Spring 2023

Using Citizen Science to Create Meaningful Learning Experiences and Enhance the Learning of Science for Second Grade Students

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by

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A capstone project submitted in partial fulfillment of the requirements for the degree of Masters of Arts in Natural Science & Environmental Education

Hamline University

Saint Paul, Minnesota

September 2022

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I hear and I forget
I see and I remember
I do and I understand

Chinese Proverb

Positionality Statement

As an educator who spent thirteen years teaching preschool through kindergarten students, I was aware of how hands-on activities are beneficial to the student's learning, understanding, and growth, but lacked the understanding of the effects of hands-on activities on second graders. I wanted to understand more about how the introduction of real-life, hands-on science activities can benefit the learning, understanding, and growth of second graders, specifically in science.

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CHAPTER ONE

Introduction

Citizen science is a new and growing field of research that brings about new knowledge and understanding through the collaboration of citizens in scientific research. As citizen science continues to grow, it is important to consider the potential it has to encourage education and learning opportunities. People of all ages can engage in citizen science, participating in projects in which volunteers and scientists work together to answer real-world questions. Citizen science projects vary greatly in topics, length, and skills required. Projects can range from astronomy, conservation, biology, and ecology. Participation in citizen science projects can assist in developing science literacy, enhance learning, increase interest in science, increase understanding of the scientific process, and connect students with the world around them.

I was introduced to citizen science during my Community Based Environmental Science class at Hamline. During the class, I was asked to participate in a citizen science project. Citizen science is when the general public helps collect and analyze data, usually as part of a collaborative project with professional scientists. I enjoyed participating in a citizen science project and gaining a better understanding of the topic I was participating in and felt like the work I was doing was as important as the data being collected. This data was going to help scientists with their research. For my portion of this project, I was asked to observe a maple tree in spring and make observations about the tree's phenophase stages. I observed the tree multiple times a week and noted the weather, the temperature, and the maple trees' phenophase stages. I would input my data into the

Nature Notebook website, where scientists used the data I provided to track the effects of global warming. During this process, I developed a better understanding of maple trees, especially the red maple I was observing, collecting data on, and learning about. I was able to see data from past years and see that maple trees are starting to bloom earlier in the spring. After my personal experience with citizen science, I started to consider how I can use citizen science in my classroom and what effect it may have on my students. This led to the question: *How can citizen science create meaningful learning experiences and enhance the learning of science for second grade students*?

This chapter will focus on my personal and professional background and how my experience has led me to this capstone. I will also explain the rationale for why I have chosen to create a supplemental curriculum that correlates with the current second grade science curriculum.

Personal Background

Childhood

Growing up in Maryland I experienced all four seasons. A majority of the summer days were hot, while the nights, while still warm, cooled off enough for one to enjoy. We would have extremely hot and humid days, but they would be limited and occur towards mid to late summer. Fall was warm until mid-October when the temperature would start to drop into the 60's then cooled down into the 50s in late October or early November. Winters were cold and would have some amount of yearly snowfall and every 4-5 years there would be a big snow which would result in at least a foot of snow. During this time we were known to have blizzards where we could receive over two feet of snow. Spring always seemed to come later than we liked and the weather would begin to warm up

around mid-April. I spent a great deal of my childhood outdoors year-round exploring and observing the world around me. If I was not exploring my yard and the area around me, I was exploring ponds, fields, mountains, and farms with family members. I realized at a young age that things seemed to happen around seasons. This included when my family members planted and harvested their crops, hunted, and calved and slaughtered animals. I can remember sitting around a table and listening to them discussing the weather and how the weather may affect their crops and how they may need to adjust things. This included planting later in the spring and sometimes changing what they planted in their gardens. At a young age, I knew there was a connection between the seasons and when gardens were planted and fields were harvested but did not have an understanding of what those connections were. As I got older, I started to understand the connection between seasons, temperature, and phenological events. I began to notice that as the seasons changed, specifically between winter and spring, and the temperature began to rise that flowers, bushes, and trees began to bloom. This is when I also began to notice that various vegetation blooms at different times. For example, I noticed that daffodils sprout and bloom early in spring before temperatures increase and stay at a steady temperature.

Young Adulthood

After graduating from college I started noticing new changes around my childhood home. I started to notice that the winters were not as cold and there was less snowfall. I observed that the summers were getting hotter for longer periods and that it was warm later into fall as temperatures did not start to decrease until late October. I also started to recognize how these changes were affecting my family members who were

farmers. They were losing crops, having issues with crop yields, and having difficulty with hunting and gathering food. There were also times when they had shorter growing seasons. As I continued to get older, I noticed more changes in weather patterns and started to observe changes in some animal behaviors as well. Animals and insects that I would not typically see in winter, such as finches and bees, I would sometimes see during winter months. I also observed that some birds were starting to migrate later in the year. I started observing some trees and plants sprouting and blossoming earlier as the winter months have been warmer or temperatures started getting warmer in late March or early April.

Graduate School

While in the Natural Science and Environmental Education (NSEE) program at Hamline, I learned about citizen science and realized that people have always been citizen scientists, using their observations of the natural world to decide when to plant home gardens, fields, and when to harvest their crops. If they noticed an early frost, they may have decided to harvest crops early to not lose any of their crops' yield. Some may have observed the migration of birds, noticing that their migration pattern has changed over the years and making the connection that the migration has a connection with earlier warming in spring and later cooling in fall. While the information gathered through observations was not used formally or given to scientists for analysis, the information they gained from their observations has been used to help themselves and their communities. I was even a community scientist gathering data through my observations. After my Community Based Environmental Science class, I realized my observations can have connections with real-world science experiments and have an impact. This led me to

be more interested in citizen science and how it can be used in the classroom asking: *How can citizen science create meaningful learning experiences and enhance the learning of science for second grade students?*

Professional Background

I have been working with students in an educational setting for 17 years. For the past 12 years, I have worked with students between the ages of 3 and 6. Throughout my career, I have had a passion for teaching science. I have worked with others that have shied away from teaching science either due to a lack of knowledge or interest in the subject. I took my love of nature and what I enjoyed when I was a kid and created hands-on lessons the students enjoyed and thrived on. My passion grew more while working in the inner city as a pre-k teacher. I realized quickly that the students knew little of nature. Most of what the students knew was what they observed in their neighborhood which was the infrastructure of the city such as buildings, concrete, roads, and other man-made objects with little nature around them. Over the years I have worked hard on creating meaningful science lessons and experiences for my students.

During my professional career, the focus on teaching reading and math has created a larger gap in science education (Carlone, et al., 2010). Where science was once taught regularly, it is now taught for short periods. This can make it difficult for students to enjoy the subject and understand the scientific process. I have tried to persuade other educators that they can easily integrate science into their classrooms and have fun, meaningful lessons. Unfortunately, they did not have a passion for science and chose to stay focused on reading and math. I started to create lesson plans for them and provided them with materials when possible so their students could experience the joys of science.

