with the idea of teaching outdoors (Graham et al., 2005). I believe that these barriers are leading gardens to be underutilized and misunderstood. For that reason I have selected the following research question, *How can school gardens increase teachers' use of experiential outdoor learning?* In this chapter I will share the details of why I believe that school gardens are an underutilized resource, the benefits of garden-based teaching, and my personal journey to this research topic.

Context

My teaching career started six years ago in a suburban district in central Iowa. I was fortunate to begin my career as a sixth grade science teaching in one of the most successful and well-funded districts in the state. The staff was creative, professional, and hard working. During my four years in this district I learned a lot about teaching and working with kids. However, I was surprised to find that in a district known for being progressive there were no outdoor learning spaces. Students conducted their entire school day within the school building, except for

an occasional PE class. After asking around I learned there was once a school garden, but it had long been paved over to make room for additional parking.

My second teaching experience came in the form of an eighth grade science position in rural Minnesota. Again, I was surrounded by a core of experienced and passionate teachers. There were several significant differences between this district and my previous experiences in Iowa. The first was the demographic makeup of my students. It may be surprising coming from someone who taught in Iowa, but I had never taught somewhere where the local economy was almost entirely dependent on agriculture. From family-owned farms, to tractor supply employees, to immigrant laborers, the community revolved around the production of crops. This focus was evident in the types of opportunities that were available to students. There was an active FFA (Future Farmers of America) organization, a popular 4-H club, and a large competitive trapshooting team. While there were a wide range of outdoor activities available beyond the school day, there were still a limited number of times during the school day when a student stepped outdoors. There was a small outdoor flower garden, but it was primarily cared for by a single teacher who had created the space.

My final, and current, teaching position arrived when I was hired in a district in a western suburb of Minneapolis. I was hired as a fifth and sixth grade science and social studies teacher. During my initial tour I was delighted to learn that the school had recently created a classroom garden space. It was created through the joint efforts of the Jeffers Foundation (a local non-profit focused on environmental education), a group of community volunteers including a local boy scout troop, the Three Rivers Park District, and of course the school. Finally an outdoor learning space where teachers could take their students to see the concepts being taught inside the school; however, I quickly learned this was not the case. After discussing the garden with staff, it

became clear that just like my first two schools, most teachers saw the outdoors/garden as a space for extracurricular activities.

I am aware that my experiences do not provide an accurate picture of every school, however the growing sense that this was an issue in many schools was a feeling that I could not ignore. During the preliminary research into this topic my suspicions were confirmed. A study performed by Heather Graham and her colleagues (2005) at the University of California - Davis surveyed all of the principals in the state of California. Over 4,000 principals participated in the study, 57% of whom had gardens at their schools. Most principals (87%) responded that the primary reason for the garden was to enhance academic instruction (Graham et al., 2005). However, time constraints and a lack of curricular materials were identified as significant barriers to use. These findings raised two concerns. First, gardens are being built with the purpose of enhancing classroom instruction, which in my experience is less common that extracurricular use. And secondly, that there is a disconnect between the organizations that provide free and high-quality gardening curriculum and classroom teachers.

Rationale

My personal interest in gardening began at an early age. Some of my earliest childhood memories were of my grandfather's garden and apple orchard. My brothers and I picked green beans in the summer. We turned apples into cider in the fall, and ate canned peaches and pears all winter. Home grown fruits and vegetables were a part of almost every get-together or holiday in some way.

As my own family grows I have an increasing desire to share those experiences with my daughters. We started small last summer with a few tomato plants, and expanded into raised bed

gardens this year. Nostalgia is only one of the many reasons that I want to start a home garden. The other benefits are the same reasons that I believe that garden-based teaching is important.

First, gardening has been shown to have positive impacts on childhood nutrition. These impacts include improvement in children's ability to identify vegetables, and more importantly an increase in children's preference for vegetables (Ratcliffe, Merrigan, Rogers, & Goldberg, 2011). We live in a country that is currently facing an obesity epidemic. According to the CDC more than one third of adults in the United States are obese (Ogden, Carroll, Fryar, & Flegal, 2015). We have a moral obligation to protect our students and children from the dangers of type 2 diabetes, heart disease, and stroke. In addition, the Child Nutrition and Women Infants and Children(WIC) Reauthorization Act of 2004 made it a legal obligation. According to the act, each local educational agency has a legal requirement to develop a wellness policy for its students. These policies are designed to ensure the health and wellbeing of our students, and gardening can provide many of those requirements. Gardening exposes children and adults to the entire food production process, from start to finish. Students learn to respect and understand their foods, and as a result are more likely to eat them (Ratcliffe et al., 2011).

The second benefit of garden-based education is increased academic performance (American Institutes for Research, 2005). Hands-on inquiry and active investigation are two educational best practices, but they can be difficult to manage and challenging to pull off. Gardens provide a safe and controlled outdoor environment where nature can be observed in a semi-natural state. A variety of scientific principles can be addressed in a garden. Elementary students can observe the basics of plant development and ecosystems. Middle school students might use the gardens to demonstrate concepts like erosion, photosynthesis, and agriculture. While high school students might discuss genetics and the works of Gregor Mendel. These real-

life experience will lead to far more related questions and observation than a classroom experiment. These questions are the driving force of the inquiry model. As a science teacher, I see countless ways that the outdoor space can be used to enrich science, but the applications go beyond one subject. English teachers can use the space for creative writing, math classes can calculate the most efficient use of garden space, and social studies classes can demonstrate the traditional planting techniques used by the Ojibwe and Dakota tribes. Students are naturally engaged when learning in a garden, and engagement is the first step in the learning process.

Finally, garden-based learning leads to environmental awareness (Lohr, Pearson-Mims, Tarnai, & Dillman, 2004). Gardens are a great place to study the systems that make up our planet. At times the environmental awareness might be passive, without active teaching about the subject. Students will simply spend time outdoors and interact with nature. Other times the increased awareness will come from the conversations and questions that arise from gardening. These active and passive interactions influence the future choices we make about the environment as adults (Lohr et al., 2004). Gardens provide a microcosm of the larger environment. They demonstrate the same concepts that are in place in the ecosystems around us: water quality and conservation, land use, erosion and soil contamination, even pesticides and their impact on pollinators. School gardens are an excellent location to learn how inputs control the outcome, and how human choices can affect the spaces we live in. Children have a right to know how their actions will affect our planet, and gardens are a great place to learn those lessons.

Summary

My research question, *How can school gardens increase teachers' use of experiential outdoor learning?,* was influenced by two personal discoveries. The first was the overwhelming

evidence that garden-based education can positively impact the classroom experience for students. Students in garden-based programs have improved outcomes in nutritional awareness, academic performance, and environmental awareness (American Institute of Research, 2005; Lieberman & Hoody, 1998). These outcomes have been well studied and the impacts are evident to many teachers, yet in my experience there is limited use of classroom gardens. Which leads me to my second discovery, my personal experiences and the data of the California study mentioned earlier lead me to believe that there is a gap between classroom teachers and gardening curriculum. Teachers are unaware of the possible connections between their classroom and existing or future gardens. In this capstone I will to examine this gap in understanding, and explore ways to engage more classroom teachers in garden-based teaching. I will also to use what I learn to develop a set of curriculum tools that can be shared with teachers as a means for bridging this gap.

In the upcoming chapter, a literature review will provide a comprehensive summary of the following related topics; environmental teaching methods, advantages and challenges of outdoor education, and an overview of garden-based education. The examination of environmental teaching methods will be more broad, and will include strategies that may or may not take place in the garden. However many of these methods could be applied in any outdoor setting, and would be appropriate for use in the garden. Next I will examine the various advantages and challenges of outdoor education. Availability of garden-based curriculum is only one of the challenges that teachers and administrators must overcome. I plan to explore the other possible barriers. Finally I will examine the resources that are currently available for classroom teachers planning to teach using a school garden.

Following the literature review I will explore the methods used to develop an outdoor curriculum project. This will require an examination of curriculum frameworks, demographics and the educational context for the project. Chapter three will concluded with a description of the curriculum project and how it was created.

The fourth and final chapter will explore the challenges encountered when developing the curriculum project. A detailed reflection will provide insight into what was learned during the curriculum writing and drafting process. This chapter will also explore policy implications, limitations of the project, and future project expansion ideas. How the project will be shared and communicated will also be explored in the concluding chapter.

Chapter Two

Literature Review

Outdoor education is not a new idea. In fact, outdoor education is old enough that it is difficult to determine exactly when it first began. Some authors cite the early works of Americans like John Muir as the beginning of environmentally focused education (Watters, 1986), others describe Swiss scientists Jean-Jacques Rousseau and Louis Agassiz as the fathers of outdoor education (McCrea, 2006). Regardless of where it first began outdoor education is an instructional strategy with real value. There is a growing body of evidence supporting the idea that outdoor education can improve outcomes in nutritional awareness, academic performance, and environmental awareness (American Institute of Research, 2005; Lieberman & Hoody, 1998). This literature review explores academic literature related to the research question, *How can school gardens increase teachers' use of experiential outdoor learning?* There are many facets to this question. In order to make a more informed decision about the answer to this question these facets are explored in more detail.

The first subtopic addressed in this literature review is outdoor learning methods. Outdoor learning refers to educational experiences that take place outside. This approach to education can take many different forms. In some cases the outdoor learning takes place on field trips to local parks. In other situations the experience might move the students from the classroom to the school yard. Approaches vary greatly, from a simple lesson relocation to an extreme adventure-based curriculum. Research into the history of outdoor learning provides insight into how to justify and implement an outdoor learning experience. The first part of this section provides an overview of the history of outdoor education, focused primarily on outdoor

education in the United States. The second portion of this section describes the general methods of outdoor learning.

The second subtopic of this literature review is the advantages and challenges of outdoor learning. School buildings are designed to meet the needs of students. They provide a safe and efficient learning environment. In contrast, outdoor education is full of challenges including environmental hazards, changing weather, and transportation issues. Teachers and non-formal educators must be prepared to deal with issues that would not occur in a traditional classroom. Overcoming these challenges takes considerable planning and effort. In order to decide if those efforts are justified a study of the advantages of outdoor education is necessary. The first portion of this section examines the advantages of outdoor education. The second portion explores the challenges that are presented by leaving the traditional school setting.

The final topic addressed by this literature review is garden-based teaching practices. Garden-based education is a specific type of outdoor learning where the lessons take place in a school or community garden. This approach is a compromise between the relative wilderness of parks and the generally inorganic traditional classroom. Gardens provide an organized space where teachers and students can experience nature and academic content. While the most obvious content connections with a garden are science and agriculture, other content areas can use the space as well. The first part of this section explores how gardens can be used as educational tools for science. The second part describes how gardens can be used to enrich other content areas like math and social studies.

History of Outdoor Education

Outdoor education has deep roots. It is difficult to determine the exact origin of outdoor education, but early contributors like Jean-Jacques Rousseau and Louis Agassiz were among the

first to address the role of natural environments in education (McCrea, 2006). Jean-Jacques Rousseau, born in 1712, urged teachers to maintain a focus on the environment in order to facilitate learning opportunities for students. Louis Agassiz, born nearly a century later in 1807, became a successful and popular biologist. He later used his popularity to share his ideas about experiential learning. Agassiz once said "study nature, not books" (as cited in McCrea, 2006, p. 1). While neither of these men can be given credit for creating outdoor education, they both played important roles in bringing the study of nature into the spotlight.

Others built on the ideas of these early contributors as the idea of outdoor education continued to grow. The term "outdoor education" emerged in the United States during the early 1900's (Quay, 2013, p. 12). It was originally used in reference to outdoor or open-air classrooms. These classrooms were created in response to the growing tuberculosis epidemic. Using an open classroom decreased the risk of tuberculosis and similar diseases (Quay, 2013, p. 13). During this time teachers also began to observe the educational value of learning outdoors.

> The advantages of studying nature at first hand and of substituting live growing things for museum specimens or book descriptions, and of cultivating habits of observation, is apparent to every student of elementary education. The advantage, also, of substituting the natural activities of play and work for the more artificial physical exercises of the schoolroom is too obvious to need more than a passing mention. Less obvious but no less important is the subtle influence of forest and field upon aesthetic and emotional nature of children usually ignored in discussions of educational questions. (Curtis, 1909, p. 188)

This growing understanding of the advantages of outdoor learning added momentum to the outdoor education movement. By 1916 the term "outdoor education" was commonly used to

refer to a variety of outdoor educational activities including nature-study, school gardens, agricultural education, home credits, and vacation schools (Quay, 2013, p. 13).

The 1930's were a period of change in education. John Dewey led the progressive movement with his educational philosophy called Pragmatism. Pragmatism was defined by the philosopher William James as, "The tangible fact at the root of all our thought-distinctions, however subtle, is that there is no one of them so fine as to consist in anything but a possible difference of practice." (as cited in Hookway, 2008). Dewey and others described pragmatism as exploration of "the logic and ethics of scientific inquiry" (Hookway, 2008). This holistic approach was adopted by many educators during the 1930's and created a more student-centered view of education. This model emphasized many of the concepts used in modern environmental education programs including experiential learning, lifelong learning, and interdisciplinary teaching. Another factor that shaped the educational landscape in the 1930s was the Dust Bowl. A long drought, combined with poor soil management, had caused massive dust storms and severe erosion. These issues prompted local and federal agencies to create conservation education programs, again contributing to the history of outdoor education (McCrea, 2006).

