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Best Practices in Science Education and Next Generation Science Standards: A Review of Systems Thinking, Inquiry-based Learning and Culturally Sustainable Practices

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Best Practices in Science Education and Next Generation Science Standards: A Review of Systems Thinking, Inquiry-based Learning and Culturally Sustainable Practices

by

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Public School science educators are given the task to teach students dynamic, interpretable material based on grade level as well as national and state standards. Science is at the forefront of many jobs and future economic stability and also encompasses a wide range of disciplinary topics. Having educators use the best resources in curriculum development and teaching methodology is crucial to successfully empowering future scientific research and understanding. The *Whole Ecosystems in Balance (WEB), A Natural Resource Curriculum*, originally created in 1995, was used to support science teaching efforts in Eastern Oregon. In order to continue its relevance, the curriculum needed to be revised and aligned with current standards. In an attempt to use the most pertinent and current resources available in WEB curriculum revision, this capstone puts into practice findings in answer to the research question, *How to develop a high-quality sixth-grade science curriculum to meet Next Generation Science Standards while incorporating teaching best practices?* Inquiry-based learning, Systems Thinking and Culturally Sustainable Practices (CSP) were identified through research as the most effective means by which to encourage student growth and comprehension. The WEB curriculum which was created as an Environmental Education (EE) resource developed for Public School use, incorporated these principles as they are part of founding EE principles. Next Generation Science Standards were developed in 2013 and adopted by the state of Oregon in 2014, were not included in the WEB curriculum. Considering the depth of science education and the constant need for high-quality resources, Environmental and Public School education would benefit from a more cohesive bond between curriculum development and classroom incorporation. By so doing will help achieve the consistent use of teaching best practices and science education relevancy. As a result of this capstone, the WEB curriculum was successfully aligned with NGSS and revised to better meet the identified best practices for the sixth grade. It stands as an example of a high-quality curriculum resource for teachers in Eastern Oregon and for future curriculum revision.

CHAPTER ONE

Introduction

Background

In April 2013, the Next Generation Science Standards or as they are more commonly known, NGSS, were completed (Next, 2021). The idea behind creating these standards was to create a more robust and dynamic set of standards to replace various existing science standards across the United States. "Through a collaborative, state-led process, new K-12 science standards have been developed that are rich in both content and practice, and arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education" (Next, n.d., para. 4). The state of Oregon adopted the NGSS in March of 2014, essentially replacing any existing standards which had been used.

Starting in 1957, Oregon public schools began implementing the Outdoor School program (ODS) for fifth and sixth-grade students. ODS is a week-long offsite camp, where students are immersed in an outdoor setting and instructed in an array of science-based activities and lessons, many of which are related to their local natural resources and communities.

> For many children, ODS is their very first experience hiking in a forest, getting their feet wet in a stream or exploring sea life along a sandy beach. For others, ODS gives them new understandings and perspectives about

> the natural world they thought they already knew. (What is Outdoor School, 2018, para. 2)

As of 2014, ODS program curriculum, although unique to each camp and area providing the programs, attempt to design their unique curricula to meet Next Generation Science Standards. It is up to each ODS to determine at what level they want to meet NGSS. Schools do not review ODS curriculum, but as a means of encouraging high-quality educational experiences for students, external organizations associated with science curriculum creation have sought to create content for ODS that meets these standards.

In 1992, the Blue Mountain Natural Resource Institute partnered with Eastern Oregon University in La Grande, Oregon, and developed *Whole Ecosystems in Balance, A Natural Resource Curriculum* for sixth-grade students. Together they wanted to create a curriculum that would, "develop an awareness in students of the need for sound resource management and to help them understand that the components of an ecosystem are interconnected and must be viewed as a whole system and not just independent parts of the same system" (Rainboth, 1995, p.iv). In addition, the purpose behind creating Whole Ecosystems in Balance (WEB) was to supplement and support public school teachers' existing science curriculum and local ODS programs with a program designed to be used in school classrooms, and another set of curricula reserved for use at ODS.

In order to maintain relevance for public classroom teachers, the original WEB curricula need to be brought up to Next Generation Science Standards and content should be analyzed to ensure it utilizes the best methodologies available. This capstone aims to investigate, *How to develop a high quality sixth-grade science curriculum to meet Next Generation Science Standards while incorporating teaching best practices?*

For the remainder of this chapter, I will review my experience with science curricula which engaged learners by using local and relatable content. Then, a review of how this involvement influenced my career choices, as well as my experience, being a professional Environmental Educator navigating the public school system. Next, what ultimately led me to Eastern Oregon University's WEB curriculum. Concluding this chapter, I will review my capstone goals and the remaining related chapters.