I am always trying to find new ways to incorporate meaningful science activities into my classroom. As I have learned about citizen science, I have started to think about how it can be incorporated into my classroom. After discussing citizen science with my team and seeing their interest, I started thinking about how I can create a supplemental curriculum to incorporate citizen science into the science lessons and classroom. Teachers can incorporate citizen science into the current science curriculum, which will create real-world, hands-on science activities for the students to participate in which will provide students with meaningful learning experiences that can enhance their learning of science.

Rationale

Teaching citizen science to second grade students incorporates various skills that develop science-minded students and eventually citizens. The problem is that many elementary teachers are focused on reading and math due to the change of focus in school systems and because they may not feel equipped to teach science (Kazempour, 2013). Participation in citizen science projects can assist in developing science literacy, enhance learning, increase interest in science, increase the understanding of the scientific process, and connect students with the world around them. By incorporating citizen science into the classroom, students will experience hands-on science while developing various skills. Citizen science projects incorporate various skills such as research, writing, data collection, problem solving, and teamwork (Koomen, et al., 2019). By adding citizen science to our current science curriculum, we can create meaningful learning experiences. For citizen science to be successful it is vital to equip students with the knowledge, skills,

and materials to feel confident while participating in and working through the scientific process and completing the citizen science project.

Summary

Chapter one focuses on my personal and professional background experiences and how they led me to ask the question: *How can citizen science create meaningful learning experiences which enhance the learning of science for second grade students*? My capstone will create a curriculum to incorporate citizen science into the classroom to help create meaningful learning experiences for second grade students. I will show that citizen science can enhance the learning of science for the second grade students in various ways.

In chapter two, I will review academic literature surrounding citizen science and how it can create meaningful learning experiences and enhance the learning of science. I will focus on how the hands-on aspects of citizen science can affect students' academics and educational experiences. Citizen science can help enhance science literacy and enhance learning by incorporating multiple learning styles. Using various learning styles to teach a subject creates connections in the brain that allow the student to have better recall (Arnholz, 2019). Chapter three details the capstone project, a curriculum my coworkers and I can use to incorporate citizen science into the classroom to amplify students' learning of science. In chapter four I will discuss the conclusion of my project and reflect on my major learnings, implications and limitations of the project, the next steps, and how the project can benefit my profession.

CHAPTER TWO

Literature Review

Introduction

This capstone is designed as a supplemental curriculum to correspond with the current second grade curriculum to help answer the question: *How can citizen science create meaningful learning experiences and enhance the learning of science for second grade students*? The literature reviewed explored three themes, hands-on learning, enhanced learning, and science literacy. Each of the themes provides background information and how it relates to the capstone question. The result of this literature review provided a clear view of how citizen science can create meaningful learning experiences and enhance the learning of science for second grade students.

To understand how Citizen Science can create meaningful learning experiences and enhance the learning of science for second grade students, I will start by discussing how the hands-on approach to learning involved in citizen science projects can help students explore and learn about the materials they are using and the topics they are studying (Learning Through Citizen Science, 2018). First, I will review literature that discusses the effects hands-on learning has on a student's experience with education, student engagement, how it can affect the students academically, and finally make a connection between citizen science and hands-on learning.

Secondly, I will discuss how citizen science can help second grade students enhance their science literacy. Students involved in citizen science projects work through the various stages of the scientific process. By working through the various stages of the

scientific process, students gain an understanding of science, how it works, the tools they use, and the topic they are investigating. The addition of citizen science to the classroom can help the students learn how to ask questions, do research, understand what they are reading, and learn how to collect and interpret data.

Finally, I will discuss how the use of citizen science can help enhance the learning experience of second grade students. Citizen science can enhance learning in several ways. Citizen science can help students of various academic levels and English Language Learners (ELL) have access to gain knowledge through real-life, hands-on experiences whereas they may not be able to access that same knowledge through traditional means. Citizen science engages students of all learning styles. Arnholz (2019, p.2) states "hands-on learning engages both sides of the brain by combining multiple learning styles". Engaging both sides of the brain creates stronger connections allowing one to store more relevant information. The literature also shows that through citizen science, teachers can use alternative assessments which will allow students who may have difficulty with traditional assessments to demonstrate their understanding, knowledge, and growth.

Definitions

Citizen Science: The practice of public participation and collaboration in scientific research to increase scientific knowledge. Through citizen science, people contribute to data monitoring and collection programs (Ullrich, 2022).

Science Literacy: Knowledge of science and the scientific process. Can ask, find, or determine answers to questions attained from curiosity about the natural world and everyday experiences (National Science Education Standards, 1996).

Enhanced Learning: the enhancement of individual learners; the augmentation or improvement of learners' attributes, knowledge, ability, skills, and potential (Harvey, L., 2004-23).

Hands-on Learning

Hands-on learning is a form of education in which children learn by doing. Instead of listening to a teacher lecture about a given subject, the student engages with the subject matter to create something or solve a problem. This philosophy provides students with engaging hands-on experiences that will further develop the learning process (Martin, 2020). A few examples might include: solving problems, completing lab experiments, building circuits or working machines, and recreating artifacts.

Using a hands-on method of learning in the classroom not only allows a teacher to target their kinesthetic learners, but also engages their visual, auditory, social, logical, and reader/writer learners as well. This creates an environment for the students to become active learners. When the students are active learners they are taking an active part in their learning versus a passive part (Ho, 2022). This leads to students becoming more engaged in the activities and their learning. This may lead to the students having higher retention rates. Hands-on learning has the students participate in problem solving and critical thinking skills.

Theories in education have been around since the 1860s when Pestalozzi's, a Swiss pedagogue and educational reformer, ideas of using objects for teaching started to

reach America. Petalozzi believed students should learn from experiences and observations (Haury & Rillero, 1994). In 1893, The Physics, Chemistry, and Astronomy Committee recommended that simple phenomena should be introduced into elementary schools and be explored via experiments carried out by the students (National Educational Association, 1893). McMurray (1921) wrote:

> It is a truism of our educational creed that sensory impressions based on object lessons and motor response from the primary basis of thought in dealing with the later materials of knowledge. The project conceived and executed by the child on the ground of his own experience is a still better basis of our educational efforts because it sets up in children self-determination and purposeful activity in a complete, natural and well-rounded unit of effort. (p.3)

Psychologists such as Piaget and Dewey have stated the importance of hands-on learning. Piaget recommended that teachers take an active, mentoring role in facilitating learning by providing a variety of experiences. Allowing students to explore and have experiences encourages new understanding (Lefa, 2014). Dewey believed that education should allow students to discover information and ideas on their own (Hargraves, 2021). Discovering information and ideas on one's own allows the learner to gain meaning from what they learned (Ord, 2012). Both Piaget and Dewey discuss how students working together can help create understanding. Piaget emphasizes opportunities for students of different cognitive levels to work together as this can help encourage less mature students to advance and create understanding (Lefa, 2014, p.1). Dewey believed that when “students communicate ideas and meaning within a group, they have the opportunity to consider, take on and work with the perspectives, ideas, and experiences of other students”

(Hargraves, 2021). Instead of teachers forcing information on students while they passively sit and listen, teachers should share the learning experience with their students by encouraging them to be actively engaged. “Teachers can supplement traditional lectures with relevant, hands-on classroom activities that let students experience the content for themselves” (McAnarney, 1978).