The next evolution of outdoor education took place following World War II. During the early part of the war a German-born man named Kurt Hahn was asked to develop a program that would prepare well-rounded British soldiers. His methods were experience-based and designed to challenge both the mind and the body (Watters, 1986). Hahn's approach was named Outward Bound, and it gained popularity following the war as a way to build character in young men and women. Later, an American named Joshua Miller brought the practice to the United States. Miller's first Outward Bound program took place in Oregon in 1962 (Watters,1986).

By the late 1960's a variety of nature-based educational philosophies had developed. Outdoor education was found in programs like Outward Bound and the Young Men's Christian Association (YMCA). Nature-study used outdoor spaces to learn about scientific concepts. Conservation education taught students how to conserve and protect natural resources. Each of these non-traditional approaches had a distinct purpose and goal, until a man named William Stapp PhD. seeing each of these branches as too limited, combined them under the umbrella of "environmental education" (Monroe & Krasny, 2016). Stapp and his students at the University of Michigan believed that there was need for a new field that considered the whole environment and emphasized a problem-solving approach. Stapp's ideas were first published in the first issue of the Environmental Education Journal in 1969 (Monroe & Krasny, 2016). After publishing his work Stapp continued as an active member of the environmental education community. He served as the first director of the International Environmental Education Programme (IEEP). The IEEP was one of the first international organizations with the goal of environmental protection. The goals of the program focused on international cooperation, research for environmental issues, and development of new methods and programs for use inside and outside of schools (Monroe & Krasny, 2016). Stapp was also an organizer of the international conference in Tbilisi, Georgia, USSR in 1977. This conference was the first intergovernmental conference on environmental education. The resulting Tbilisi Declaration set international goals and guidelines for environmental education (Monroe & Krasny, 2016). While outdoor education is only one part of the larger category of environmental education these changes in international policy surely affected outdoor education as we know it today.

Outdoor Learning Methods

Using the history of outdoor education as a backdrop, this section describes the actual methods used for outdoor education. As was mentioned earlier, outdoor education can take many forms depending on the purpose or goals of the program. Each program has access to different resources and uses available resources differently; however, there are methods and trends that are common among programs. These common aspects of outdoor teaching are explored next in an effort to better understand how the philosophy mentioned in the previous section can be applied.

Experiential learning. Experiential learning is an approach where first-hand experiences are a priority. Students are exposed to phenomena, and this experience provides the engagement and context for future discussion or exploration. These direct experiences are a cornerstone of outdoor learning because the outdoor environment provides an abundant source of experiences. Students do not read about ecological relationships in a textbook, they observe a bird feeding on bugs. This approach is also sometimes called the "discovery approach" (Rillo, 1985). Rillo(1985) broke the discovery approach down into three parts, observation, research, and reflection. Observation arouses interest in a topic, reflection uses additional resources to extend the learning, and reflection provides a time for analysis and further questioning. Rillo(1985) also mentions that experiential learning does not require a teacher to be an expert in field work.

> Many teachers think that they are not adequately prepared to teach in the outdoors. They think that one has to be a naturalist, geologist, botanist, zoologist, herpetologist, ornithologist, entomologist, ichthyologist, lichenologist, ecologist, or conservationist in order to teach students in the outdoors. Although it would be wonderful to be proficient in all of these fields, realistically this is not possible. (Rillo, 1985, p. 8)

He goes on to explain that the teacher's role is to support students in asking questions, rather than providing the answers to all the questions they ask. Teachers must be willing to explore the world with their students. Teachers also have the task of supporting student research, and while they may not know all of the answers, they should have the skills and resources needed to find them.

Small group learning. Experiential learning is a part of many outdoor learning experiences. Another common approach to outdoor learning involves the use of small group learning. Rillo explained that the use of small groups is critical for outdoor education because it allows all of the students to participate in the hands-on activity. Each student should be allowed to touch, taste, smell, see, or hear the subject of their study, and this can be challenging with larger groups (Rillo, 1985). Small group work is also used so that members can ask each other questions, and create a safer outdoor experience. While small groups are commonly used in outdoor education this approach can present some challenges for educators. Supervising multiple small groups in an outdoor setting can be difficult, and considerations about how the groups are supervised should not be overlooked.

Service learning. Outdoor education offers a unique opportunity for teachers and students looking to make a difference. There are countless opportunities for service learning. Service learning combines an educational opportunity with a service project where participants work to improve some aspect of their community (Pope, 2015, p. 105). The Restoration of the Outdoors Organized by Teen Students or ROOTS program in New York City is one such program (Pope, 2015, p. 137). High school students spend a semester working to improve Central Park. Students perform a number of hands-on jobs in the park, including removing invasive plant species, maintaining trails, planting native species, and working on erosion control

projects (Pope, 2015, p. 138) This program is intensive and designed to build a sense of connection between participants and the park. Other programs are smaller in scope. Individual service lessons might include collecting garbage or constructing rain gardens in the school yard. Regardless of the size of the program, service learning is designed to improve the community and increase participant connectedness.

Outdoor locations. The ROOTS program is a great example of service learning, and is a little unexpected considering the participants are performing woodland preservation in the middle of a metropolis. New York City is not the first place most people would think of when considering outdoor education, but there is growing interest in using outdoor education with urban children. These urban programs have the same goals as their suburban or rural counterparts. These goals including increased physical activity, socialization, exposure to nature, environmental education, psychological development, restorative experiences, and individual and community wellness (Pope, 2015). However finding locations for the outdoor activities may require a little more work. Urban outdoor spaces include parks, zoos, nature centers and preserves, bioregions, and urban farms. Most people are familiar with parks, zoos, and even nature centers. Bioregions are natural areas with unique characteristics like coastal areas, mountain ranges, plains, and valleys. Often times the areas are found close to or even within city limits (Pope, 2015). Urban farms come in all shapes and sizes. Some farms are large and supported by local organizations like neighborhood organizations, and others are small single family projects. Regardless of size, urban farms offer a valuable opportunity for students to see first-hand how food and flowers are produced. Field trips are also an option for schools, even rural schools, who do not have sufficient natural resources in their areas or who are seeking to explore something new.

Technology in outdoor education. One final consideration when planning an outdoor learning experience is technology. In some situations a case can be made to leave the technology in the classroom, especially if the outdoor lesson is designed to allow students to connect with nature or each other. However there are a growing number of digital and technological resources that can be used to enrich the outdoor experience (Daniels & Clarkson, 2010). Digital cameras or cell phone cameras are a great tool for outdoor learning. Cameras allow students to capture and share observations with other students. They also give students an active reason to use observation skills. Digital probes are another tool that can be used to enhance the outdoor experience. These probes come in a variety of designs, and can be used to capture environmental information including temperature, wind speed, solar radiation, and water quality. Digital tools like cameras and probes can provide valuable information, but special consideration should be given to whether they are necessary to achieve the goals of the outdoor lesson, as they may be more of a distraction than a resource.

Advantages of Outdoor Education

Outdoor education offers many advantages. As Cooper stated "A growing body of scientific literature indicates that play and learning in a diverse, natural area provides a wide array of health, learning, gross motor, and mental health benefits for children" (Cooper, 2015, p. 88). The following sections address the advantages of outdoor education and the research that supports them. The research is grouped into three main categories: learning and cognitive development, mental health and behavior, and physical activity and nutrition.

Increased Student Learning. The first advantage of outdoor education is the one most cited by teachers as the reason for implementing an outdoor lesson: increased student learning. In a survey of more than 4000 California principals 89% of the participants responded that

enhancement of academic instruction was the purpose for outdoor learning (Graham, Beall, Lussier, McLaughlin, & Zidenberg-Cherr, 2005). This should come as no surprise; the role of teachers and administrators is to help their students learn. However, if so many teachers and principals are using outdoor learning to increase academic instruction, educators must be certain that outdoor education does in fact increase student learning and cognitive development.

There are many articles and blog posts that describe the cognitive benefits of outdoor learning. The facts seem to be common knowledge, but upon further inspection the truth is revealed. Most of these so called facts are actually opinions based on personal experience. While these opinions are helpful, they come with inherent bias, and should not be used to make instructional decisions. In order to make a scientifically-based decision about outdoor education one must look a bit deeper. The research is available, but takes more effort to find. One scientific study of the effects of outdoor education was conducted by the American Institutes for Research (2005). This study focused on 255 sixth grade students. These students were taken from four different elementary schools, and attended three separate outdoor science programs. The remaining students were scheduled to complete the same experience, but not until after the study was completed. Those students not in the outdoor science programs studied the same concepts in a traditional classroom-based program. After the experience, all of the participants were given the same assessment. The group that took part in the outdoor experience had significantly higher achievement on the assessment. The students who attended the outdoor lessons outscored their indoor counterparts by an average of 27 percent. A pre- and post-survey was used to measure student growth. (American Institutes for Research, 2005. p. vi) This research provides evidence of the power of outdoor education to enhance classroom learning. Students taking part in the

treatment group also maintained their scores for six to ten weeks following the experience. (American Institutes for Research, 2005. p. vi).

Cognitive development. Another often cited reason for outdoor education is increased cognitive development. Cognitive development is defined by the Encyclopedia of Children's Health as "the construction of thought processes, including remembering, problem solving, and decision-making, from childhood through adolescence to adulthood" (Bayne, 2015, p. 632-634). Dr. Nancy Wells (2000), a research professor at the University of Michigan, evaluated these claims in her study of childhood cognitive development and "greenness" at home. While her research sought to understand the connection between a natural home environment and cognitive development, many of the same concepts can be applied to schools. Dr. Wells surveyed families that were moving from one home to another. The families were surveyed using a tool called the Attention Deficit Disorders Evaluation Scale (ADDES). This nationally-standardized assessment tool was given to families before and after moving homes. The results of the ADDES were then compared to the self-reported "greenness" of the home. This included outdoor spaces and views of outdoor spaces from within the home. Wells summarized the results of the study by stating "This exploratory study suggests that the effects of natural elements within the home environment have a profound effect on children's cognitive functioning."(Wells, 2000, p. 790). This study provides another piece of evidence that outdoor education has positive impacts on the learning and development of children.

Academic achievement is the primary goal of the education system, but if someone asked a teacher what is most important to them, the safety of their students would probably be their first response. This feeling is likely based on a moral obligation to the students, but there is a logical connection here as well. Abraham Maslow was a well known psychologist who theorized

that humans must meet their basic needs before more sophisticated thoughts can be developed. Maslow's hierarchy of needs places safety as a prerequisite to "self-actualization" (as cited in Bayne, 2015). Self-actualization is the idea that, if all of a person's needs are met, then they will strive to be the best possible version of themselves. Teachers who want motivated and successful students must ensure the students feel safe and accepted in the instructional setting. There is evidence to suggest outdoor education can improve the mental health, self-regulation, and behavior of students.

Classroom behavior. A study by the National Wildlife Federation in 2010 surveyed over 1,800 teachers. The responses provided important information about classroom behavior and the effect of time spent outdoors. The majority of respondents (78%) believed that children who spent more time outside were more able to concentrate during class (Coyle, 2010). An even higher percent of participants (82%), believed that students need daily unstructured time to balance the amount of time spent on computers throughout the day (Coyle, 2010). These teachers work with students on a daily basis and understand the current classroom atmosphere. They also understand the effects of physical activity on classroom behavior. This perception of outdoor learning is shared by many teachers, and is supported by additional studies.

One such study is the State Education and Environment Roundtable (SEER) study (Lieberman & Hoody, 1998). This program was a collaborative effort by 12 states to implement a model called Environment as a Integrating Context (EIC). The EIC approach was not focused on teaching environmental concepts, instead it called on teachers to use the surrounding community as a context for teaching. The schools were located in different states and in different communities so the teaching methods and types of outdoor spaces used by classes varied, but the goals remained the same, breaking down the barriers between content areas, and using the

surrounding community as a context for learning. The participating schools saw significant growth in student learning and behavior. The formal report breaks the results into subject area, and provides a summary of impacts on student behavior. The results showed a strong positive correlation between the use of outdoor spaces and student achievement. One statistic that was measured was the ability of a student to work in a group setting. The study found that of the classrooms that participated, 98% saw significant growth in group work abilities. The authors of the SEER study explained this change, " Environment-based learning helps students discover their own skills and appreciate those of others because it capitalizes on a variety of abilities." (Lieberman & Hoody, 1998, p. 9). Another area where the study identified significant growth was personal communication skills. Student growth was measured in 94% of the participating classrooms. Again the SEER study offers the following explanation, "As they work together, students learn to share ideas, discuss their reasoning, and develop new ideas that emerge from team discussions." (Lieberman & Hoody, 1998, p. 9) The final significant finding of the 12-state study was the impact of outdoor learning on inter-student attitudes. The study found that in 93% of the classrooms surveyed, students were found acting with greater civility towards each other. (Lieberman & Hoody, 1998) The program included more than 400 students, from 40 schools across 12 states. It also involved more than 250 teachers and administrators.