Relating to our Environment

During my time as a middle school student, I joined a 4-H and Future Farmers of America national program called the Wildlife Habitat Evaluation Program. In this hands-on program, participants study wildlife species, their rural and urban habitats and the natural resources which they utilize. Teams compete in areas of wildlife habitat quality, and management practices and planning. The knowledge and skills garnered during the four years I participated and competed directly guided my professional ambitions. By gaining a deep understanding of the natural resources and wildlife in my home state of Utah, and in other states in which my team competed, I developed a connection with the environment and aspirations to help others do the same. While working through my undergraduate degree in Environmental Studies, I found a place in the field of Environmental Education and Interpretation. In this field the relationship between people and the environment took center stage. As I drew on notable environmental figures like Aldo Leopold, John Muir and Rachel Carson, my desire to assist in providing people opportunities to foster relationships with natural resources grew.

Over the course of eight years, after completing my undergraduate, I worked or volunteered for several environmental education nonprofits. One of the most memorable organization I worked with was Project Learning Tree (PLT) in Colorado. At this time I acted as Assistant State Coordinator for Colorado Project Learning Tree. From this position, I was able to work directly with the local public school system, specifically a K-5th grade Elementary school. A highlight from this particular opportunity was enacting a mentoring program customizing PLT activities to fit into the needs of the teachers and their curriculum standards. From meeting with school principals to one-on-one sessions with teachers, I was able to gain a thorough understanding of how alternative curriculums are incorporated into public school classrooms and what teachers are looking for.

The Public School System

Having inside access to the public school system may not seem all that noteworthy to most traditional educators. For an Environmental Educator, it is actually a big deal. Ten years ago, at the time of this PLT project, Environmental Education was not as well-known as it is today. Typically, when instructing a new group of public school teachers, it would take the first fifteen minutes to simply explain what Environmental Education was and what it was not. So, being invited to engage on a regular basis with public school teachers gave me a lot of insight. I observed three lessons from the teachers, over the course of that particular school year: First, many teachers do not have time nor do they want to adopt an entire new curriculum into their existing lesson plans. A lot of the teachers preferred to use activities which support their needs. Second, using curriculum or activities that require a great deal of setup or background information was intimidating. They like activities that are to the point and time-efficient. Lastly, many teachers were put off by the idea of Environmental Education. They did not connect it with science education. However, when I could show how the activities being introduced were linked with state standards for science or social studies or literacy, they became interested in incorporating them. Overall, these insights motivated my future aspirations and influenced how I perceive the utilization of Environmental Education.

Old Curriculum Meets New Standards

Spending eight years with Colorado Project Learning Tree (PLT), and three years as a preschool teacher, motivated me to use my unique insight to help improve public-school education. Due to my past experiences in WHEP and PLT as well as Environmental Education, I was drawn to an opportunity presented by my local university, Eastern Oregon University, to update an existing curriculum designed for science teachers but lacking the Next Generation Science Standards. Through a mutual acquaintance, I met Donna Rainboth, a professor of education at Eastern Oregon University. Dr. Rainboth was the original creator of the curriculum and recognized the need to reform it. Since it was created pre-2013, the curriculum does not meet NGSS required by the state of Oregon. The unique combination of classroom curriculum and complementary outdoor school lessons, originally designed to represent natural resources common to Oregon, is a teacher resource worth cultivating. The Whole Ecosystems in Balance (WEB) curriculum provides Oregon science teachers and students lessons and activities, once aligned with NGSS, relevant and relatable environmental education.

I know from experience how important it is to have an Environmental Education curriculum aligned with NGSS. Once brought to current standards the curriculum will offer educators relevant and engaging curricula they can use in and outside of the classroom.

Chapter Summary

Over the course of this chapter, my Capstone Project has been introduced. Asking the question, *How to develop a high quality 6th science curriculum to meet Next Generation Science Standards while incorporating teaching best practices?* Next Generation Science Standards and the WEB curriculum were also introduced. My history with Environmental Education from secondary school, using local natural resources and first-hand experience was reviewed. Furthermore, I investigated how these experiences led me to follow Environmental Education in a professional position as Assistant State Coordinator for CO PLT, and the knowledge gained from working with the public school system. Moving forward into chapter 2, I will review supporting literature associated with aligning Environmental Education curriculum with NGSS and dive deeper into the relationship between EE and the benefits of incorporating local natural resources into public school science curriculum. Lastly, a review of the role of, and impact of Culturally Sustainable Practices in relation to effective science curriculum creation and instruction will be addressed.