Effect Students Experience with Education

The practice of hands-on learning can have many effects on a student's education. One way in which hands-on learning can affect a student's education is that it provides students with a similar set of experiences so everyone can participate in discussions on a level playing field regardless of their socio-economic status. When students are placed on a level playing field, a student with more experience behind them due to their circumstances does not have any special benefits (Haury & Rillero, 1994, p. 24). Many citizen science projects are created to reach diverse audiences and can also be used with individuals with whom literacy may be limited (Lewistein, 2022). Citizen science provides hands-on learning opportunities that allow the students an opportunity to actively participate in the learning progression and take more of an interest in their education (Kong, 2021). Student engagement can be directly related to interests, motivation, and pleasure with learning (Yin, 2018). According to Voukelatou (2019), hands-on learning takes place in all dimensions which encompass the cognitive, affective, and behavioral dimensions encompassing the whole person. Students participate in mental, emotional, and social interactions during the learning process.

Student Engagement

Participation in hands-on learning creates an environment for students to become more engaged with the learning process. Hands-on activities help students pay attention, connect with, and enjoy what they are learning. When students enjoy and connect with what they are learning about they are more likely to listen to the teacher to understand the next steps and how to overcome challenges (Arnholz, 2019). Doing hands-on, real-life activities can provide students with a more realistic and exciting experience of the content (Franklin & Peat, 2005). Students can have increased engagement in learning when participating in such activities which may lead to an increase in the student's academic satisfaction. In a study about the impact of hands-on approach on students' academic performance, Ekwueme (2015) surveyed 110 students, where 91.7% of the students stated that they preferred activity-oriented activities.

Hands-on learning gives students more authority and responsibility as it involves them engaging directly in their own learning (Kolb & Kolb, 2017). When this occurs students become more liable for their learning which creates a stronger connection between learning involvement, practices, and reality (Salas et al., 2009).

Effect Students Academically

Hands-on learning has proven to be more effective at helping students understand what they are learning. “Knowledge is built through converting practice into understanding” (Kong, 2021). One of the reasons that it is so effective is because students are engaging both sides of their brains. According to Arnholz (2019) combining various learning styles, the brain creates stronger connections and stores more information. As the hands-on method involves both physiological and psychological impacts of learning styles, there is a higher level of information retention. Students who participate in

hands-on learning activities during their learning process are more likely to have a higher level of learning (Arnholz, 2019).

When students are participating in hands-on activities they are taking the knowledge and skills they have learned in class and using that information in real life. This can help foster active learning that can bring about better retrieval (Bradberry & De Maio, 2019). Ekwueme's (2015) study revealed that hands-on activities can be a means to increase students' academic achievement and understanding of concepts. Ekwueme (2015) states that "the average retention rate of learning by lecture is 5%, while that of hands-on approach is around 75%" (p. 47). By manipulating objects students will be able to make abstract knowledge more concrete. They can observe change and illustrate concepts they are learning about (Ekwueme, 2015).

Citizen Science and Hands-on Learning Connection

Classroom teachers are beginning to understand the benefits of using citizen science and looking for opportunities to incorporate it into their classrooms (Shah & Martinez, 2016). Citizen science, when correctly taught, implemented, and carried out, allows students to make inquiries, gather and interpret data and participate in the entire scientific process (Citizen Science Toolkit, 2015). Citizen science requires students to be involved in the observation, collection, input, and interpretation of data. While the projects that are being worked on can be simple to understand, others may require the students to learn about a topic, such as the phenophase of a plant or tree to collect and interpret data (Queiruga-Dios, et al, 2020). For students to learn science they need to do science. Citizen science projects allow students the opportunity to use their classroom

knowledge and participate in real-life science investigations. The students will be involved in real-life scientific inquiry (McDonald, 2014).

While involved in citizen science projects students will be learning about and using the scientific method. The age of the students and the type of citizen science project chosen can affect the number of steps of the scientific method the students participate in. According to McDonald (2014), a teacher can also expand on a citizen science project to incorporate more steps of the scientific method and to create a more in-depth investigation. McDonald also states that hands-on scientific observation of the entire scientific process, not just data collection, is necessary for the growth of critical thinking skills. Critical thinking skills can be developed as the teacher does not simply inform the students about what they should know, but facilitates active learning by posing problems and questions for students to investigate and follow from start to finish (Condon & Wchowsky, 2018).

Conclusion

Hands-on learning encourages students to be active participants in their learning. By having students manipulate materials, a teacher can create an environment where students are engaged and encouraged to ask questions. Hands-on education can also create environments that place all students on the same level of equal footing no matter their socio-economic background (Haury & Rillero, 1994). A group of students will not have an advantage over another group based on previous knowledge they may have gained due to being more affluent.

Participation in hands-on learning provides an environment for students to become more engaged with the learning process. Hands-on learning provides students

with the opportunity to be more engaged in the learning process by putting into practice their classroom knowledge. Students can take the abstract information they know and apply it to real-life activities, more specifically science investigations and experiments. While walking through the science investigations and experiments, students are engaging both sides of their brains which helps them make connections and have a higher rate of retention (Arnholz, 2019). Students who participate in hands-on activities are more likely to enjoy and connect with what they are learning (Ekwueme, 2015). Students involved in hands-on activities are taking the knowledge and skills they have learned in the classroom and using the information in real-life which can allow the students to have a better understanding of the subject. The average retention rate can increase 70% when a teacher uses a hands-on approach to teaching versus lecture (Ekwueme, 2015).

Citizen science requires a hands-on approach to learning and involves the students to be actively involved in the project. Students make inquiries, gather and interpret data and participate in the scientific process. While working through the scientific process students will develop an understanding of science, the scientific process, and the tools used. Engaging in hands-on experiences will help further develop the learning process (Martin, 2020).

Science Literacy

According to Laughksch (1999) science literacy is one of the most important facets of science education. Science literacy is the knowledge one has of science and the scientific process (Gucluer, 2012). It includes the ability to ask, find, or determine answers to questions of the natural world and everyday experiences. Educators are striving to raise science standards and science literacy. Building on ideas from the

National Science Education Standards (1996), scientific literacy implies a base level of scientific understanding and ability that enables a student to effectively "ask, find, or determine answers to questions derived from curiosity about everyday experiences". In order to be able to ask, find, and interpret data, students must understand the scientific process. To develop students' understanding of the scientific process, teachers need to create lessons that allow students to work through all the steps of the scientific process. Citizen science will provide students with the opportunity to learn and understand the steps involved in the scientific process by participating in real-world experiments and research. According to Zwicker (2015) to become scientifically literate, one has to "do science."

Students can strengthen their scientific literacy and use their skills to assess and address real-world science and issues. **"**Citizen science projects emphasize engagement in the process of inquiry rather than rote memorization of facts-based content" (Citizen Science Toolkit, 2015). Citizen science allows students to participate in the scientific process by observing, questioning, planning, interpreting, and communicating their findings. By completing these processes through citizen science, second grade students can improve their comprehension of the scientific process (Queiruga-Dios, 2020).