Physical health. The final benefit to explore is physical activity and nutrition. To many this is the most obvious benefit to moving students outside. Students usually move through the school day with limited opportunities for physical activity. Most classroom activities take place in desks, or sitting down. There is practical reason for this, classrooms lack the space for students to move around without disturbing one another, so teachers create rules and guidelines for how and when to move. There are regular breaks from this routine, like passing periods, recess, and

physical education, but for the most part these rules remain. Outdoor education provides an opportunity to break from this routine. Students can take advantage of the space by walking, running, and moving when desired. This physical activity can have positive impacts on children and adults. A Norwegian study by Ingunn Fjørtoft (2001) found that children who spend time outside are generally more physically fit, and have significantly better motor fitness. This fitness is demonstrated in coordination, balance, and agility (Fjørtoft, 2001). This increased focus on fitness could have an impact on the obesity epidemic in the United States. Approximately one third of people living in the United States are obese (Ogden, Carroll, Fryar, & Flegal, 2015). These positive impacts would include the time spent outside during class, but would hopefully extend to the habits of children beyond school.

Another important aspect of overall physical health is diet. School gardens, which are explored in one of the following sections, are a common outdoor learning activity. A school garden is any type of horticulture that takes place as a part of a school program (California School Garden Network, 2006, p. 6). This can include, but is not limited to, the planting of flowers, fruits, vegetables, and even non-flowering plants. There are many reasons for planting school gardens. One common reason is to grow fruits and vegetables to learn more about the plants they come from. There is a growing body of evidence that student participation in a school garden has positive outcomes for overall nutrition. These impacts include improvement in children's ability to identify vegetables, and more importantly, an increase in children's preference for vegetables (Ratcliffe, Merrigan, Rogers, & Goldberg, 2011). Vegetables are an important part of a healthy diet, and developing healthy eating habits at an early age is particularly important. Increased physical activity and improved diet are two benefits of outdoor education that teachers and administrators would surely support.

There are clearly advantages to using outdoor learning spaces like school gardens. The research mentioned in the previous sections explored how outdoor learning could benefit academic performance (American Institutes for Research, 2005), cognitive development (Wells, 2000), classroom behavior (Coyle, 2010), and physical health (Fjørtoft, 2001). These advantages justify an increased effort to incorporate outdoor learning into the daily lives of students. However, these advantages come with a new set of instructional challenges which are explored in the following section of this text.

Challenges of Outdoor Education

The previous section detailed the advantages of outdoor education. To provide a complete and balanced assessment of outdoor education, the challenges of outdoor education are addressed in the following sections. These challenges fall into three main categories, supervision and physical hazards, curriculum requirements, and lack of knowledge or resources.

Teaching outside can be an intimidating prospect for many teachers (Davies & Hamilton, 2016). Classrooms are designed to keep students safe and provide easy access to needed facilities. In a school, students are seconds away from the bathroom, a parent phone call, or the nurse's office. Working outside can move students and teachers farther from these resources and introduces other physical hazards (Davies & Hamilton, 2016). Physical hazards include allergens, like pollen and bees. Uneven terrain and water are also possible hazards. Even the weather can present a hazard in the case of extreme heat or cold, and unexpected storms. Weather, specifically rain, is regularly cited as an obstacle to outdoor education (Davies & Hamilton, 2016, p. 9). While there are practical solutions to many of these hazards, they are factors that practitioners identified as significant challenges. Growing demands of curriculum and state-wide testing were also identified as challenges by teachers (Davies & Hamilton, 2016).

Two of the participants in this mixed-methods study summarized the effects of curricular demands in the following ways, “Things are becoming so data driven, so prescribed, you have to do them inside because you need to have proper evidence. You’re losing the outdoors because of this pressure.” (Davies & Hamilton, 2016, p. 13) A second teacher expressed their concern, “The Literacy and Numeracy Framework is going back to a formal style of learning. I can teach children to follow tests or I can teach them the Foundation Phase, life and thinking skills. Some teachers don’t follow the Foundation Phase anymore because they have to pass tests. It’s like going back to Standard Assessment Tests.” (Davies & Hamilton, 2016, p. 13) The challenges associated with curriculum requirements come down to one constraint, time. Teachers often struggle to cover the concepts required for state or federal assessments, and the time commitment of outside education is seen as too significant. This may be due to the view of outdoor education as supplementary and not an alternative to traditional teaching methods (Davies & Hamilton, 2016).

The final category of outdoor education challenges is lack of knowledge or resources. This barrier takes many forms. In some cases teachers may not be aware of the advantages of outdoor education. Other times teachers may understand the advantages of outdoor education, but are unfamiliar with the strategies used to implement it. Lack of curriculum was cited as the primary reason for avoiding outdoor education in a study of California schools (Graham et al., 2005). In some circumstances teachers may not even be aware of outdoor education as an educational approach. In one such instance a survey of teachers revealed that more than half of the teachers in a school had never heard of outdoor education (Palavan, Cicek, & Atabay, 2016). Additionally, some of the teachers who claimed to be familiar with outdoor education had a limited understanding of the concept (Palavan, Cicek, & Atabay, 2016). Teachers may be

uncomfortable teaching outdoors if they have a limited knowledge or experience with outdoor education.

Teaching is not an easy profession. Lesson planning requires teachers to know content, pedagogy, and the individual needs of the students in their classes. Outdoor education adds the challenges of supervision and physical hazards, curriculum requirements, and lack of knowledge or resources (Davies & Hamilton, 2016, Graham et al., 2005, Palavan et al., 2016). These additional challenges may prove to be much for teachers to handle if support is not provided. Garden-based education may provide the compromise that teachers need to bridge the gap between classroom practice and outdoor education.

Garden-based Education

The first American school garden was planted at George Putnam School in Roxbury, MA in 1891 (Subramaniam, 2002). The garden was planted at the urban school for aesthetics not educational purposes, but it marked the start of an educational movement that has grown for more than 100 years. The following sections describe examples of garden-based education and its application for various topics. The first portion refers to curricular connections between gardens and science, while the second half of the section is reserved for the other content areas including math and social studies. In order to limit the scope of the inquiry, the content discussed focuses on middle school curriculum.

Science is a natural fit for garden-based education. Gardening integrates the three dimensions found in the Next Generation Science Standards (NGSS) which have been adopted or modified for use in more than 16 states (NGSS Lead States, 2013). These dimensions are scientific practices, core ideas, and cross-cutting content. Scientific practices are the actions that scientists use when investigating a question or solving a problem. These practices are broad and

have a wide range of applications. Examples include developing and making models, asking questions and defining problems, and obtaining, evaluating, and communicating information (NGSS Lead States, 2013). Developing these skills requires application, and gardens provide a place where students can apply these practices in a meaningful setting. For example, a class creating a planting map before sowing seeds is creating a model with a real world purpose and constraints. The second dimension of the NGSS is referred to as "core ideas", and they most resemble traditional content-focused curricula. These statements define the subject specific information that students should master. The final dimension of the Next Generation Science Standards is cross-cutting concepts. This dimension addresses the "big ideas" that connect all of science. Students and teachers create cognitive connections between specific ideas by discussing these overarching constructs, which include patterns, structure and function, cause and effect, energy and matter (NGSS Lead States, 2013). Gardens can provide the context for discussing the big ideas. Students can observe patterns in nature, and see first-hand how changes to the garden cause effects over time.

The Next Generation Science Standards divide the "core ideas" into the familiar science subjects: physical science, life science, and earth science. Each of these subjects contains topics which can be explored in a garden. The Collective School Garden Network (CSGN), an organization which supports school gardens in California and Arizona, provides ideas for incorporating garden-based teaching. Life science has obvious connections to the growing of plants, but gardens can also be used to explore heredity, adaptations, and reproduction. The CSGN (2006) suggested using the seeds produced by garden plants to discuss transportation and dispersal of offspring. Earth science is another natural fit for garden-based teaching. The CSGN suggested creating a weather station where students can practice their measurement skills. The

garden is also a great place to talk about soil quality and conservation. Erosion is a common topic in middle school curriculum, and it can be observed in the garden setting quite easily. The last subject, physical science, might seem like a strange topic for the garden, but there are number of physical science topics that can be investigated outdoors. CSGN (2006, p.22) suggest pH and its relationship with plants, the water cycle and the phase changes that occur within it, and the properties of light and solar energy. Each of these topics offers a real world connection to a physical science topic.

Science has been taught in gardens and greenhouses for years, but there is a growing demand for real-world mathematics, a strategy where students use math to solve "real problems" (Clarkson, 2010). This demand can be met by garden-based teaching strategies. Teachers in Australia recognized this potential and designed a multi-grade mathematics unit focused on water conservation (Clarkson, 2010). This unit used the local drought conditions and the school garden as a context for mathematical investigation. Students in different grades analyzed planting and watering strategies, and evaluated the efficiency of different designs. Students in primary grades planted different species of plant and recorded optimum watering conditions. Older students designed irrigation systems and calculated the waste water (Clarkson, 2010). This long-term use of the garden as a context allows students to connect previous concepts to new ones. Clarkson emphasized that the use of gardens and problem solving in math engages students and challenges their mathematical understanding in important new ways.

Plants and humans have a long and complex history. Exploring this relationship as part of social studies is another great opportunity to get students into the school garden (California School Garden Network, 2006). Teachers and students can explore the cultural and ethnic difference of foods found the in garden (California School Garden Network, 2006). They

can investigate the history of agriculture in their region. They can even use the garden to create maps and practice geography skills. The Vista de Las Cruces School, in Gaviota, CA combines gardening with social studies by creating an Ancient Civilizations Farmers Market. Students at the school learn about the origins of vegetables and grains, and present their learning in a farmer's market style presentation (California School Garden Network, 2006). This approach combines social studies, gardening, mathematics, fine arts, and even 21st Century skills. While these lesson ideas present only a few of the available social studies topics, they demonstrate that school gardens are not only for science.

Summary

Garden-based education has been around for more than a century. The techniques and motivations have changed, but their value has remained the same. Gardens provide an engaging, safe, and interesting place to learn. Teachers face a number of challenges when teaching in an outdoor setting, but with proper preparation and training the advantages of outdoor education can shine through.

The following chapter explores the methods used to develop a curriculum to answer the research question, *How can school gardens increase teachers' use of experiential outdoor learning?* The next chapter describes the intended audience of the curriculum project, the basic theory for curriculum development, and a basic outline of the format and content of the unit.

Chapter Three

Methods

How can school gardens increase teachers' use of experiential outdoor learning?

Chapter One presented this question and provided my rationale for choosing it as a topic. It also provided a brief description of the context of this study within my history as an educator. Chapter Two explored the related literature and research on this subject. Topics included the history of outdoor education, the advantages and challenges of outdoor education, and the applications of garden-based teaching. Next, the context described in Chapter One was explored in greater detail, including an outline of the curriculum project. The first step in that process was selecting a research-based framework for curriculum development. In this case that framework was the Understanding By Design (UbD) model developed by Wiggins and McTighe (2011). The second step was to examine the demographics and educational context of the project. Finally, a brief scope and sequence provides an outline of the lessons in the project.

Curriculum Framework

The curriculum materials that make up the body of this capstone were developed using the Understanding By Design (UbD) framework, created by Wiggins and McTighe (2011). The name, Understanding by Design, describes the two main ideas of the curriculum framework. First, that instruction should be focused on understanding and learning transfer. Wiggins and McTighe described understanding as the capacity to explain, interpret, apply, shift perspective, empathize, and self-assess. The second component of UbD is that curriculum should be developed backwards, by beginning the curriculum planning process with the final goal in mind (Wiggins & McTighe , 2011).

Teaching for understanding may seem like an odd phrase. Don't all teachers teach in order to help students understand their content better? The answer to this question is yes, but Wiggins and McTighe (2011) argued the intention to help students understand is not always backed up with meaningful assessment or application of understanding. They argued that factual knowledge and skills should be learned as a means to a larger end, not taught for their own sake (Wiggins and McTighe, 2011). In order for students to demonstrate a level of understanding that goes beyond memorization of facts, students should be required to transfer their learning in a meaningful way to a new situation. For example, math students might apply a newly learned concept to solve a real world problem. This fits well with the garden-based curriculum that I developed. The garden provides a wealth of problems that young math students can solve using measurements and calculations.

The second part of the Understanding by Design framework, also known as "backwards design" is broken down into three steps; Desired Results, Evidence, and Learning Plan (Wiggins & McTighe, 2011). The first step, identifying the desired results, requires teachers and administrators to state the desired outcome. What should students know, understand, and be able to do as a result of the curriculum? This results-focused approach helps teachers prioritize the concepts that will be explored in a given unit. This is crucial given the number of topics and concepts that teachers are expected to teach. The second step, evidence, calls on the teacher to identify the assessments that will be used to determine if the learning goal was achieved. This step serves two purposes. First it prompts teachers to reflect on the purpose of the learning target. Does the assessment demonstrate a meaningful growth in student understanding? It also requires the curriculum designer to refine the topic further. The final step in the UbD process is Learning

Planning, which is where teachers plan the lessons which will help students reach the goals outlined in the first two steps (McTighe & Wiggins, 2011).