CHAPTER TWO

Literature Review

Introduction

This chapter provides an overview of the literature used in developing and answering the research questions associated with the capstone project, *How to develop a high-quality sixth-grade science curriculum to meet Next Generation Science Standards while incorporating teaching best practices?* This chapter will begin with an introduction to Next Generation Science Standards (NGSS) and why they were created. Next, an overview of how NGSS affects science instruction will be reviewed. This will be followed by NGSS integration recommendations. The chapter will continue to investigate best practices for science education instruction consisting of systems thinking, inquiry-based learning, and culturally sustainable practices. A review of the role of outdoor learning and outdoor school will also be analyzed in relation to science education. The use of local natural resources as they pertain to high-quality science curriculum and their place in culturally sustainable pedagogy will also be investigated. Considering the location of this capstone is in Oregon, the unique demands of Oregon science education and NGSS need to be accounted for and addressed throughout the chapter.

Next Generation Science Standards, NGSS

For sufficient understanding of the importance and relevance of developing a science curriculum aligned with NGSS, a thorough understanding of the motivation behind their creation as well as what the standards consist of will be addressed.

Due to increased complexity, new innovations and compilation of knowledge and skills, United States science standards for public education needed to be updated to enable American school children, from K-12, better job preparedness, comprehension, and overall forward-thinking (*Understanding the Standards*, n.d). Next Generation Science Standards were developed as the answer to this problem. A conglomeration of twenty-six states collaborating on a forty-person committee consisting of various scientific organization agents, state educational system representatives and private educational institution members developed the standards, releasing them for public use in 2013 (*Understanding the Standards*, n.d). Conception began with the creation of the Framework for K-12 Science Education. The National Academy of Sciences oversaw the development of the Framework. It was a vital first step towards the NGSS, as it utilized the most up to date instructional methods and clarified the scientific knowledge students should know. The framework laid the foundation for the NGSS. (*Understanding the Standards*, n.d).

Following the Frameworks completion, state education leaders met and developed the NGSS based off the information provided by the framework. The twenty-six-member state led committee which was not associated with nor funded by the federal government, formed the standards and organized them into coherent groups. (Science, 2015; *Understanding the Standards*, n.d).

The standards were developed and organized individually for K through 5th grade, and by group for 6th to 8th grade and 9th to 12th grade. Completed in April 2013, the standards were published for public use after receiving public and teacher reviews (Next generation science standards, 2021; Science, 2015; *Understanding the Standards*, n.d).

Understanding the Standards

The NGSS published in 2013, use three main areas designed to give students a deeper understanding of key scientific processes, theories, and practices: disciplinary core ideas, scientific and engineering methods, and crosscutting-concept (*Understanding the Standards*, n.d). NGSS also incorporates teaching scientific content while integrating scientific and engineering practices. A coding system is used to identify the correct science field, grade level and order in which the standards should be applied. The standards are mainly categorized into fields of physical, life, earth, and space science. Connections are also made to other science disciplines at the same grade level, disciplinary core ideas for younger and older students, math, and language arts standards found in Common Core (Next generation science standards, 2021; *Understanding the Standards*, n.d).

Effect of NGSS on Science Education

As of November 2017, nineteen states in the United States of America had adopted the NGSS to help guide their science curriculum and instruction (Next generation science standards, 2021). NGSS are standards to be used in conjunction with science curriculum. They are not a curriculum to be used independently (*Understanding the Standards,* n.d). Since the standards are not curriculum, it took several years for many states to incorporate them into instruction after they were released in 2013. The creation and revision of the existing curriculum was a large undertaking for many states (Guide, 2015; Science, 2015).

Due to the increased workload required to adopt NGSS, many states have engaged in adopting new curriculum and incorporating revisions over time (Science, 2015). NGSS is best applied with the increased use of varying resources and can be costly. Since NGSS has no financial support, many states began utilizing NGSS-aligned products developed by other organizations (Next, 2021; *Understanding the Standards*, n.d). In the state of Oregon, NGSS was adopted in 2014 as the standard for science education, replacing any pre-existing standards (*Science Standards,* 2021).