Learn to Ask Questions

"Pursued properly, a good question also can be an excellent vehicle with which to start a process of inquiry" (Vale, 2013). Investigating an answer to a question does not require a laboratory, special equipment, or money. The goal of asking and answering a question should be a personal quest to resolve a curiosity and struggle with trying to understand the answer. Researching one question often leads to asking more questions

that dig deeper into a phenomenon (Vale, 2013). The first step in the scientific process is to ask questions (American Museum of Natural History, 2009). Second grade students tend to be inquisitive and ask questions often as they are naturally curious about the world around them. Teachers can use students' natural curiosity as motivation for learning foundational habits such as asking questions, investigating, and observing (Murcia, 2007). Provided with the opportunity to work on a citizen science project, students will have the opportunity to explore the researcher's questions while having the chance to create their own. While engaged in the project students may come up with more questions, which then may lead to more research, observations, data collection, and analysis. Through this process, teachers can also guide and teach students how to create scientific questions. If students can ask a scientific question, they can, along with a teacher's guidance, create their own citizen science project and apply the scientific process to answer their question (Thompson et al., 2018).

Learn to do Research

Understand What One Reads. Due to a lack of scientific literacy, students' science vocabulary is limited which is causing students to not have the ability to read and understand scientific text (Thelien, 1991 as in Gucleuer, 2012). Being able to understand what one reads is important in all areas of literacy. The ability to do research and understand what one reads is an important aspect of science literacy. In order for one to understand what they are reading, they need to understand the terms and language being used. Students will develop their science vocabulary as they go through the process of reading about what they are investigating and completing the hands-on aspects of a citizen science project. Students will establish a connection between their current

knowledge of science and the scientific knowledge found in many sources (National Science Education Standards, 2015).

***Reliability of Sources*.** One must also determine the reliability of the information they are reviewing and the source from which that information is coming from. Students should be able to understand which sources of information are more trustworthy and why (Zucker, 2021). According to Ashbrook (2020), "Children's educational experiences and dialogue with teachers should support their understanding of scientific knowledge and prepare them to evaluate explanations from others (p. 18)." It is important with the number of media platforms students have access to and the misinformation posted on some platforms that students learn to differentiate between reliable and unreliable sources. While researching information for a citizen science project, teachers should take the time to discuss with their students how to determine if their information and sources are reliable (Zucker, 2021). For example, if students are observing, researching, and testing water quality they would need to consider where they get information about water quality. Students should consider which would be more reliable, information from a research paper about water quality, or a report from a water company. Students should consider which source would be the most reliable as the water company may be posting misinformation for their benefit.

According to Vale (2013), educators should not completely restrict students from Internet research, rather, "spend more time teaching them best practices, such as directing them to good Internet sources, teaching them how to identify potentially flawed information, how to integrate information from multiple sources, and how to reference them".

Learn to Collect and Interpret Data

Understanding how to collect and interpret data is important to science literacy. While participating in citizen science projects, students will actively be collecting data over a period of time. By actively collecting data over time, students will have multiple opportunities to practice and learn this skill. The repeated opportunities to use tools and collect data can help students build confidence and skill in using these tools and start to recognize when they have made an error. Students will have opportunities to collaborate with one another to review and interpret the data. As students go through this process, it will help strengthen their understanding of how this is done. As students continually review their data and compare data with others, they may notice discrepancies between their data and other students or groups. If a discrepancy is noticed, students can discuss the differences and why they may have occurred (Queiruga-Dios, 2020).

Conducting Experiments. Experiments are a crucial component of the scientific process and students enjoy the hands-on exploration that experiments offer. Various learning opportunities occur during the process of conducting an experiment. If an experiment goes wrong, take advantage, and investigate with your students to see what went wrong. A mistake can provide opportunities for you and your students to improve your ideas, understanding, and hypotheses (Lan, n.d.). “Writing, drawing, or taking photographs are all ways to record observations which is an important scientific skill. Such records allow children to keep track of what they saw, heard, questioned, or discovered” (Lan, n.d.).

Interpreting Data. “Data analysis is the intersection of science and math purposely integrating both subjects. Because we traditionally separate math and science

content in schooling, students lack the opportunities to make decisions with analyzing and representing data" (Dubiel, 2022). If we look back at how we did science experiments in school and how we teach science experiments today, we did and teach "cookie-cutter" experiments. Students simply conduct an investigation to collect specific data and fill out a specific form. The students are then told how to interpret the data and possibly how to represent the data in a graph. They are then given a set of questions to answer (VanTassel, n.d.). Conducting science investigations in this manner does not allow the students to learn how to ask questions based on their data or to discover what the data means as they are being given the information.

The ability to make inferences and predictions based on data is a critical skill students need to develop. Learning about how to interpret and make better sense of data can help you learn the best way to collect data. Learning how to collect, summarize, and analyze data is a very important science skill, central to the newly released Next Generation Science Standards (NGSS).

Conclusion

Teachers who "prioritize developing students' scientific literacy, help develop adults who will apply science as knowledgeable decision-makers and become lifelong learners" (Zucker, 2021, p. 9). All students have the ability to achieve understanding of science if they are given the opportunity and should be allowed to attain high levels of science literacy (NAP, 2022). Students achieve understanding in different ways and citizen science can provide the opportunity for students to gain science literacy through hands-on and personally interesting experiences. "Extended projects would require

students to collect and interpret information, learn key science content, evaluate evidence, and then use evidence to support their argument or conclusion" (Murcia, 2007)

"By participating in citizen science projects teachers can help students critically analyze the way that scientists collect data, develop their study projects, enter data, and make sense of what they find. Children learn science through trial and error. They need time to experiment, try things out, and think on their own" (Lan, n.d.). This can help students understand how the scientific process is applied in the real world. Teachers may also encourage "spin-offs" of the citizen science projects by having students develop their own studies using the scientific method, and modeling their projects after the projects of other researchers. Participating in citizen science projects allows students to learn critical thinking skills and the steps of the scientific process which can be applied to almost any field.

Enhanced Learning

Teachers work on putting practices in place that help ensure that students are given the opportunity to make meaningful progress in learning. When creating lessons and activities, teachers need to consider the needs of all the students in their class. There are various techniques and methods a teacher can use to enhance the learning of second grade students. Citizen science can allow teachers to use various teaching styles and methods to reach students by incorporating different learning styles (McDonald, 2014). Using various teaching styles and methods and allowing students to work through the scientific process can also help students with learning disabilities, students who are below grade level, and ELL students (Schuttler, 2019). By providing alternative methods of

learning and assessment, teachers can assess a student's understanding, comprehension, and growth.