Understanding by Design as a research-based framework was invaluable during the curriculum writing process. The process of writing the curriculum in reverse was challenging, especially because it required knowledge of multiple content areas. However, the resulting curriculum benefited from the structure and rigor of the Understanding by Design model.

Demographics

This curriculum project was designed for use in my current classroom setting, but could be easily adapted for use under other conditions. I teach in a suburban Minnesota school near Minneapolis. The district consists of one high school, one middle school, two elementary schools, and an early learning center. I teach in the middle school which serves students in fifth, sixth, and seventh grades. This project is intended for sixth grade students, and is designed to address sixth grade Minnesota instructional standards.

According to the Minnesota Department of Education (MDE) the student population of the school is predominantly white middle class. Minority populations make up just over 11% of the student population, with the greatest percentage of those minorities being Hispanic. Other student populations include English Language Learners (0.3%), homeless students (0.1%), and students receiving free and reduced-price lunch (17.1%). It should also be noted that 101 of the 590 students receive special education services (MDE, 2016). These statistics are similar to the demographics for the district as a whole, and have been relatively unchanged over recent years. There has been some growth due to suburban development, but student grade numbers are growing by less than 20 students per year. Student achievement scores rank in the top 5% of

schools in the state. In 2016, 83% of students demonstrated academic proficiency, while statewide achievement was significantly lower at 59.5% (MDE, 2016).

I am currently on a team of three teachers who share two subjects, social studies and science. Together we teach all of the sixth grade students. These two teachers, along with most (97.8%) of the teachers in the building hold master's degrees (MDE, 2016). While this unit will was designed with a science focus, many of the lessons are intended for use in other subjects. Cooperation and flexibility are important attributes for any grade-level team that wishes to implement this unit. My grade-level team includes two math teachers, two Language arts teachers, two social studies/science teachers, and a special education teacher.

Context

The curriculum that was developed as a part of this capstone was designed to be as flexible as possible. The first reason for this was the fact that outdoor education in Minnesota is challenging due to weather. Teachers need to be able to adjust the date and time of the lesson to fit the current weather conditions. This curriculum project was intended to demonstrate the benefits of outdoor education to other teachers, and making the lessons flexible will hopefully encourage a positive experience. The second reason for making the unit flexible was that the unit was designed as a collaborative unit between multiple content areas. This type of project requires a great deal of coordination between teachers, each of whom has a unique scope and sequence to their curriculum. For that reason the lessons are not intended to be completed in a specific order, or on specific dates, but will focus on building important concepts over the course of the school year.

In the state of Minnesota there are grade-level specific academic standards for each subject. (Minnesota Department of Education, 2010) Teachers have limited ability to move

subjects or rearrange the content taught in each course. For that reason it is important to be generally familiar with the content of each subject, so that lessons in the curriculum project fit within the courses being taught.

In Minnesota 6th grade science students study physical science. This includes topics like elements and the periodic table, energy and energy transformations, force and motion, and waves (Minnesota Department of Education, 2010). These topics do not naturally lend themselves to outdoor education, but there are still opportunities for garden-based learning. Sixth grade social studies is reserved for Minnesota History. Topics include early Native Americans, the Fur Trade and European settlement, Industrialization, the role of Minnesota in world conflicts, and modern Minnesota. At my current school these courses are offered on alternate semesters. Due to the use of 85-minute block schedules, a year's worth of science and social studies curriculum can be covered in one semester. Unlike science and social studies, which only offer one course per grade, 6th grade math is divided into two courses. The first "standard" 6th grade math course explores a variety of number and operations concepts including fractions, ratios, and coordinate grids. It also introduces a few algebraic concepts like variables and inequalities. Polygons and angles are explored as well, as a part of the basic geometry covered in the course. The second course offered for students in 6th grade is a pre-algebra course. Although this course is designed for the 7th grade, a growing number of 6th graders are enrolling in the advanced course. For the sake of simplicity, I limited the curriculum to only the standard 6th grade math course. The final core class is 6th grade language arts. This course explores reading and writing, as well as research, critical thinking, and inferencing.

I created the curriculum documents this summer as I complete my capstone project. The curriculum would be shared with my team the following semester, with most of the

implementation taking place in the spring of 2018. This will allow sufficient time to collect any required materials, plan necessary accommodations for students with special needs, and allow comfortable weather to return to Minnesota. Social studies lessons will need to take place in the fall, as the fall is the only time that social studies is offered. However, by working closely with my team members I am confident that implementing the lessons in the fall will be possible.

Scope and Sequence

There are ten lessons that make up this curriculum. The activities vary greatly in length. Some of the lessons can be completed in a single day, while others are long-range studies that require regular attention over the course of a few weeks. As was mentioned earlier, the lessons are not intended to be completed in a specific order, but should be used when they fit within the other scheduling needs of the course.

The ten lessons share the common thread of taking place in the school garden. This was an intentional decision that connects each lesson to the next, even though the lessons cover a wide variety of topics. Each of the ten lessons has been paired with the Minnesota 6th grade academic standards that are addressed in the activity. Some of the lessons addressed one standard, while in other activities two or even three standards were explored.

The secondary goal of expanding into the arts, health, and physical education remains. However, many of the activities contained within this curriculum could be used to address these content areas. There simply was not sufficient time to explore the standards and goals of these subjects.

Timeline

This curriculum project was created in the summer of 2017. The first draft was completed on July 19th, 2017. The lessons were written following extensive research into the advantages

and challenges of outdoor education. This research began the previous semester in the spring of 2017, and carried thru the completion of the curriculum documents. The final chapter, a reflection on the curriculum writing process, was completed in the days following. A final draft of the curriculum project and supporting capstone was completed and submitted for approval on August 7th, 2017.

Project Evaluation

This project will be evaluated after implementation. Conversations with the participating teachers will provide feedback about the effectiveness of the project. The project was designed to increase the use of outdoor experiential education. The use of the curriculum itself will help move teachers towards this goal. However; the ultimate goal is to promote independent use of the outdoor spaces around the school. Conversations following the use of the curriculum will reveal how teachers feel about the program and use of garden-based lessons. The actions of teachers and students following the first implementation will be used for future redesign of the curriculum.

This curriculum project was designed for use in a highly successful suburban middle school. The lessons were based on academic standards in 4 core-content areas, however I intend to expand into other contents at a later time. The individual lessons are connected through the shared context of the garden, but work towards mastery of different academic standards. The unit was designed using the Understanding by Design curriculum framework developed by Wiggins and McTighe (2011). After thoroughly examining the academic standards of the content areas, and deciding on assessment goals, the lessons were developed. Each portion of this project was designed to be a flexible part of a larger overall unit. Development of these materials took place in the summer of 2017, and is explored in the next section of this capstone.

Chapter Four

Conclusions

This curriculum project was created with a single underlying purpose, connecting students and teachers with outdoor experiential learning. Experiential learning in an outdoor setting increases student learning (Graham et al., 2005). It also provides benefits to the health and overall well-being of the students involved (Cooper, 2015). Gardens provide an engaging, safe, and interesting place for these lessons to take place. Teachers face several challenges when teaching in an outdoor setting, but with adequate preparation and the right resources these challenges can be overcome. The following reflection contains my thoughts and experiences as I sought to answer the question, *How can school gardens increase teachers' use of experiential outdoor learning?*

The first portion of this reflection details my overall experience during the capstone process. These general conclusions will describe my thoughts about the project as a researcher, writer and learner. It will also revisit portions of my literature review, highlighting the research that had the greatest impact on my capstone. The next section, curriculum development process, explores my experience as a curriculum author. The Understanding by Design model (Wiggins & McTighe, 2011) has multiple steps, and each of these steps are discussed in my reflection. The third portion of this chapter addresses possible implications and limitations of my capstone. What impacts might this project have on the larger learning community? What challenges will I face in implementation? This portion of the reflection will also explore possible variations and extensions of the lessons in the curriculum.

General Conclusions

The term “capstone” is a fitting title for this project. This document, and the curriculum contained within its appendix, represents a survey of the learning that has taken place during my time as a student in the Master of Education program at Hamline University.

Chapter One required me to reflect on my personal journey and my own social context. It required me to think about how I developed my passions and interests. Reflecting on my own past allowed me to identify the meaningful events and experiences of my youth. These experiences shared a common thread, learning about the world while spending time outdoors. The capstone that followed was an effort to recreate some of those same experiences in a school setting.

Chapter two was a difficult but necessary step. As with most research topics, outdoor education has a wide variety of subtopics. It quickly became clear that the subtopics would make or break the literature review. If there were too many subtopics, or the topics were too broad, the literature review would have been overwhelming. If the topics were too few, or too narrow, the literature review would be incomplete. While there is always room for improvement the number and scope of the subtopics seemed to comprehensive, yet manageable. Another challenge of the second chapter was the fact that there are a very large number of articles on the topic of outdoor education, but the majority of them are completely opinion-based. Many people have a passion for the outdoors, and want to share that passion with others, but few of these authors conduct research or even cite the research of others to support their claims.

However there were a few articles and texts that were well researched and were critical to the success of this capstone. Across the Spectrum, a manual designed for environmental educators was one such resource. The first chapter provided a comprehensive history of

environmental education. This was helpful for building my own knowledge base, as well as writing about the history of environmental education in my literature review. Another aspect of the Across the Spectrum manual that made it impactful was the way the authors discussed the relationship between an individual and the environment, which they called environmental identity. "Environmental identity is one part of the way in which people form their self-concept: a sense of connection to some part of the nonhuman natural environment, based on history, emotional attachment, and/or similarity, that affects the way in which we perceive and act toward the world; a belief that the environment is important to us and an important part of who we are" (Clayton, 2003, p. 222). This sense of attachment to the environment is what I described in my introductory chapter. It was developed during my youth, and it is what I hope to encourage in students with this curriculum. The literature review was certainly the most challenging portion of this capstone, but it was also the most rewarding.

Chapter two may have been the most rewarding chapter to write, but chapter three was the most enjoyable. After all of the reflection and research it was finally time to put the pieces together and create something of my own. In the following section I outline the process that I used to develop the ten lessons that make up the garden-based curriculum project.

Curriculum Development Process

The lessons in the curriculum were developed using the Understanding by Design model. This model, created by Wiggins and McTighe (2011), was a natural fit for a unit based on experiential education. The Understanding by Design (UbD) model requires curriculum authors to complete three steps, identifying the learning target, identifying acceptable evidence that the target has been reached, and then designing learning activities that help students achieve the desired results (Wiggins and McTighe, 2011). Experiential learning and outdoor education

provide a variety of opportunities to evaluate students in a meaningful way. The challenge is creating an assessment tool that works within the lesson, without stopping the flow of learning.

As an example, let's explore the lesson Lights, Camera, Garden!, found in Appendix C. This lesson explores connections between science and language arts using the garden as a central topic. While looking for suitable standards in the language arts I found standard 6.7.2.2 which states, "Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content" (Minnesota Department of Education, 2010) As a science teacher, I was familiar with the science standards related to engineering and saw a natural connection to standard 6.1.2.1., Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive (Minnesota Department of Education, 2010). In this lesson students combine both of these standards in a meaningful and relevant way. Students identify a skill or process that relates to the school garden. This could be building, planting, caring for, harvesting, or even cooking plants. After selecting the topic the student conducts research in order to become an expert on the topic. After completing this research the student then records a video tutorial of how to perform the task. This video tutorial is similar to the YouTube tutorials that students in 6th grade are very familiar with. The tutorials provide an goal for students, and offer a valuable assessment tool for teachers, the "acceptable evidence" called for in the UbD model.

Next, the implications of this capstone and curriculum will be explored. This section will discuss the potential of this curriculum project for teacher and students. It will also discuss how this project may evolve over time or be adapted for use in different contexts.

Implications and Variations

It is difficult to guess what the impact of these lessons might be until they are used for the first time with real students. The intention of creating this curriculum was to create a collection of lessons that teachers from a variety of content areas can use, which would hopefully encourage an increase in the use of outdoor experiential learning. Not only would this provide an engaging learning experience for students, but as was discussed in the literature review, "a growing body of scientific literature indicates that play and learning in a diverse, natural area provides a wide array of health, learning, gross motor, and mental health benefits for children" (Cooper, 2015, p. 88).

The limitations of this curriculum are the same as any curriculum. It will only work if teachers are willing to go outside and give it a try. My intention was to close the gap and soften the transition to outdoor education, but it still requires a commitment from classroom teachers. Sharing these lessons with my colleagues will be the first step in the process of implementation. I plan to share these lessons, collect feedback, and make any necessary changes in order to make the curriculum work for those that will teach it. It is by no means is a finished product, and will surely adapt over time.