NGSS Integration and Instruction

NGSS will take time to incorporate and effectively use. The NGSS are coded numerically with the intent of helping teachers organize them into their lesson plans. The coding was not to limit the use of or the order in which they are presented (National Research Council, 2015). The standards are not meant to be taught one after the other. Their numeric designation is to show the sequence of concepts and for standard identification (National Research Council, 2015; *Understanding the Standards,* n.d). For instructional purposes, teachers should consider grouping standards into instructional units, connecting the most appropriate and logically related standards together (National Research Council, 2015; Next, n.d)

NGSS is designed to help students meet performance expectations after teacher instruction using NGSS aligned curriculum. Performance expectations are the measurable concepts of what students should know and be able to do after receiving instruction (*Understanding the Standards,* n.d). This is different from traditional standards which typically list out exact benchmarks students have to reach during and after instruction. Benchmarks are often testable and include repeating facts, where expectations require the synthesis and application of knowledge (National Research Council, 2015; Science, 2015).

Methods. The methodology behind NGSS is learning science by doing. To promote learning by doing, space, equipment, and extra materials will need to be well-thought-out and adequately provided. These should be considered an important part of providing high-quality NGSS aligned curriculum and resources (National Research Council, 2015). Teachers can use a singular NGSS aligned curriculum or multiple resources combined with NGSS activities to meet their classroom needs (National Research Council, 2015). It is not about what standards need to be taught in a school year; it is more than that. “Coherence within a unit, between units across a year, and from one year to the next is key in engaging students in the type of knowledge building targeted in the NGSS” (National Research Council, 2015, p 53).

In general, the NGSS are widely accepted and received positive reviews. Over forty states have shown interest in adopting them, as of November 2017 (Next, 2021). However, in a study from 2016, the lack of representation for the Nature of Science or NOS among the standards was investigated (McComas & Nouri, 2016). Nature of Science covers many of the belief systems associated with science (McComas & Nouri, 2016). Conversations of philosophy, morals and inherent knowledge related to scientific learning are part of NOS. Before NGSS, NOS was found in the existing science curriculum, albeit sparingly. (McComas & Nouri, 2016). Supporters of NOS had great hopes, and shared them with the NGSS committee, for NOS to play a larger role in NGSS. They note how high quality, thorough science education needs to include comprehensive NOS resources and information. McComas and Nouri (2016) analyzed NGSS looking for appropriate inclusion of NOS. Results from their study show NOS not being a substantial part of the standards. NOS is recognized in NGSS, but not to the extent of other fields. Nor is it incorporated at the level hoped for. (McComas & Nouri, 2016).

In summary, to educate future generations, the science education curriculum needs to meet the best standards available. NGSS are the best standards for science curriculum to be correlated with, for all grades K through 12. Applying NGSS to existing science curriculum will elevate curriculum to better engage, influence and educate students (*Understanding the Standards, n.d*). Becoming NGSS aligned, can encourage high-quality content development and improved instructional methods.

Best Practices in Science Education

Students engage in unique ways, especially when it comes to science. The importance of utilizing multiple instructional practices and valuing unique outcomes is prudent for high quality science education (Tan & Barton, 2010). Diversifying instructional methods allows teachers to expand learning opportunities and gives students more platforms to learn from (Hanafin, 2014). In this section some best practices for science education will be reviewed and applied to the research question.

Systems Thinking Practices

According to Blatti et al. (2019), systems thinking is defined as the concept of teaching a subject while incorporating other disciplines in an interactive way. It creates relevancy among learners and adds to the value of instruction. Systems Thinking is key to educating for comprehensive science understanding and promoting lifelong learning (p. 2853). Benefits from systems thinking methodology include increased competency as well as greater enjoyment and engagement. (Blatti et al., 2019). Through their investigation, centering around a community college undergrad chemistry class being instructed using Systems Thinking methodology, Blatti et al. (2019) observed high involvement and overall enjoyment of subject matter. Students reported being more engaged with added comprehension and expressed improved creativity and overall higher enjoyment of the material being presented (Blatti, et al., 2019). According to Duschl and Bybee, students benefit from acquiring competency in writing and communication skills along with science education. Students are better prepared to comprehend and contribute to the scientific learning process (p. 3).