Multimodal Learning

In multimodal learning, teachers prepare an assortment of aids and activities to target many modalities throughout a lesson. The use of multimodal learning means supplementing content delivery with a variety of media, assessing students' knowledge with differentiated applications of content mastery, and tailoring feedback so that it matches the content presentation and assessment as well as students' ability to interpret the teacher's remarks (Ferguson & Hudgens, 2022). Litonjua (2020) states that:

> Research has proven that students learn best when educators apply multiple learning styles simultaneously. Multimodal learning creates an exciting learning environment, which leads to increased engagement from the students. It is because they aren't required to conform to a particular learning style that doesn't suit them (The Importance of Multimodal Learning section).

There are many different learning styles in the classroom. Some students learn best by reading, some by listening, some by drawing, and some by talking with others. The benefit of citizen science is that many different learning styles can be incorporated into each project. Citizen science lends itself to kinesthetic learning (hands-on) by collecting data and measurements, reading and analysis of data or background research, cooperative group sharing, and opportunities for verbal instruction, graphs, drawing, sharing, and analysis. Because of the hands-on nature of citizen science, it may also be a candidate for students with autism or special needs or those that learn best through kinesthetic activities (McDonald, 2014).

Access of Information for Students With Various Learning Challenges

Teaching with one mode risks alienating students who cannot fully comprehend the content in the chosen delivery method. With multimodal learning, every student is guaranteed to have at least one of his or her learning preferences met at some point during the lesson. Teachers understand that not all students can access information the same way, for example, ELL students and students with reading disabilities, are below reading levels, or have difficulties with comprehension may not be able to access the information their classmates are by reading an article or their textbook and other traditional means of education. These same students can however learn through participating in the task of the scientific process during citizen science projects (Schuttler, 2019). While reading is still a part of the process when they are doing research, observing what they are reading about can help with their comprehension.

Hands-on activities let the students' minds grow and learn based on the experiences and the environment they are exposed to. ELL's learn while discussing, investigating, creating, and discovering with other students. As the students become familiar with the subject they are learning, they begin to make decisions, requiring less teacher support and allowing more interactive learning experiences to occur (Cooperstein & Kocevar-Weidinger, 2004).

Assess Knowledge in Various Ways

If teachers use practices that ensure students have meaningful progress in learning, they also need to have ways to successfully assess the knowledge a student has gained. Traditional assessments are more focused on testing knowledge and memory skills, whereas alternative teaching assessments evaluate performance, proficiency, and

skill sets. “Alternative assessments are designed to understand what a student can do rather than what he or she knows. Think about it as an authentic form of assessment that measures proficiency in relation to knowledge application rather than recitation. It brings out the ability of students through designated projects, portfolios, and activities. In many ways, alternative assessments are also said to be more inclusive” (Importance of Alternative Assessment in Education). Students with disabilities or students who struggle with reading, comprehension, and writing along with ELL students can have difficulty with regular assessments. As citizen science projects are hands-on and can occur over a short or long period of time, teachers can access the students' growth and understanding through non-traditional methods. A teacher can assess understanding by observing the students doing the activity, the students verbally explaining what they are doing and what they have learned, drawing pictures, presentations, and projects. These assessments, though different from standard tests, still allow the students to show what they know. For students who are below grade level, have disabilities, and ELL students this will help with their success as they may fail a standardized test that is given to assess their knowledge.

Conclusion

Teachers regularly put practices in place to help ensure students are given the opportunity to make meaningful progress in learning. Some of these practices include providing the students with various materials such as books, manipulatives, various media, and using supplemental materials to assess students' knowledge and provide feedback. Students learn best when teachers apply more than one learning style at a time

as it creates an exciting learning environment. An exciting learning environment can lead to increased student engagement.

The use of citizen science can help enhance the learning for all students, especially students who are below grade level, have learning difficulties, and ELL students. By using various teaching styles, materials, and participating in hands-on activities students can learn information through non-traditional means. The use of non-traditional teaching methods can help students who struggle with traditional teaching methods gain access to knowledge they may not otherwise have access to. Citizen science allows teachers to assess students' knowledge, growth, and understanding through alternative means. Teachers may lead discussions with the class, review student observation packets, and have students participate in presentations. These methods of assessment are beneficial for students who struggle with traditional assessments.

Studies have shown that when students learn through various learning styles they use both sides of their brain. As both sides of their brain have been activated students form a stronger overall connection and can store more information (Arnholz, 2019).

Literature Review Summary

The literature reviewed in this chapter has helped answer the question: *How can citizen science create meaningful learning experiences and enhance the learning of science for second grade students?* The goal of hands-on lessons is to get students at any level of education to become physically engaged in the learning process. Through hands-on activities, students are actively engaged in the lesson allowing them to be active participants in their learning. The basic idea is for students to no longer be passive learners who simply listen to a teacher, take notes, and answer occasional questions.

Students who actively participate in their learning gain responsibility and authority over their learning as they are invested in doing the work. Doing something also means involving a student's brain in thinking about what is going on around them as he or she tries to learn science. Active involvement greatly enhances learning. Ekwueme (2015) states that retention rates increase from 5% to 75% when participating in hands-on activities. Citizen science creates opportunities for students to experience meaningful learning experiences and enhance their learning of science through hands-on science experiences.

Incorporating citizen science into the classroom can help increase student science literacy by gaining knowledge of science and the scientific process. Actively participating in the scientific process allows students to learn to ask questions, do research, understand what they read, check the reliability of sources, learn to collect and interpret data, and conduct research. All of these components included in science literacy are important for students to learn so they may be able to assess and address real-world science and issues and use their knowledge to make informed decisions as adults.

Citizen science also allows teachers to enhance learning for their students by incorporating supplemental materials and assessments. Alternative materials, teaching methods, and assessments can allow students who may not have access to knowledge by traditional means to gain the same knowledge as their peers. This can be highly beneficial for students who are below grade level, have learning difficulties, and ELL students. These same set of students will also benefit from alternative assessments in which they can demonstrate their knowledge, growth, and understanding. Citizen science creates an

environment for multimodal learning, ensuring students are learning from various learning styles.

I have seen firsthand how the use of hands-on activities can affect students. I have witnessed how students with less experience and background knowledge can shy away from activities and participation in class as they can feel uncomfortable. We can not expect students to learn information on a topic they do not have past experiences with. I have seen how creating an environment that eliminates socioeconomic barriers will allow students on all levels to learn and thrive. Citizen science also allows the opportunity for students who are below grade level and ELL students to gain knowledge and be assessed in alternative ways. While discussing life cycles with my students, I do not just show them videos, images, and lecture them about it. I bring in examples so they may observe the stages. This is done mostly with butterflies. This leads to all of my students being on the same level field. While some have learned about life cycles, none have seen the changes occur. All of the students were going to be experiencing it at the same time. The students no matter their ability and background knowledge were able to observe and document the changes while sparking their inquisitive nature leading to the students asking questions. Students then use what they have learned and observed so far to create hypotheses for their questions.

In chapter three I will summarize my plan to create a supplemental curriculum that corresponds with the current second grade science curriculum. I will start by discussing the setting in which the project will take place and the intended audience. Next, I will describe my project. I will review the framework I will use to create the lesson plans and how the lesson plans will support the NGSS learning progression.