There are a few modifications that would improve the curriculum no matter how well it is received. One area where future work could add value is the introduction of new content areas to the curriculum. As the lessons were being developed I found many places were an art, music or health standard would fit; however, in the interest of time these lessons were focused on the core content areas of language arts, math, science, and social studies. As teachers become more comfortable leaving the classroom, future lessons could also take advantage of the other natural areas around the school. School forest, parks and local lakes provide great spaces of outdoor

learning. The garden is just the starting point. Finally, I would like to create a more comprehensive curriculum by working more with local agencies like the Department of Natural Resources, watershed districts, and park services. These resources were not fully explored in the curriculum and could provide valuable feedback for improvement.

I look forward to seeing where this project goes and how it changes over time. I am also excited to see how students respond to the lessons, as many times they are the toughest critics. I hope that they can benefit as much as I have from my work on this curriculum. I learned a great deal about curriculum development, this history of outdoor education, and the research process.

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Appendix A

Content Area Overview

Lesson Name	Language Arts	Math	Science	Social Studies
Fresh, Frozen or Canned?			x	
Persuasive Essay	x		x	x
Greenhouses and the Scientific Method	x		x	
Lights, Camera, Garden!	x		x	
Green Spaces		x	x	
Irrigation Challenge		x	x	
Topsy Turvy Plants			x	
Changes in the Garden			x	
Plant Origin Stories	x			x
Maple Syrup Making		x	x	x

Appendix B

Unit Overview

Lesson Name	Summary
Fresh, Frozen or Canned?	Students learn about the nutritional differences between fresh, frozen and canned vegetables by comparing product labels.
Persuasive Essay	Students read The Omnivore's Dilemma: Young Reader's Edition, by Michael Pollan. Following garden demonstrations students will select food-related topics and create persuasive essays using an outline.
Greenhouses and the Scientific Method	Students design greenhouses and complete scientific experiments to learn about the germination of plants. Students will identify and control variables that may impact the growth of plants.
Lights, Camera, Garden!	Students create a tutorial video about a garden-based skill. Students will plan, record, and share the videos as a form of informative text.
Green Spaces	Students use area and volume formulas to calculate the dimensions of the school garden.
Irrigation Challenge	Students construct a water transportation system that will allow them to irrigate three separate locations equally from a single source. Students will calculate various percentages to determine the reliability of their design.
Topsy Turvy Plants	Students learn about the effects of gravity on plant growth. They will plant seeds in different directions and record the results as part of an ongoing study.
Physical vs Chemical Change	Students look for evidence for physical and chemical changes in the garden. A whole class discussion will demonstrate examples of both, and an exit card will provide a formative assessment of the subject.
Plant Origin Stories	Students create origin stories similar to those told in the Native American oral tradition. The stories will be based on observations from the school garden.
Making Maple Syrup	Students learn about the maple syrup/sugaring process used by the Indigenous People of early Minnesota.

Appendix C

Lesson Plans

Fresh, Frozen or Canned?

Minnesota 6th Grade Academic Standards

Science	6.1.3.4	Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.

Summary/Overview

Students will learn about the nutritional differences between fresh, frozen and canned vegetables by comparing product labels.

Gardening Connection

Students will learn about the nutritional advantages of eating fresh produce, which can be grown in a home or school garden. Ideally this lesson would be taught in the school garden, using produce from the garden, but fresh bought produce can be substituted or used as supplements.

Background Information

Nutrition labels will provide most of the data for student analysis. Students will need to be familiar with reading nutritional labels and should have a basic understanding of calories, nutrients and serving size.

Objectives

- Interpret a food label.
- Compare and contrast nutritional data.
- Create a presentation using the data from the label.

Materials

- One can of green beans
- One can of sweet corn
- One can of peas
- One bag of frozen green beans
- One bag of frozen sweet corn
- One bag of frozen peas
- Fresh green beans
- Fresh sweet corn
- Fresh peas
- Digital device + internet (1/group)
- Notebooks/Clipboards
- Handout A - Beans (1/ group)

- Handout B - Corn (1/ group)
- Handout C - Peas (1/ group
- Video - http://kidshealth.org/en/parents/nutrition-label-video.html

Procedure

1. Ask students to begin by writing down everything they can remember eating in the last 24 hours. They should list all of the ingredients in prepared meals separately (i.e. hamburgers = ground beef, buns, cheese, lettuce, ketchup, mustard). After listing all of the foods ask them to compare their list with the students at their table.

2. Now ask them to identify the foods on their list that are from frozen food ingredients. Have them circle the items that were frozen at any point in time, if they are unsure allow them to ask questions or look ingredients up online.

3. Next ask them to identify the items on their list that were canned as some point in time. Draw a box around these foods. Discuss why food ingredients might be canned. (The canning process allows foods to last longer and makes them easier to transport and store).

4. Finally ask students to review the list of remaining ingredients. Are they all fresh foods? Were some of them packaged in other ways? Then ask students to identify the fresh vegetables that were in their diets in the last 24 hours.

5. Explain that today the class will be exploring the difference between fresh, frozen, and canned vegetables. As a class, try to come up with a list of vegetables that can be found in all three styles.

6. Next explain that today the class will be using nutritional labels along with samples of three vegetables in order to learn about the differences. In order to do that it will be necessary to review how to read a nutritional label and its parts. This will be done with a video. Show the nutritional label video from Kid's Health.

7. Break the students into groups of four if they are not already sitting this way. Each group will get one of the three vegetables (beans, corn, peas). Place a few of each of the types of the same vegetable on the plate in the middle of the table. Ask students to look for differences, such as color, texture or smell. Discuss which is most appealing and how they are similar/different. Rotate the plates until each group gets to see all three types. (optional: allow students to taste samples)

8. With the original vegetables in front of the group pass out the matching handout. It contains nutritional labels for the three different types of vegetable. Ask the students to use what they learned from the video to compare the nutrients in the foods. Students should use the data to answer the questions at the end of the worksheet.

9. Once the handout is complete ask students to prepare a brief presentation of the results. This can be done informally, but students should be prepared to answer questions from their classmates.

Review/Summary

Complete the activity by sharing the results from the handout and presenting the findings to the class.

Sources/Credits

Adapted from: National FFA Organization Middle School Food and Agriculture Literacy Curriculum, https://www.ffa.org/documents/learn/MS.FS.4.1.pdf

HANDOUT A - FRESH, FROZEN OR CANNED?

Green Beans

1. Frozen

Nutrition Facts
1 servings per container
Serving size 17 oz

Amount Per Serving
Calories 180

	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 0mg	**0%**
Total Carbohydrate 30g	**11%**
Dietary Fiber 12g	**43%**
Total Sugars 0g	
Includes 0g Added Sugars	**0%**
Protein 6g	**12%**
Vitamin D 0mcg	0%
Calcium 0mg	0%
Iron 0mg	0%
Potassium 0mg	0%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

2. Fresh

Nutrition Facts
1 servings per container
Serving size 3.9 0z

Amount Per Serving
Calories 35

	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 5mg	**0%**
Total Carbohydrate 8g	**3%**
Dietary Fiber 4g	**14%**
Total Sugars 3g	
Includes 0g Added Sugars	**0%**
Protein 2g	**4%**
Vitamin D 4mcg	20%
Calcium 15mg	2%
Iron 30mg	170%
Potassium 6mg	0%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

3. Canned

Nutrition Facts
1 servings per container
Serving size (120g)

Amount Per Serving
Calories 35

	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 380mg	**17%**
Total Carbohydrate 7g	**3%**
Dietary Fiber 3g	**11%**
Total Sugars 1g	
Includes 0g Added Sugars	**0%**
Protein 2g	**4%**
Vitamin D 0mcg	0%
Calcium 0mg	0%
Iron 0mg	0%
Potassium 110mg	2%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

(Nutritional Facts created using Free Nutrition Label Maker at https://www.onlinelabels.com/label-generator-tools/Nutrition- Label-Generator.aspx)

Which type of green beans has the largest serving size? _____

Which type of green beans above has the most calories per serving? _____

Which type of green beans has the most sodium?_____

Which type of green beans above is highest in protein?_____

Which type of green beans has the least nutrients?_____

Which type of peas has the most sugar? _____

HANDOUT B - FRESH, FROZEN OR CANNED?

Sweet Corn

1. Frozen

Nutrition Facts

1 servings per container

Serving size	5 cups
Amount Per Serving	
Calories	**100**
	% Daily Value*
Total Fat 1g	1%
Saturated Fat 0g	0%
Trans Fat 0g	
Monounsaturated Fat 0g	
Cholesterol 0mg	0%
Sodium 0mg	0%
Total Carbohydrate 21g	8%
Dietary Fiber 1g	4%
Total Sugars 5g	
Includes 0g Added Sugars	0%
Protein 3g	6%
Vitamin D 0mcg	0%
Calcium 0mg	0%
Iron 0mg	0%
Potassium 0mg	0%
Vitamin C	6%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

2. Fresh

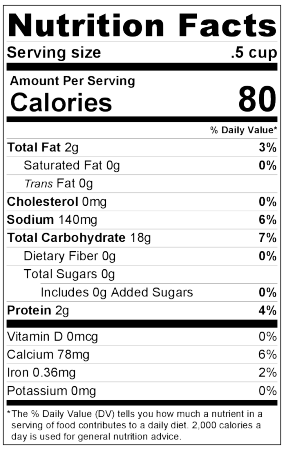
Nutrition Facts

1 servings per container

Serving size	1 lg ear
Amount Per Serving	
Calories	**120**
	% Daily Value*
Total Fat 2g	3%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 20mg	1%
Total Carbohydrate 0g	0%
Dietary Fiber 4g	14%
Total Sugars 5g	
Includes 0g Added Sugars	0%
Protein 5g	10%
Vitamin D 0mcg	0%
Calcium 0mg	0%
Iron 0.72mg	4%
Potassium 18142mg	390%
Vitamin A	6%
Vitamin C	15%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

3. Canned



Nutrition Facts

Serving size	.5 cup
Amount Per Serving	
Calories	**80**
	% Daily Value*
Total Fat 2g	3%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 140mg	6%
Total Carbohydrate 18g	7%
Dietary Fiber 0g	0%
Total Sugars 0g	
Includes 0g Added Sugars	0%
Protein 2g	4%
Vitamin D 0mcg	0%
Calcium 78mg	6%
Iron 0.36mg	2%
Potassium 0mg	0%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

(Nutritional Facts created using Free Nutrition Label Maker at https://www.onlinelabels.com/label-generator-tools/Nutrition-Label-Generator.aspx)

Which type of corn has the largest serving size? _____

Which type of corn above has the most calories per serving? _____

Which type of corn has the most sodium?_____

Which type of corn above is highest in protein?_____

Which type of corn has the least nutrients?_____

Which type of corn has the most sugar? _____

HANDOUT C - FRESH, FROZEN OR CANNED?

Peas

1. Frozen

Nutrition Facts	
Serving size	.5 cup
Amount Per Serving	
Calories	320
	% Daily Value*
Total Fat 9g	12%
Saturated Fat 5g	25%
Trans Fat 0g	
Cholesterol 5mg	2%
Sodium 340mg	15%
Total Carbohydrate 46g	17%
Dietary Fiber 11g	39%
Total Sugars 13g	
Includes 0g Added Sugars	0%
Protein 18g	36%
Vitamin D 0mcg	0%
Calcium 38mg	2%
Iron 2mg	10%
Potassium 367mg	8%
Vitamin C	220%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

2. Fresh

Nutrition Facts	
1 servings per container	
Serving size	(100g)
Amount Per Serving	
Calories	170
	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 0mg	0%
Total Carbohydrate 10g	4%
Dietary Fiber 5g	18%
Total Sugars 5g	
Includes 0g Added Sugars	0%
Protein 0g	0%
Vitamin D 10mcg	50%
Calcium 40mg	4%
Iron 35mg	190%
Potassium 0mg	0%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

3. Canned

Nutrition Facts	
1 servings per container	
Serving size	(100g)
Amount Per Serving	
Calories	170
	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 0mg	0%
Total Carbohydrate 10g	4%
Dietary Fiber 5g	18%
Total Sugars 5g	
Includes 0g Added Sugars	0%
Protein 0g	0%
Vitamin D 10mcg	50%
Calcium 40mg	4%
Iron 35mg	190%
Potassium 0mg	0%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

(Nutritional Facts created using Free Nutrition Label Maker at https://www.onlinelabels.com/label-generator-tools/Nutrition-Label-Generator.aspx)

Which type of peas has the largest serving size? _____

Which type of peas above has the most calories per serving? _____

Which type of peas has the most sodium?_____

Which type of peas above is highest in protein?_____

Which type of peas has the least nutrients?_____

Which type of peas has the most sugar? _____

Choosing Foods - Persuasive Essay

Minnesota 6th Grade Academic Standards

Science	6.1.3.1	Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems.
Language Arts	6.7.1.1	Write arguments to support claims with clear reasons and relevant evidence.
Social Studies	6.1.1.1	Address a state or local policy issue by identifying key opposing positions, determining conflicting values and beliefs, defending and justifying a position with evidence, and developing strategies to persuade others to adopt this position.