To further look into systems thinking, English & Mousoulides (2015) investigated several sixth-grade mathematics classes in Australia. These classes used Systems Thinking as they investigated a real-life situation requiring a combination of mathematical and scientific inquiry along with engineering design. Students were given information and resources to understand a bridge collapse in Minnesota, USA. Students were asked to investigate the structural failure and offer solutions. The students received literature, videos, and teacher guidance to help understand the event and assist in planning for their recommendations (English & Mousoulides, 2015). English & Mousoulides reported that teachers used this activity as part of their existing curriculum and supported it in their lesson planning. Teachers remarked how useful integrating the activities into their existing curricula was. It helped them focus on assisting students in recognizing and appreciating how math and science apply to real world problems (English & Mousoulides. 2015).

It is important to recognize that Systems Thinking utilizes various methods to engage and incorporate other fields. There is no one particular method for inclusion of other subjects. Rather, using various methods in context with one another is recognized for optimal instruction.

Barrick et al. (2018) researched the best ways to educate AgScience students in order to generate innovative and successful students. Barrick et al. encouraged the incorporation of science, technology, engineering and mathematics (STEM) in AgScience in order to generate the most up to date and innovative learners (2018). Melding these fields together is utilizing the Systems Thinking methodology. In order to generate students who are ready to work in the field of AgScience, educators need to expand on the importance of math and science and the part they play resulting in students who are able to understand everything that goes into this discipline. AgScience is categorized as part of science education, but covers its own unique field properties and is often excluded from standard science education (Barrick et al., 2018). The ability to connect multiple disciplines is seen as an integral part of systems thinking. Barrick et al. encourages AgScience teachers to collaborate with science teachers and communicate how the two fields are related and compliment each other. They should seek out cooperation amongst the two disciplines in order to improve both fields comprehension and depth. (Barrick et al., 2018). Using the disciplines together will create more relevancy and add to the value of the subject matter (Blatti et al., 2019).

Inquiry-based Learning Practices

Helping learners actively explore questions and cultivate critical thinking skills from which can be drawn on for later learning is known as inquiry-based learning (Falk & Blumenreich, 2005). Further exploration into inquiry-based learning clarifies, “The goal is to support learners to explore their world through a variety of lenses…experiment with tools in their environment and invent new problems and ideas” (Falk &

Blumenreich, 2005. p.6). Students need to learn how to think about science, not what to think. John Dewey coined this phrase in his work *How We Think.* Dewey wanted to convey the importance of enabling students to utilize the knowledge they had received. Through the creation of new thoughts and expressions, students can come to understand and contribute to their own mastery (Dewey, 1910).

Recognized in varying degrees, science teachers often utilize inquiry-based learning and see it as a principal piece to high-quality science instruction. Duschl & Bybee discussed organizing class members into working groups in such a way that contributed to increased diversity of thought and technique. Termed 'coming together making sense' opportunities, students could learn from each other's ability to see through different lenses and reach unique conclusions (2014). Here inquiry-based learning can be seen as groups work together to find solutions. It is important to realize how being selective in creating groups containing diversity of thought adds to the inquiry process. To understand one another, questions have to be asked. To work together, different points of view need to be synthesized (Duschl & Bybee, 2014).

In the previously referenced study of Australian sixth-grade mathematics classes, inquiry-based learning can be examined in action as students took part in systemic learning coupled with inquiry-based learning (English & Mousoulides, 2015). Teachers commented how creative, critical, and flexible thinking skills were encouraged through the dynamic subject content. Using multiple disciplines together while giving students the opportunities to come to their own conclusions improved the learning experience. Teachers remarked how they often see these skills lacking in more traditional textbooks and resources (English & Mousoulides, 2015).

Increased comprehension and utilization of inquiry-based learning opens up active exploration of scientific principles and allows students more ownership in their learning. Teachers and students alike can achieve improved diversity of thought as well as expanded problem-solving capabilities (Falk & Blumenreich, 2005). Inquiry-based learning requires teachers to improve their knowledge of how students learn. Teachers need to help students recognize their own questions and understand how they can find the answers (Falk & Blumenreich, 2005). As a result, students are more engaged and show increased comprehension of the materials being taught.

Culturally Sustainable Practices

Culturally Sustainable Pedagogy, CSP, is defined by Kidwell & Penton in 2019 as teaching using culturally significant context for activities and resources to aid in curriculum instruction. Paris & Alim include in the CSP definition the addition of diversity in literature and culture as a necessary part to achieving positive results in education (2019). Advocates for CSP need to also recognize that CSP is not only the inclusion of culture, but also that identifying relevant area natural resources and incorporating them into the curriculum can improve overall science education retention, involvement, and sustainable ethical behavior (English & Mousoulides. 2015; Nugrohoa, Permanasari, Firman & Riandi, 2019).