CHAPTER THREE

Project Description

Introduction

In this chapter, I will describe my capstone project. This project was designed to answer the question: *How can citizen science create meaningful learning experiences and enhance the learning of science for second grade students*? Citizen science is when the general public helps collect and analyze data, usually as part of a collaborative project with professional scientists. My capstone will be to create a supplemental curriculum that will correspond with the current science curriculum used in the second grade classroom. The supplemental curriculum will incorporate citizen science into the classroom. For the project to be successful students need to know how these projects work, how they can be incorporated into the classroom, and best practices for integrating them. Students will learn about citizen science and best practices for participating in a project through science lessons in the classroom.

Throughout my career, there has been a large emphasis placed on teaching math and reading. Due to this emphasis, science seems to have turned into a minor subject in schools being taught when there is time, or limited to an hour a week. I work at a STEM school and there is still more emphasis on teaching math and reading as math and reading have a designated allotment of 1.5 hours to 2 hours a day. The allotted time for teaching science is 30 minutes a day, which does not get taught on a daily basis. The teaching of science has also been regulated to the reading of information from a text with little to no science experiments or activities occurring in the classroom. The supplemental

curriculum that I created will help assist second grade teachers at my school integrate citizen science into their classrooms. By integrating citizen science projects into the classroom, a teacher can use time designated for other subjects to learn about science. For example, during the literacy block, a teacher may choose to have students read informational text on what the students are observing and also write about their observation and interpretation of data. During social studies, teachers may study what plants and animals are local in the area and review maps of migration patterns. One can also compare historical data of what plants, trees, and animals used to dominate the area to what currently dominates the area. Teachers may also use a portion of the math block to have students calculate and interpret data.

In this chapter, I will discuss the capstone description, setting, audience, and proposed timeline for creating and implementing the citizen science curriculum. I will also discuss how to assess the effectiveness of the curriculum.

Setting and Audience

The setting for this project is a STEM elementary school located in the suburbs of Washington DC and Baltimore, MD. The school is located in a business park and is surrounded by offices, a water filtration plant, and a UPS distribution center. Due to the location of the school, there is little green space provided. As the green space we have available at the school is limited to strips of grass between the building and the parking lot, this activity will occur in raised garden beds. The raised garden beds will be placed in the grass strip along the backside of the school to ensure that the garden beds receive the required amount of sunlight for tulip growth.

This curriculum is created for second grade classes and to correspond with the current second grade science curriculum. A majority of the students who attend the school are African American. Out of 102 second grade students: 95 are African American, 2 are Caucasian, 3 are Hispanic, and 2 are of middle eastern descent. The project is designed for students that attend a public charter school. The school services the entire county which results in a student body with diverse socio-economic backgrounds.

Project Description

For my capstone, I developed a citizen science curriculum to coincide with the second grade science curriculum about plant life cycles and plant needs. The curriculum I created allows students to have real-life experiences observing the life cycle of a tulip while noting the weather conditions during the plant's growth. Once a week, students will input data collected through their observations into the Journey North website. The use of this curriculum provides students with a meaningful experience and enhances their understanding of the second grade science curriculum through real-life observations, data collection, and analysis. The curriculum is designed to occur over the course of one to two months and will take place in an outside garden and the classroom.

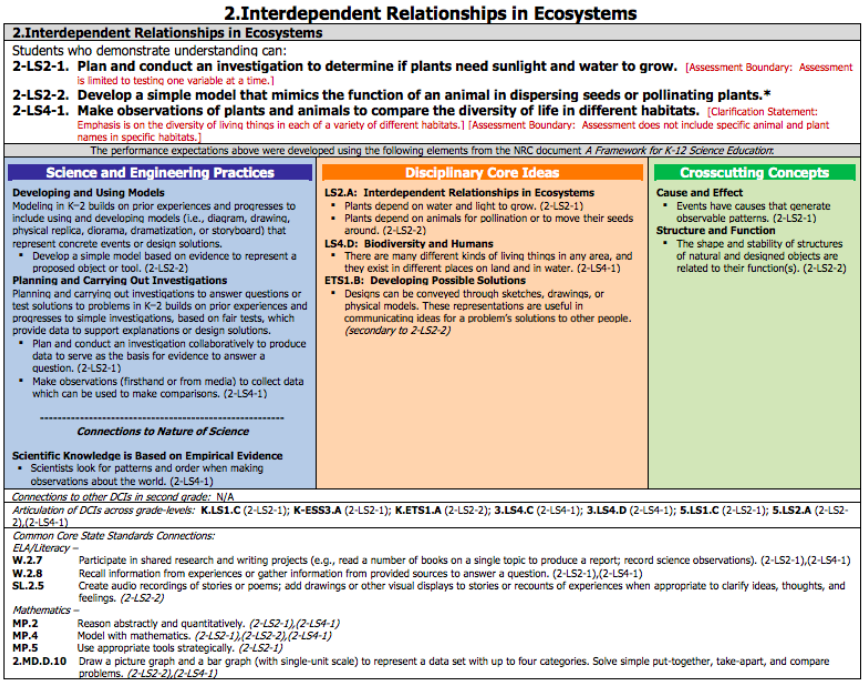
Second Grade Science Standards

Before I began creating the curriculum, I reviewed the second grade science curriculum used at my school to see if I could make a connection between the current curriculum and a citizen science project that already exists. I discovered that I could use a citizen science project to help enhance the learning of plant life cycles and needs. The standards that I used to create this curriculum are the Next Generation Science Standards

(National Academy Press, 1996) (see Figure 1), which are the same standards used by our school curriculum.

FIGURE 1

NGSS 2nd Grade Standards for Ecosystems



2.Interdependent Relationships in Ecosystems

2.Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

2-LS2-1. **Plan and conduct an investigation to determine if plants need sunlight and water to grow.** [Assessment Boundary: Assessment is limited to testing one variable at a time.]

2-LS2-2. **Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.***

2-LS4-1. **Make observations of plants and animals to compare the diversity of life in different habitats.** [Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.] [Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. ▪ Develop a simple model based on evidence to represent a proposed object or tool. (2-LS2-2) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. ▪ Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (2-LS2-1) ▪ Make observations (firsthand or from media) to collect data which can be used to make comparisons. (2-LS4-1) --- ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** ▪ Scientists look for patterns and order when making observations about the world. (2-LS4-1)	**LS2.A: Interdependent Relationships in Ecosystems** ▪ Plants depend on water and light to grow. (2-LS2-1) ▪ Plants depend on animals for pollination or to move their seeds around. (2-LS2-2) **LS4.D: Biodiversity and Humans** ▪ There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1) **ETS1.B: Developing Possible Solutions** ▪ Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. *(secondary to 2-LS2-2)*	**Cause and Effect** ▪ Events have causes that generate observable patterns. (2-LS2-1) **Structure and Function** ▪ The shape and stability of structures of natural and designed objects are related to their function(s). (2-LS2-2)

Connections to other DCIs in second grade: N/A

Articulation of DCIs across grade-levels: **K.LS1.C** (2-LS2-1); **K-ESS3.A** (2-LS2-1); **K.ETS1.A** (2-LS2-2); **3.LS4.C** (2-LS4-1); **3.LS4.D** (2-LS4-1); **5.LS1.C** (2-LS2-1); **5.LS2.A** (2-LS2-2),(2-LS4-1)

Common Core State Standards Connections:

ELA/Literacy –

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-LS2-1),(2-LS4-1)

W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (2-LS2-1),(2-LS4-1)

SL.2.5 Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. *(2-LS2-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(2-LS2-1),(2-LS4-1)*

MP.4 Model with mathematics. *(2-LS2-1),(2-LS2-2),(2-LS4-1)*

MP.5 Use appropriate tools strategically. *(2-LS2-1)*

2.MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems. *(2-LS2-2),(2-LS4-1)*

Understanding by Design Framework

To develop the curriculum, I followed the Understanding by Design (UbD) framework by Wiggins and McTighe (2011). One goal of UbD is to develop and deepen a student's understanding. Understanding of a topic is shown through a student being able to make meaning of the learning, make connections, and transfer and apply their new knowledge to new situations (Wiggins & Mc Tighe, 2011).