Summary/Overview

Student will read The Omnivore's Dilemma: Young Reader's Edition, by Michael Pollan. After reading the text students will experience some of the ideas from the book in the school garden. Following the demonstrations students will select food-related topics and create persuasive essays using an outline.

Gardening Connection

Garden demonstrations will give students a better understanding of topics like organic farming, sustainable agriculture, and environmental stewardship. Reading time can also be spent outside or in the garden.

Background Information

Students will be building background knowledge as they read "The Omnivore's Dilemma: Young Reader's Edition". Teachers must have a basic understanding of the concepts discussed in the book. Food choices have one of the biggest impacts of all our daily decisions.

Objectives

- Identify the basic impacts of different food choices.
- Create an argument that is supported with fact-based evidence.
- Integrate a graph, flowchart, or model as supporting evidence.

Materials

- Copies of “The Omnivore’s Dilemma”, by Michael Pollan (1/student, or one read-aloud)
- Handouts A-E (1/student)
- Writing Utensils (1/student)
- Computers + internet access (1/student)

Procedure

1. Begin the project by reading The Omnivore’s Dilemma, by Michael Pollan with students. The book can be read individually, as a part of literature circles, or as a read-aloud for the entire class.

2. Throughout the text, take students to the garden to provide real-world examples of the concepts from the book. Students will read about commercial farms, large organic farms, local/small-scale organic farms, and hunter-gatherer approaches. Discuss the economic and environmental advantages of local farms using the garden as an example.

3. Return to the classroom. Brainstorm a list of food related topics as a class. Examples include: commercial farming, commercial organic farming, local/small-scale farming, Community Supported Agriculture (CSAs), vegetarianism, veganism, grass-fed meats, shopping local, genetically modified foods (GMOs), ethically sourced foods (i.e.coffee, chocolate), etc..

4. Pair up students. Each pair will select a topic that is interesting to them. Allow students to conduct a little pre-research before deciding on a topic if they are not familiar with the concepts. After selecting a topic give each student a copy of the student handout. Explain that each pair will be arguing opposing sides of the same topic (i.e. Pro-GMO vs. Anti-GMO).

5. Provide time and computer access for students to conduct research. Have students check in after completing sections of the handout, use the checklist as a guide. To create a well-balanced argument, students must collect evidence to support their 2 reasons. They must also create a graphic based on factual data that supports their claim.

Review/Summary

Once students have completed their arguments allow them to record a video of their debate. Students should take turns following the format of the outline. These should be posted or shown during class to allow feedback.

HANDOUT A - CHOOSING FOODS ARGUMENT CHECKLIST

Name: _____ Opponent: _____

Topic:

_____

Question:_____

Position:_____

Check in after completing each of the following items. You must have approval before moving on to the next step.

Rough Draft

- ❏ Intro Statement
- ❏ Reason #1
  - ❏ Evidence #1
  - ❏ Evidence #2
- ❏ Reason #2
  - ❏ Evidence #1
  - ❏ Evidence #2
- ❏ Create Supporting Graphic
- ❏ Consider Counter Argument
- ❏ Prepare Closing Statement

Final Draft

- ❏ Intro Statement
- ❏ Reason #1
  - ❏ Evidence #1
  - ❏ Evidence #2
- ❏ Reason #2
  - ❏ Evidence #1
  - ❏ Evidence #2
- ❏ Create Supporting Graphic
- ❏ Consider Counter Argument
- ❏ Prepare Closing Statement
- ❏ Complete Analysis #1-6
- ❏ Record Debate
- ❏ Upload to YouTube

HANDOUT B - CHOOSING FOODS ARGUMENT MAP (ROUGH DRAFT)

Introduction

Reason #1

Evidence #1 | Evidence #2

Reason #2

Evidence #1 | Evidence #2

Graphic

Description | Analysis

Counter Argument

Closing

HANDOUT C - CHOOSING FOODS ARGUMENT MAP (FINAL DRAFT)

Introduction

Reason #1

Evidence #1	Evidence #2

Reason #2

Evidence #1	Evidence #2

Graphic

Description	Analysis

Counter Argument

Closing

HANDOUT D - WORKS CITED

Source #1

Title Author

Summary:

Citation:

Source #2

Title Author

Summary:

Citation:

Source #3

Title Author

Summary:

Citation:

HANDOUT E - SUPPORTING GRAPHIC ANALYSIS

Respond to the following questions about the graphic you selected.

1. What is the topic of the graphic?

2. Describe the data displayed within the graphic (range/scale of axes, units used, etc.)

3. What is the purpose of the graphic? What is it trying to convince the reader to believe?

4. How does the graphic support your specific argument?

Respond to the following questions about your opponent's graphic.

5. Is there any aspect of the graphic that could be misleading?

6. How might you counter-argue the graphic actually supports your position?

Greenhouses and the Scientific Method

Minnesota 6th Grade Academic Standards

Science	7.1.1.2	Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.
Language Arts	6.14.2.2	Write informative/explanatory texts, as they apply to each discipline and reporting format, including the narration of historical events, of scientific procedures/experiments, or description of technical processes.

Summary/Overview

Students will design greenhouses and complete scientific experiments to learn about the germination of plants. Students will identify and control variables that may impact the growth of plants.

Gardening Connection

These experiments will take place in the school garden. Students will plant seeds and grow samples outdoors. These test could be moved indoors using planters if necessary.

Background Information

Students should be generally familiar with agriculture and the basic conditions for plant growth. They should also have an understanding of the Scientific Method.

Objectives

- Apply the scientific method to learn about an agricultural problem.
- Write a scientific experiment with a question, hypothesis, procedures, data collection, analysis and a conclusion.

Materials

- Radish seeds
- Corn seeds
- Barley seeds
- Pea seeds
- Handout A
- Thermometers
- Measuring Tapes
- Graphing Paper
- Clipboards
- Assorted cups
- Cellophane/Wrap
- Paper
- Watering cans
- String
- Popsicle Sticks

Procedure

1. Begin the lesson in the classroom. Start by introducing the idea of greenhouses to the class. Explain that in certain parts of the world the growing season is too short or unpredictable to grow certain plants. In some cases farmers use greenhouses or large hoop houses to extend the growing season and protect their harvests. Continue the review of greenhouses with a quick video about how they work.
   Video: https://www.youtube.com/watch?v=a-m8lallM4Y&t=19s

2. Next explain that students are going to design greenhouses to help seedlings grow in the school garden. These greenhouses will be designed and constructed in class, and then placed over seedlings in the garden. Data will be collected twice a week, for the next 4 weeks.

3. Group the students into groups of four. Give each group a copy of Handout A. As a group they should design a greenhouse that can be constructed using the materials available in class (cellophane, wrap, plastic cups, popsicle sticks, etc.) When they complete Handout A they should check in with the teacher before beginning construction.

4. Allow student groups to build greenhouses following their design plans. Any changes should be updated on the handout. Once the greenhouses are constructed students will need to select a type of seed and plant two plots in the school garden. Explain that the same planting technique should be used to plant both plots in order to maintain the accuracy of the experiment.

5. Students should place their greenhouse over one of the plots and label both with popsicle sticks for later identification. The second plot should be planted but remain uncovered.

6. Return to the school garden at regular intervals during the growing season. Allow time for students to make repairs, record growth and make observations. On the last day ask students to remove greenhouses.

Review/Summary

Following the last day of observations, provide time in class for groups to reflect on the results of the experiment. End by allowing each group to present their greenhouse design and the results of the experiment.

HANDOUT A - GREENHOUSES AND THE SCIENTIFIC METHOD

Question

How do greenhouses affect vegetable seed germination?

1. Hypothesis

If_____,
then_____,
because_____.

2. Procedure

Step	Description
1	_____ _____ _____
2	_____ _____ _____
3	_____ _____ _____
4	_____ _____ _____
5	_____ _____ _____
6	_____ _____ _____
7	_____ _____ _____

3. Data Collection

Date	Observations (Greenhouse)	Observations (Control Group)

4. Analysis

Which group of plants grew fastest?

_____

_____

Which group of plants developed more leaves?

_____

_____

Which group of plants had the greatest number of seeds germinate?

_____

_____

5. Conclusion

Summarize the results of your greenhouse experiment. (Summaries must include 3 measurements, and the words *hypothesis*, *germinate* and *greenhouse.)*

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Lights, Camera, Garden!

Minnesota 6th Grade Academic Standards

Science	6.1.2.1	Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive.
Language Arts	6.7.2.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Summary/Overview

Students will be creating a tutorial video about a garden-based skill. Students will plan, record, and share the videos as a form of informative text.

Gardening Connection

The tutorials will be based on skills and activities in the school garden. Students can demonstrate how to plan, plant, prune, harvest, or even cook foods from the garden.

Background Information

Students will need basic research skills in order to learn about their garden-based topic. They will also need guidance on how to record and edit video.

Objectives

- Identify the steps in a gardening skill.
- Create an informative script explaining the skill.
- Demonstrate and explain the skill using a video tutorial.

Materials

- Computers + Internet access
- Handout A - HANDOUT A - LIGHTS, CAMERA, GARDEN
- Video recording equipment (cameras/smart phones)
- Materials for demonstrating student activity (seeds, soil, pots, pruners, trowels, shovels, etc.)

Procedure

1. Start with a question, “What do you do when you want to do something new, but you don’t know how?” “Where might you look to learn how to do something new?” List all of the ideas that are presented by students. YouTube tutorials will most likely come up. Discuss what types of tutorials are found on YouTube (Minecraft, makeup, hair braiding, etc.) Show an example.
   Paper Airplane Tutorial: https://www.youtube.com/watch?v=V-rBmbBSGIA

2. Explain that today students will be selecting topics and creating their own YouTube tutorials. These videos will be used by young students to learn more about gardening. Discuss ideas regarding which gardening skills could be demonstrated with a video tutorial. List ideas on the board.
   Examples: plantings seeds according to package directions, transplanting existing plants, water and weeding techniques, pruning and harvesting, preparing and/or cooking foods from the garden.

3. Give each student a copy of Handout A. Allow time for students to select a topic and begin research. This will take a considerable amount of time depending on amount of experience the student have with research. Students will also need to pick skills they can demonstrate using the materials in the classroom or they can bring in from home.

4. When the handouts are complete plan a period or two where time can be spent in the garden using cameras/smartphones to record the tutorials. Additional time will also be needed to edit the videos and prepare them for sharing.

Review/Summary

Share the videos according to your district video policy. If possible they can be uploaded to a classroom page on YouTube.com. If privacy is a concern videos can be shared within the classroom.

HANDOUT A - LIGHTS, CAMERA, GARDEN

Brainstorm - Based on your interests and the discussion we had as a class, create a list of 5 ideas that could be a part of your tutorial.

1. _____
2. _____
3. _____
4. _____
5. _____

Select - Pick one of the ideas you listed above. Use the resources in class to conduct 5 minutes of background research. Does this topic still seem like a good fit? If so write your topic below.

My tutorial is about _____.

Outline - Use the classroom resources to create a 10-15 step process that will be explained in your tutorial. This will help you develop a complete script later on.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____(optional)
12. _____(optional)
13. _____(optional)
14. _____(optional)
15. _____(optional)

Elaborate - Use the space below to create a script for your tutorial. Consider what props and materials will be need to make your video interesting and educational. Remember that your audience is young and may not have much gardening experience.

Materials Needed

From the classroom...

From home...

Green Spaces

Minnesota 6th Grade Academic Standards

Science	6.1.2.1	Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive.
Math	6.3.1.1	Calculate the surface area and volume of prisms and use appropriate units, such as cm^2 and cm^3. Justify the formulas used. Justification may involve decomposition, nets or other models.
Math	6.3.1.2	Calculate the area of quadrilaterals. Quadrilaterals include squares, rectangles, rhombuses, parallelograms, trapezoids and kites. When formulas are used, be able to explain why they are valid.

Summary/Overview

Students will use area and volume formulas to calculate the dimensions of the school garden.

Gardening Connection

Using the school garden as a setting for area and volume calculations exposes students to a place where these calculations might be used in the real world.

Background Information

Students should have some experience with multiplying to find area and volume. They should also have basic measurement skills, but reviewing how to use a tape measure may be helpful.

Objectives

- Calculate the area of triangles and squares.
- Calculate the volume of rectangular and triangular prisms.
- Create a scale map of the school garden.
- Calculate the volume of the school garden beds.
-

Materials

- Handout A - GREEN SPACES (1/student)
- Writing utensils
- Calculators
- Colored pencils
- Tape measures (1/student)

Procedure

1. Begin the lesson by reviewing the formulas for area and volume. Complete a few examples as a class. Write the formulas on the board.
   Area of a rectangle = LxH *Volume of a rectangular prism = LxWxH*
   Area of a triangle = ½ LxH *Volume of a triangular prism = (LxWxH)/3*

2. Give each student a copy of Handout A - GREEN SPACES. Ask them to complete the first and second portions (#1-12), practicing area and volume calculations. Review the answers as a class, asking students to share how they arrived at their answers.