Kidwell & Penton (2019) investigate two educational systems a world apart and how the idea of CSP is received in these varying learning atmospheres. Dita, an Indonesian teacher is highlighted for using CSP methods with songs, native stories and actions in order to help children understand their daily lessons and connect with their culture. Students are more interested in the content Dita is teaching because they are familiar with the stories and recognize the genre of songs. (2019). Their focus and energy is not distracted by foreign context. Instead, the students feel comfortable with the context and are more able to apply their focus into the content they are being taught (Kidwell & Penton, 2019). The next example personifies the extensive impact CSP can have on just one student.

Diosdado is a third-grade student from Guatemala attending school in Maryland (Kidwell & Penton, 2019). At first, he was lost in the shuffle of attending a new school in a new country; he struggled to engage in, or understand classroom lessons and the new culture. After some time, Diosdado's teacher became more aware of his situation and was educated on his cultural background. His teacher begins to incorporate activities Diosdado would recognize and connect with. As a result, Diosdado immediately begins to have a more positive learning experience. He begins interacting in class and thriving under the mantle of more culturally sustainable practices infused with familiarity (Kidwell & Penton, 2019).

These examples help establish grounds for the benefits of using CSP. However, to fully understand CSP, the elements of familiarity, identity and instruction, need to be reviewed in order to understand what knowledge is needed to implement CSP successfully into the classroom and why it works.

Familiarity. Raymond De Young, an Environmental Psychologist, reviews the power of familiarity. De Young (2013) explains how human beings want to explore and learn new things, simultaneously, to make sense of their surroundings. This desire leads a person back to what is familiar and comfortable. Familiarity gives the learner confidence to move forward with their exploration in learning. In summary, coupling familiarity with exploration can develop powerful insight and learning (De Young, 2013). Tan & Barton visited this topic with their investigation of the 6th-grade science classroom and the relevancy of context and content. Students' participation increased in the assigned activities as a result of the content being grounded in things that were familiar to the students' lives. Familiarity helped students identify with what was being taught (Tan & Barton, 2010).

Identity. Recognizing the power of a student's sense of identity and its impact on learning behavior is central for developing a high-quality science curriculum. McGuire examined the concept of identity in relation to behavior change and found the concept of identity a powerful determinant in reaching positive behavior change (2015). In fact, McGuire reported the influence of education on behavioral change was not as effective as the influence of appealing to one's identity. Duschl & Bybee made the connection in their work that the content and context of science education matter (2014), and Tan & Barton (2010) and English & Mousoulides (2015) showcased how students' participation and interest improved with content and context they could relate to. To further apply these principles to cultural significance, Kidwell & Penton Herrera reviewed the impact of a culturally sustainable curriculum inside the classroom and its ability to better support student learning (2019).

Instruction. The role of teacher and importance of instruction is addressed in association with the creation of a culturally sustainable teaching environment in the book by Paris & Alim, Culturally Sustaining Pedagogies. They state that teachers need to be aware of their own bias. Underlying opinions can direct actions and expectations for students' learning outcomes (Paris, 2017). Bias as it relates to natural resources can manifest itself in many ways. Often fear or prejudice for specific species or habitats can pose a threat to the effectiveness of CSP. In the environmental education curriculum for early childhood, by Project Learning Tree (2010), educators are advised to consider their opinions about certain natural resources before teaching. For example, spiders. If a teacher has a fear of spiders, it is not advisable for that teacher to teach the lesson on spiders (Project, 2010). They should utilize outside resources, such as incorporating an expert guest presenter in the lesson plan. By doing so the teacher is less likely to pass on their bias to the students, as well as limit the knowledge offered to students because the teacher did not feel comfortable with the curriculum content. Background information is very important for teachers to become better prepared for instruction (Project, 2010). The effectiveness of CSP is not solely placed on the shoulders of curriculum. A high-quality curriculum is important, but it is within the circle of responsibility for the teacher to create an amiable learning atmosphere in order to support the curriculum goals (Paris, 2017).

In summary, best practices for science education were determined by the overall influence on student learning and performance. The ability for teachers to utilize these methods was also taken into consideration. Systems thinking, inquiry-based learning, and culturally sustainable practices work well together but are equally important as independent practices. All three are considered indispensable components to high-quality science education either working together or separately.