I began designing the curriculum by first deciding on the final curriculum goal, students will be able to understand and work through the scientific process. After creating a final goal, I created an outline of the order in which materials and information should be provided to the students. First, the students will be taught about citizen science, what it is, and how they can participate in a project. Next students will be introduced to the Journey North (jounrynorth.org) website and shown how they will use it. After learning about citizen science and the website that will be used I created lessons on the scientific process, what makes for good scientific observations, hypothesis, data collection, and analysis. During these lessons, students will be provided with tulip observation packets and taught how to use the packets. Throughout one to two months, students will observe the raised garden beds twice a week and document their observations in their tulip observation packets. These observations will occur until the tulips are in full bloom. Students will input their observation data into the website once a week. The last lesson I created in the curriculum is an extension lesson on parts of the flower and tulip reproduction.

The curriculum was created to support the NGSS learning progression while addressing the different levels and learning styles of the students. While creating the lessons I reviewed the NGSS and Maryland science standards. I have created a curriculum that touches on first grade standards while ensuring that the students master the second grade standards so they may be ready to progress to third grade standards. While working through the curriculum students will be drawing, writing, reading, observing, and listening. This ensures that various learning styles are addressed, students are engaged, and students are exposed to information in various ways. Throughout the

curriculum, I have created various checkpoints to assess the student's progress. Students will be assessed through small group activities, class discussions, written activities, and diagrams in their observation journals.

Timeline

The initial research and planning for this capstone began in September 2022. I focused my research on how citizen science can create meaningful learning experiences and affect the learning of science for second grade students. Writing Chapters 1-3 occurred between September 2022 and December 2022. Curriculum development began in January 2023 and was completed in April 2023. Compilation of the capstone and submission will occur in May 2023.

The curriculum I have developed is based on observing the sprouting and growth of tulips, therefore implementation of the curriculum will occur in the Spring. In Maryland, tulips, on average, begin to sprout in early April with peak bloom being the last week of April through the beginning of May.

Summary

The curriculum created for this capstone was designed as a supplemental curriculum to coincide with the second grade science curriculum currently being taught at my school. This capstone was created with the goal of creating meaningful learning experiences to enhance the learning of science for second grade students. Through the use of citizen science, students will engage in the scientific process while gaining knowledge about the life cycle and needs of plants. Students will also learn about how weather affects the growth of plants through the Journey North website. Students will understand that the data they are providing on the website is aiding real-life scientists in their

research about global warming. Students can review past data on the website and discover how the earth's weather has been changing over the past few years introducing the students to the concept of global warming.

In this chapter, I described the curriculum that was created and how and when it is to be implemented. The citizen science curriculum that I created is designed to be implemented in the spring as it involves the observations of tulip growth. The hope is that by the end of the citizen science curriculum, students will be able to understand and work through the scientific process. In this chapter, I also discussed the setting and audience for this capstone and the timeline in which it was created, implemented, and completed.

In chapter four, I will reflect on my project and discuss what I have learned through the process of creating a supplemental curriculum. I will explain major learnings that I had, which include learning about various citizen science projects and websites and how projects can be incorporated into the classroom. I will review important aspects from chapter two, the literature review. I will explain the implications and limitations of my project and the next steps to be taken. Lastly, I will discuss the benefits the capstone project has on my profession as a teacher.

CHAPTER FOUR

Introduction

I have been working in school systems for the past fifteen years, in which the last ten years have been working in elementary schools. Over the years I have seen a decline in the teaching of science as the focus has shifted to reading and math. While taking Community Based Environmental Science, a class for my graduate program, I learned about citizen science. Citizen science is a new and growing field of research that brings about new knowledge and understanding through the collaboration of citizens in scientific research (Vohland, 2021). As citizen science continues to grow, it is important to consider the potential it has to encourage education and learning opportunities. This led me to ask the question: *How can citizen science create meaningful learning experiences and enhance the learning of science for second grade students*?

I developed a citizen science curriculum to coincide with the second grade science curriculum used at my school about plant life cycles and plant needs. The curriculum I created allows students to have real-life experiences observing the life cycle of a tulip while noting the weather conditions during the plant's growth. The use of this curriculum will provide students with a meaningful experience and enhance their understanding of the second grade science curriculum through real-life observations, data collection, and analysis.

In this chapter, I will reflect on my project and what I have learned throughout the process of creating and implementing the lesson plans. I will revisit the literature review and discuss what literature was most helpful in the development of my project. I will

discuss the implications and limitations of my project. I will discuss future research and the next steps that can be implemented to continue developing the curriculum. Finally, I will discuss communicating my results and the benefits my project may have to my profession.

Major Learnings

Through the process of developing my project, I discovered that my coworkers were highly interested in learning more about citizen science and how they can implement it in their classrooms. Like me, my coworkers are looking for ways to implement hands-on and engaging science activities in their classrooms. I was a little surprised when three of my coworkers asked if we could work as a group to help research citizen science projects and explore ways in which we can implement them in our classrooms. While working on my project, I had numerous discussions with my coworkers about how they conduct science in their classrooms and the changes they would like to make. Teachers for the primary grades, kindergarten through second grade, stated how they wanted to find activities that help the students learn how to make observations and collect data. Teachers in the third through fifth grade classrooms explained how they would like the students to learn how to work through the scientific process and work collaboratively to analyze data. I used the information I gathered from my coworkers to help create the lesson plans for my project.

While working on my project, I learned that there are several citizen science projects and websites that can be accessed and incorporated into the classroom. While I was aware that there were a few websites dedicated to citizen science, I was unaware of

how many websites there are dedicated to citizen science not only in the United States but around the world. I was amazed by some of the information I discovered about how citizen science is used in the classroom in Europe. One project that I reviewed showed me how in-depth students can get involved in citizen science by incorporating detailed and challenging lessons in the classroom. One such citizen science project and lesson I read about was a water quality project in Spain. After teaching the students about citizen science and the project, the students learned how to review resources for accuracy and dependability. The students also learned how to collect, test, and analyze water samples. Students then analyzed the data collected, discussed similarities and differences and what may have caused them, as well as created presentations to explain their findings. While this project was used for high school students, I enjoyed reading about how citizen science can be used to enhance student learning. It allowed me to see that when a teacher researches a citizen science project and takes time to create relative lessons around it, that students can be highly engaged in their learning.