3. Take the class out to the garden to complete the remainder of the lesson. Give each student a tape measure and a clipboard. Ask them to complete the map and tables using the tools you have provided. Allow them to name/label the gardens in a way that makes sense to them. If students finish early allow them to use colored pencils to color code the table and map.

Review/Summary

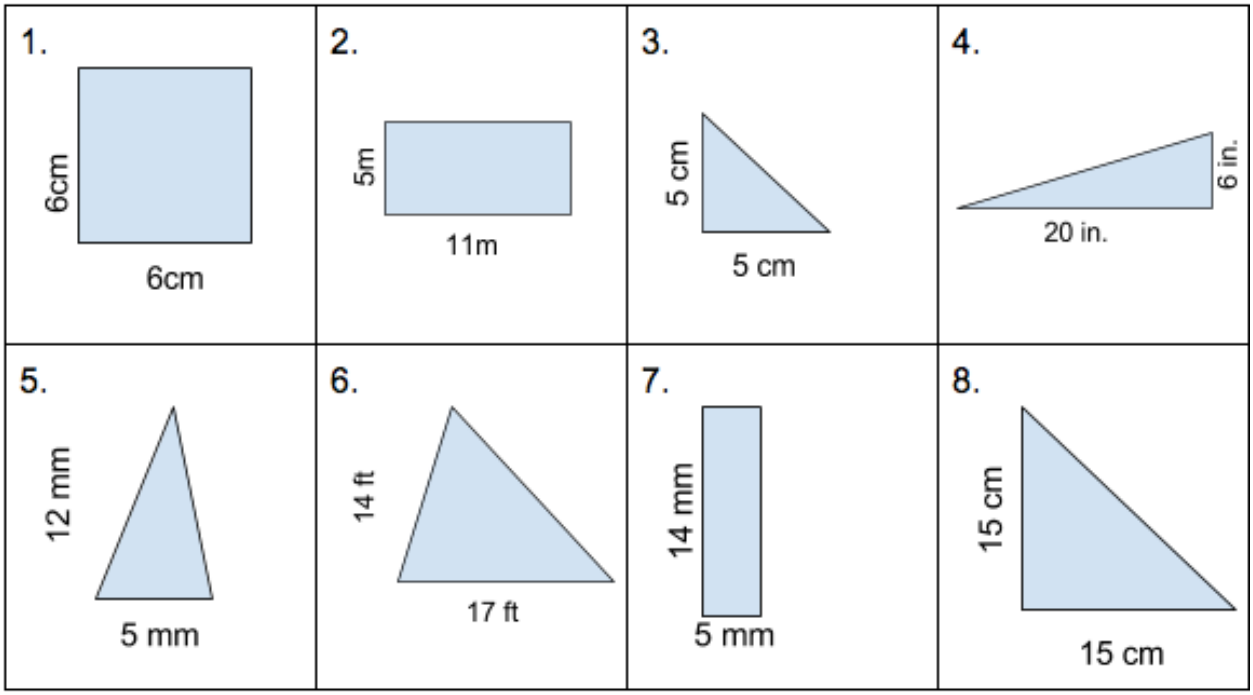
Conclude the activity by allowing students to compare and contrast their maps and calculations. Encourage students to make adjustments to their work after meeting with classmates.

HANDOUT A - GREEN SPACES

Formulas

Area of a square/rectangle Area of a triangle	Volume of a rectangular prism Volume of a triangular prism

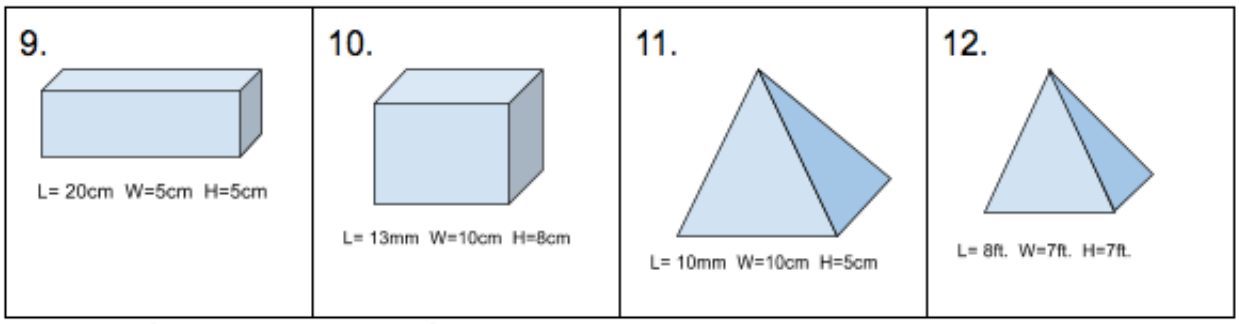
Find the area of each shape. (Units are not to scale)



1._____ 2._____ 3._____ 4._____

5._____ 6._____ 7._____ 8._____

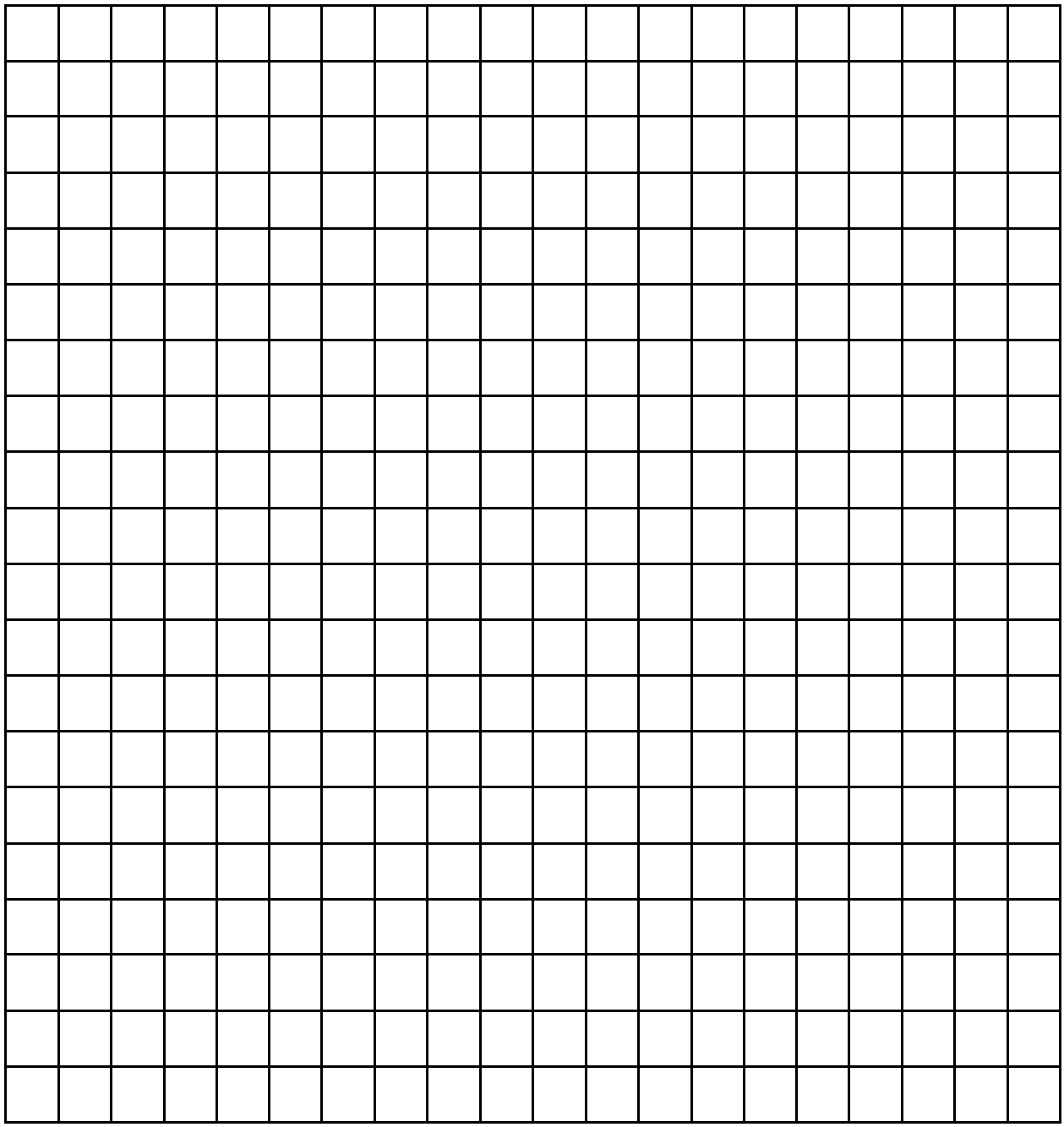
Find the volume of each shape. (Units are not to scale)



9._____ 10._____ 11._____ 12._____

13. Use a measuring tape to gather measurements and calculate the size of the school garden. Round measurements to the nearest foot. Use the measurements to create a map of the garden below.

NORTH



14. Use the area formula from part 1 to find the area of the garden planters, not including walkways and grass. Show your work below. Label your drawing with matching labels/colors.

Garden	Dimensions	Calculations	Area
	L= W= H=		
	L= W= H=		
	L= W= H=		
	L= W= H=		
	L= W= H=		

15. Calculate the volume of soil used in each garden based on the average soil depth provided by the teacher. Average Soil Depth = _____

Garden	Area	Calculations	Volume

Irrigation Challenge

Minnesota 6th Grade Academic Standards

Science	6.1.2.2	Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system that solves a problem.
Math	6.1.1.3	Understand that percent represents parts out of 100 and ratios to 100.

Summary/Overview

Students will be constructing a water transportation system that will allow them to irrigate three separate locations equally from single source. Students will calculate various percentages to determine the reliability of their design.

Gardening Connection

Water plants in the garden provides a real-world problem for the student engineers to address. Without context students may struggle to see the purpose of the engineering design process.

Background Information

Students should be generally familiar with the engineering design process.

Objectives

- Design and build an irrigation system.
- Calculate the percentage of water during transportation.
- Calculate the percentage of water in each of the three final locations.

Materials

- Clipboards (1/student)
- Water
- Scissors/Hole punches
- Straws (assorted)
- Cups (assorted)
- Handout A - Design Plan (1/student
- Tubing/Hoses (assorted)
- Putty/Clay/Playdough
- String/Yarn
- Any surrounding materials
- Graduated cylinders/beakers

Procedure

1. Begin by explaining the engineering challenge.
   Challenge: Students must work in groups of four to create an irrigation system that can transport water from the milk jug into three separate containers at least 12 inches apart. Systems should be designed to minimize water loss and split water evenly into the three containers.

2. Explain what materials are available. Students can use any of the materials provided by the teacher. They can also use any natural materials from the garden or the surrounding areas (no animals or plants should be harmed). They will have one class period to build and test, and will return the next day to redesign and retest.

3. Split the students into groups of four. Give each group a clipboard and a copy of the student handout. Allow them to examine the materials, discuss strategies, and talk amongst themselves while they complete the handout. No work should begin before the student groups have a teacher signature on the design plan.

4. Once students have teacher approval, they can begin construction. Allow them to test their design at any point in the building process. Construction and testing should continue until all groups are done. If groups finish early, encourage them to fine tune the design to ensure even water distribution.

5. When all groups have completed their designs test them one at a time. Ask all of the students to gather around the group while they test. To test the device give the student 1000mL of water in a beaker. Make sure the system is empty and dry, and allow them to run the water into three beakers. Each group should record the results of their own water tests.

Review/Summary

After completing the first day of testing remind students that they will be redesigning their systems and retesting the following day. Remind them that the engineering design process is reiterative. Return to the classroom to complete the calculations. Repeat steps 3-6 on day 2. Following the second set of tests, ask students to complete the reflection questions on the handout.

HANDOUT A - IRRIGATION CHALLENGE

Engineering Design Process

Identify a Need

1. Why build an irrigation system?

Conduct Research

2. Look at how the school garden is irrigated, record your ideas here:

Brainstorm Solutions

3. What materials will you use?

4. How will water be split evenly?

5. How will we avoid water loss?

Select a solution

6. Draw your initial design in the box below.

Teacher Approval _____

HANDOUT B - CALCULATIONS/QUESTIONS (DAY 1)

Calculations - Day 1

1. How much water was poured through your irrigation system? _____
2. How much water was in…
   container one? _____
   container two? _____
   container three? _____
3. How much water made its way through the entire system? _____
4. What percent of water made it through the irrigation system? Show your work.
5. What percent of the water that made it through the system ended up in containers one, two and three?
6. What percent of the water that was poured into the system made its way into containers one, two and three?
7. Unless you have a perfect irrigation system the answers for questions 5 and 6 are different, why?

Reflection Questions

1. In what ways was your first design successful?
2. In what ways was your first design unsuccessful?
3. What changes will you make to your design for the rebuild?