Research for the project helped me deepen my understanding of how hands-on learning helps students strengthen their learning and understanding. Learning more about how hands-on learning can enhance learning for students strengthened my belief that students should learn through hands-on activities. Not only does it help enhance the student's learning, it also helps keep the students engaged. When working on hands-on activities students take the knowledge and skills they learn in class and apply that information to real-life situations. In the case of science activities, research shows that to learn science, one needs to do science.

Literature Review

The literature review was the most challenging aspect of the capstone due to the vast amount of information I was looking for. Once I was able to narrow down my concept and focus on particular information, the literature review was easier to complete. There was a lot of useful information I discovered throughout my research. What I found the most helpful was information about hands-on learning. There was a great deal of information that discussed the connection between hands-on learning, student experiences, and retention of information.

The literature shows that hands-on learning is a form of education in which children learn by doing. I reviewed numerous articles which discussed how students who participate in hands-on science are more engaged in the activity and have better retention and retrieval. Kong (2021) explained that hands-on activities allow students to apply classroom knowledge to real-life situations which in return brings about better retrieval. Ekwueme (2015), states that learning by lecture has a retention rate of 5%, while those who learn by doing have a retention rate of about 75%. Arnholz (2019) states that hands-on learning is more effective in helping students grasp what they are taught. This is because hands-on learning uses multiple learning styles engaging both sides of the brain forming stronger connections allowing one to store relevant information. Being able to touch and see things is more beneficial than simply reading about it. Meanwhile, Toli (2021) states that students are more motivated and interested in the lesson when engaged in hands-on activities. McDonald (2014) states that the use of citizen science can help students develop the confidence to try making observations, collecting data, and exploring the real-world and that science becomes attainable.

Literature also showed that the use of hands on-learning allows English Language Learners (ELL) and students with learning difficulties to have access to knowledge they may otherwise not have access to. This can be caused by using various teaching styles and methods and allowing students to work through the science process can also help students with learning disabilities, students who are below grade level, and ELL students (Schuttler, 2019). By providing alternative methods of learning and assessment, teachers can assess a student's understanding, comprehension, and growth.

Implications

One implication I am hoping to see by using my project's curriculum with my students is that my students will have a better understanding of the scientific process. The students will be going through the steps of the scientific process as they complete the lesson plans created and participate in the citizen science project. As the students work through each step of the scientific process, they should be able to explain what the step is and be able to demonstrate their understanding of the individual steps and overall process. As there is a great deal of hands-on work involved in the lesson plans and project, I will be able to observe and assess the students in a manner that allows all students to show their understanding. This will be beneficial for English Language Learners and students with various learning disabilities. Since I can rely on observations, I do not need to depend on paper assessments to determine if the students understand the process or lessons.

Another implication I am hoping to see by using my project's curriculum with my students is that they will become interested in citizen science and want to participate in

more projects. I hope that the students will be able to see that they are naturally citizen scientists. They make observations regularly, even if they do not realize this. I hope that the students will see how easy it is to be involved in projects and will take an interest in participating in more. Continued participation in citizen science will continue to help their scientific knowledge and growth.

Limitations

There are limitations to this project. One limitation is space. My school is located in a business park, so green space is almost non-existent. For my students to participate in this project, I had to purchase 2 raised beds and dirt. There was a problem with tulip bulbs not being buried deep enough and materials being thrown on the plant beds. As the bulbs are planted in raised beds, they may begin to sprout earlier than those planted in the ground as the soil may warm faster in the raised beds. As scientists are collecting and reviewing data for their research on global warming, this may have an effect on their research.

Weather is another limitation. This year was an unusually warm winter, which had the tulips starting to sprout in February. The Journey North Website does not open for data collection until March. One can collect the data and enter it into the website when the tulip project opens up, however, you need to keep an eye on the tulips. I was not keeping an eye on them that early so I missed when the tulips first started sprouting.

Next Steps

I would like to continue researching citizen science and the benefits citizen science can have in the classroom and on the students. I am curious to see if there are

effects on the students academically and personally if they participate in more than one project a year. I would also like to spend more time reviewing the citizen science toolkit to learn more about the most effective way to participate in citizen science projects. I would also continue exploring the toolkit to learn how to create citizen science projects and create effective lesson plans and activities. I would also like to continue reviewing various websites and reviewing what they have to offer in order to be more effective in teaching citizen science and incorporating it into my classroom. I believe that the use of citizen science would be beneficial for students both academically and personally.

After starting the school curriculum on plants, I realized I need to adjust the lesson plans for my project and add more lesson plans for background information. I assumed my students knew and understood more about plants than they do. I would also add a cumulative project at the end for students to work collaboratively and share their learnings. This will also allow me to assess my students' knowledge in an alternative manner.

Benefit to My Profession

The use of citizen science in the classroom can help me and the other science teachers engage students in more investigative science lessons. Although I work at a STEM school the academic focus is on reading and math with little time allotted for science which has created various issues. Students are expected to learn mainly from reading text which is causing some problems including students not understanding the scientific process. I would like to create professional development for my coworkers to teach them about citizen science and how they may incorporate it into their classrooms. I

would begin by discussing with my coworkers what citizen science is. I would then like to create a professional learning community (PLC) team. The team will work together to create citizen science lesson plans and teach the rest of the staff how to incorporate the lessons into their classrooms. This will occur over the course of a year. Co-workers will be able to watch videos of the PLC team incorporating citizen science into their classroom as well as have a member of the PLC team watch them implement a citizen science lesson and receive feedback.

Summary

In this chapter, I have reviewed my capstone project which addresses the question: *How can citizen science create meaningful learning experiences and enhance the learning of science for second grade students?* Through the process of working on this project and creating lesson plans, I have discovered my coworkers are just as interested in the idea of using citizen science in their classroom to ensure students have the opportunity to have hands-on experience with science and work through the scientific process. The literature that I have reviewed has shown me the importance of hands-on learning. Hands-on learning allows students of various academic levels to be able to have access to knowledge, show understanding, and show growth. Hands-on learning also permits students to be engaged in their learning which helps increase a student's experience and retention of information.

While working on my project I noticed limitations to the project. Green space and weather was an issue when working through the lesson plans. There is a lack of green space at my school which can make it difficult to find a location for plants which can

affect when the tulips begin to sprout. Weather can also be an issue. If we have an unusually warm winter, such as we did this year, plants may begin to sprout and bloom earlier than usual. This can cause difficulty with the specific citizen science project used in this capstone project as the website used does not open for data collection until March. I would also like to continue researching how to most effectively and accurately incorporate citizen science projects into the classroom.

I look forward to incorporating the lesson plans into my classroom and observing how the students engage in the lessons, the lessons they learn, the growth they make, and if it makes a difference in their understanding of the scientific process.

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