HANDOUT C - CALCULATIONS/QUESTIONS (DAY 2)

Calculations - Day 2

8. How much water was poured through your irrigation system? _____
9. How much water was in…
   container one? _____
   container two? _____
   container three? _____
10. How much water made its way through the entire system? _____
11. What percent of water made it through the irrigation system? Show your work.
12. What percent of the water that made it through the system ended up in containers one, two and three?
13. What percent of the water that was poured into the system made its way into containers one, two and three?

Reflection Questions

1. What changes did you make to your second design?
2. Did the changes you made have the desired impact?
3. What would you change if you had a third design?

Topsy Turvy Plants

Minnesota 6th Grade Academic Standards

Science	6.2.2.2	Forces have magnitude and direction and affect the motion of objects.

Summary/Overview

Students will learn about the effects of gravity on plant growth. They will plant seeds in different directions and record the results as part of an ongoing study.

Gardening Connection

There are a variety of factors that affect plant growth including water, nutrients and sunlight. Helping students understand the impacts of gravity helps them see the connections between the physical and life sciences.

Background Information

Students will need a basic understanding of the requirements for plant germination. Students should also have some familiarity with the concepts of gravity and forces.

Objectives

- Record accurate observations over time.
- Explain how gravity impacts the growth of radish seeds.

Materials

- Radish Seeds (3-4/student)
- Soil
- Plastic cups
- Rulers
- Water
- Hole punch
- Handout A - Gravity and Plants

Procedure

1. Begin the lesson by discussing the requirements for sprouting seeds. Create a list on the board. Students will likely answer; sun, soil, water, air. Explain that the class will be planting seeds in the garden and observing their growth over time.

2. Start by reviewing the procedure for planting the radish seeds. Remind the students to follow the steps on the student handout. Plant the seeds in cups.

3. When students have finished planting, take the seed cups outside to plant them in the garden. Bury the cups except for the top one inch. Ask the students to complete the first observation before returning to the classroom.

4. Return to make observations every few days. Ask the students to add water as needed and remind them to make detailed drawing and list of observations.

5. After about 2 weeks the sprouts will begin to grow. Once the sprouts are 1-2 inches in length ask the students to carefully remove the cup from the garden and replace it in the soil at a 45 degree angle. Again, bury the sides of the cup to prevent drying out, and add water if necessary.

6. Continue observing the changes in growth, paying special attention to how the plants respond to the change of orientation.

Review/Summary

Once students have completed their observations ask them to complete the reflection questions on the handout. Discuss the responses as a class when students are finished.

Sources/Credits

Adapted from: Geotropism, The UGA School Garden Resource Project, http://extension.uga.edu/k12/school-gardens/pdf/Geotropism.pdf

HANDOUT A - TOPSY TURVY PLANTS

Use the steps below to plant your radish seeds.

1. Take a plastic cup and carefully poke 4-5 holes in the sides and bottom.
2. Place the cup on a paper towel and fill it with potting soil. The potting soil should be ½ inch from the top of the cup.
3. Evenly space four radish seeds in the cup. Push them into the soil using a finger or a pencil eraser. They should be ¼ inch deep in the soil.
4. Fill the holes and gently pat down the soil. (Do not over-compress.)
5. Add water until the soil is moist.

Use the table below to record your observations. Use as much detail as possible in your drawing and descriptions.

Date	Drawing	Observations
		_____ _____ _____ _____ _____ _____
		_____ _____ _____ _____ _____ _____
		_____ _____ _____ _____ _____ _____
		_____ _____ _____ _____ _____ _____

Date	Drawing	Observations
		_____ _____ _____ _____ _____ _____
		_____ _____ _____ _____ _____ _____
		_____ _____ _____ _____ _____ _____
		_____ _____ _____ _____ _____ _____

Reflection Questions

1. What surprised you most about the growth of your radish seed?

   _____
   _____

2. How did your plants respond to the change of angle?

   _____
   _____

3. What inputs affected the growth of your radish plants?

   _____
   _____

Changes in the Garden

Minnesota 6th Grade Academic Standards

Science	6.2.1.2	Substances can undergo physical changes which do not change the composition or the total mass of the substance in a closed system.

Summary/Overview

Students will be looking for evidence for physical and chemical changes in the garden. A whole class discussion will demonstrate examples of both, and an exit card will provide a formative assessment of the subject.

Gardening Connection

Students will be looking for examples of physical and chemical changes in the garden. This will help students understand that physical and chemical changes are taking place all the time in natural and man-made settings.

Background Information

Students do not require any specific background knowledge for this lesson. However, they should be familiar with making and recording observations while they work.

Objectives

- Define *physical change* and *chemical change.*
- Identify examples of physical and chemical changes and provide supporting evidence.

Materials

- HANDOUT A - Changes in the Garden
- Clipboards
- Writing utensils
- Computer + projector
- Camp stove + pan
- Popcorn
- Water
- Any fruit/vegetables from the garden
- Video - https://www.youtube.com/watch?v=37pir0ej_SE&index=8&list=PLhz12vamHOnaY7nvpgtQ0SIbuJdC4HA5O

Procedure

1. Begin by reviewing the difference between physical and chemical changes. Show the video to remind students about the evidence that might suggest that a chemical change has occurred (new substance, smell, light, color, or precipitate).Video: https://www.youtube.com/watch?v=37pir0ej_SE&index=8&list=PLhz12v amHOnaY7nvpgtQ0SIbuJdC4HA5O Also review that any change that is not a chemical change is a considered a physical change.

2. Next give each student a copy of the handout. Have them attach them to a clipboard and lead the class outside to the garden. Once there instruct the students to identify examples of physical and chemical changes in the garden.

3. Allow students to work together and ask questions about the changes they find. If the students haven't been to the garden recently, remind them what it looked like before they came. Support the inquiry with guiding questions like: *Where did the rain from last night go? Where did these flowers come from? Why do the wood chips look this way?.*

4. Provide new examples for students to use by setting up a camp stove near the garden. Using different items from the garden to demonstrate change. Pop popcorn (physical, but creates a lot of discussion), melt ice/boil water (physical), boil carrots (chemical), grill zucchini(chemical). Again, allow students to ask and answer each other questions about what they are seeing.

Review/Summary

When students have finished filling out the table in the handout, ask them to sit in a circle. Allow students to share the lists they found, and encourage them to add answers they like to their own tables. Discuss any ideas that create disagreement.

After completing the discussion ask students to complete the exit card on the back of the handout. Each student should identify whether the listed changes are physical or chemical changes.

HANDOUT A - CHANGES IN THE GARDEN

1. Identify examples of physical or chemical changes in the garden. Support your claims with evidence from our discussion earlier. If the change is chemical, what evidence of change leads you to that conclusion?

Physical Change	Evidence	Chemical Change	Evidence
1.		1.	
2.		2.	
3.		3.	
4.		4.	
5.		5.	
6.		6.	
7.		7.	
8.		8.	

2. Identify the following changes as physical or chemical changes. Check the box.

Example	Physical Change	Chemical Change
Snapping a twig		
Boiling macaroni noodles		
An old log rotting		
A nail rusting		
Folding a newspaper		
Burning gas in a camp stove		
Insects eating tomato leaves		
Writing with a pencil in a notebook		
A puddle evaporating		

3. The popcorn popping was a difficult example to classify. We decided the change was physical, not chemical. What caused the popcorn kernel to pop if there was no chemical change?

_____

_____

_____

_____

_____

_____

Plant Origin Stories

Minnesota 6th Grade Academic Standards

Social Studies	6.4.4.15	North America was populated by Indigenous Nations that had developed a wide range of social structures, political systems and economic activities, and whose expansive trade networks extended across the continent.
Language Arts	6.7.3.3	Write narratives and other creative texts to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences.

Summary/Overview

Students will create Origin Stories similar to those told in the Native American oral tradition. The stories will be based on observations from the school garden.

Gardening Connection

Students will use the school garden as inspiration for the Origin Story they tell. The subject of the story does not need to be found in the garden, but the garden provides an abundance of visuals for inspiration.

Background Information

Students will build background knowledge during the first part of the lesson. This lesson should follow a discussion of Ojibwe or Dakota oral tradition. Oral tradition refers to the use of spoken language and stories rather than written records.

Objectives

- Create a narrative text.
- Identify the common aspects of Native American oral tradition.

Materials

- Notebook paper
- Writing utensils
- Computers + internet
- http://aktalakota.stjo.org/site/PageServer?pagename=alm_culture_legends

Procedure

1. Introduce the topic of the activity, Origin Stories. Explain that today students will be telling a story to explain where an plant or animal comes from. It does not need to be based on fact, but it should explain the physical features or behavior of the organism.

2. Begin with some background research. Ask the students to pair up and sit together. Then ask them to pick one of the stories from the Lakota Cultural Center website. Website:http://aktalakota.stjo.org/site/PageServer?pagename=alm_culture_legends Remind the students to read the stories aloud to each other, which is how they would have originally been shared.

3. Ask students to share from the stories they selected. How did the storyteller explain the characteristics of the animal or plant? Did the author introduce other characters that you were not familiar with? What was the mood of the story? Was there a moral or lesson to learn?

4. After sharing as a class, take the students to the garden. Explain that today they will be selecting a plant or animal to write a story about. The subject of the story does not have to be present in the garden, but items from the garden can be used.

5. Allow time for students to write quietly in the garden. Encourage them to walk quietly and find a comfortable place to write. The stories should be a minimum of one page in length, but can vary depending on writing style and speed.

6. If students finish early, direct them to add illustrations or begin a second story while others finish. When the remaining students have finished, ask them to form a circle on the ground so they can hear the stories read aloud.

7. Begin with an example of your own, or read one for a student who is uncomfortable reading aloud. Then allow volunteers to go next. Encourage students to read, but allow them to pass if they would prefer to not share. Collect the stories, and return to the classroom.

Review/Summary

Review the stories for descriptive detail, event sequencing, and description of a natural topic.

Making Maple Syrup

Minnesota 6th Grade Academic Standards

Social Studies	6.4.4.15	North America was populated by Indigenous Nations that had developed a wide range of social structures, political systems and economic activities, and whose expansive trade networks extended across the continent.

Summary/Overview

Students in this lesson will be learning about the maple syrup/sugaring process used by the Indigenous People of early Minnesota.

Gardening Connection

If suitable maple trees are not located near the garden, trees in other locations can be used, or the activity can be modified for use without trees. Maple trees are found all over the Upper Midwest and are a natural resource that students should be aware of.

Background Information

Most people do not have experience with making maple syrup; however, a basic understanding of botany and familiarity with maple trees is helpful.

Objectives

- Identify maple trees in the area near the school.
- Explain the steps of the maple syrup making process.

Materials

- Real Maple Syrup
- Artificially Flavored Syrup
- Water/syrup mixture 40:1
- Large stock pot
- Spline + Hammer
- Sugar Maple Tree (if possible)
- Notebook paper
- Writing Utensils
- Maple Syruping article (1 copy/student) http://files.dnr.state.mn.us/mcvmagazine/young_naturalists/young-naturalists-article/maple_syrup/maple_syrup.pdf

Procedure

1. Begin the lesson in the school garden. Start with the question, “What natural resources were important to the Dakota and Ojibwe tribes in early Minnesota?” Students answers will likely include deer, beaver, bison, fish, berries, fruits, and grains. If students don’t suggest maple syrup, explain/remind them of importance of maple syrup/sugar in the Ojibwe culture.

2. Ask if anyone has ever had maple syrup. Many will respond yes; however, many of these students are probably more familiar with artificially flavored syrups. Explain that there is a difference between most commercial syrups and true maple syrup. Remind the students that true maple syrup comes from the sap of maple trees. Provide small samples of each. Ask for students to compare the two.

3. Ask “Can anyone identify a maple tree?” If there are examples nearby, allow the students to gather around the base of the tree. Discuss the defining characteristics. Explain the tapping process. If a spline is available, show the students how it could be inserted at waist height. Return to the garden.

4. Next, discuss the process for making syrup. Explain that the sap that comes out of the maple tree is not the same as the syrup found in bottles. Show the students a mixture of water and syrup (40:1). Explain that in order to produce even a small amount of syrup a large volume of sap is needed. Allow them to observe and compare the two liquids. Ask “How do we get from this large container of sap to a small concentrated syrup?” Allow students to share ideas.

Review/Summary

Leave the sap(water/syrup mixture) and syrup as a visual. Give each student a copy of the Sugar from Trees article and the handout. Ask students to read the article and complete the handout. When students are finished discuss the handout and answer any questions that may remain about the maple syrup making process.

Sources/Credits

Adapted from: Maple Syrup Production, Heather Coder, http://ecosystems.psu.edu/youth/sftrc/lesson-plans/forestry/k-5/maplesyrup-prod

HANDOUT A - MAKING MAPLE SYRUP

Read Sugar from Trees. Use the information from the reading to answer the following questions.

1. List and explain the steps of the syrup making process.

Step	Description

2. When it is removed from the tree the sap is mostly water and boiling the sap reduces the volume. Where does the lost material go? _____
_____
_____

3. What four types of trees are used for syrup making, and which of the four produces the sweetest sap? _____
_____
_____