Other Factors to Consider while using Best Practices

After investigating best practices in science education, the philosophical stage for using these practices needs to be addressed to help ensure appropriate understanding and researcher intent. Other components which cannot be identified as a best practice, but are equally important to the effectiveness and success of the best practices mentioned in this review will be explained.

Content and Context

Content and context are valuable parts in curricula. To better comprehend the best practices introduced here, content and context need to be equally understood in regards to their place in science education. Duschl & Bybee (2014), suggest curriculum and teaching styles alone cannot account for success in scientific fields and general understanding of scientific concepts. Methods, theories and hard work needed for comprehension come in partnership with engaging content as well as relatable context. Duschl and Bybee (2014), continue to expand on the role of content and context through their study of investigation as it pertains to Next Generation Science Standards. Planning and Carrying Out Investigations, PCOI, is a commonly used practice in NGSS. One, many teachers, are familiar with. However, Duschl and Bybee (2014) argue that focusing too much on any one practice can take away from authentic science education. They encourage teachers to utilize and partner with other lesser-known practices to fully engage in a thorough scientific learning experience. To consistently apply one teaching lens detracts from the depth of a true scientific learning experience. Students learn best from applying learning in ways they can relate to as well as experiencing learning from other methods. (Duschl & Bybee, 2014).

A study investigating teaching methods in a sixth-grade science classroom, recognized positive behavioral change of students to be linked with the context of their assignments. Tan & Barton (2010) evaluated Mr. M’s sixth grade classroom where students were engaged in a multi-faceted activity. Students were asked to create and investigate their own answer to an open-ended question posed by Mr. M. They were given the ability to devise and represent an interpretation of the subject, giving them the ability to create context in which they could relate. Engagement was found to be grounded in things relevant to student lives. They could connect better with the assignment and felt a sense of identity with it, resulting in greater comprehension of subject matter. Mr. M observed an increase in positive engagement and overall improved participation throughout the assignment. Tan & Barton (2010), reported that Mr. M applied diversity to his pedagogy and strove to engage and instruct students by purposeful methods to render improved understanding. Content and context are powerful players in instruction and curriculum design and should be adequately considered when using science education best practices.

Culturally Significant Natural Resources

In an attempt to avoid confusion or misinterpretation the term natural resources are used to represent the following terms found in readings cited in this capstone: wildlife, vegetation, nature, insects, soil, sunlight, weather, and environment. Natural resources are defined by a lack of human involvement in their creation, and the ability to be used by humans or other forms of life (Natural Resource, 2021).

Falk & Blumenreich (2005) discuss how the increase in complexity and expectation not only in science but also found in society, increase the need for educational institutions to focus on producing insightful and continual learners. Improving participation and increasing student interest in science materials and activities is critical to furthering scientific exploration and invention for the future. Increasing student engagement through curriculum content and additional resources found to be relatable and culturally significant has been identified to render positive behavior change, higher levels of personal accountability, increased interest and improved sense of place for students. By doing so, overall comprehension and long-term commitment in relationship to nature and related scientific processes also increase. This further encourages science curriculum and instruction to incorporate nature in culturally supportive ways to increase student's knowledge and interest in science (Falk & Blumenreich, 2005; Henderson & Lasley, 2014; McGuire, 2015; Perry, 1998; Tan & Barton, 2010). In order to further investigate the connection between natural resources and culture, a study done in 1998 found science teachers in the state of Oregon, three to four times more likely to have backgrounds in fisheries or mining. A teacher's decision to choose the field of science as their area of instruction was found to be related to past involvement in science or other experiences with natural resources (Perry, 1998). The location, schooling, professional or home life, was not specified as a key element of the experiences. The important factor identified was the inclusion of positive experiences in the teacher's daily life attributing to their comfort level with science (Perry, 1998).

Understanding Cultural Significance

In communities where natural resources impact daily activity, natural resources should be considered part of the culture. To improve student engagement and comprehension, Nugrohoa, Permanasari, Firman & Riandi (2019) state, "The utilization of local culture as teaching material offers positive effects in forming responsible environmental behavior" (p. 2). The connection between natural resources, as they pertain to wildlife, vegetation, water, and soil should be recognized as having cultural significance (2019). Having the community represented in the curriculum helps decrease the disconnect between real life and what students learn at school. A study by Miller, investigating the impacts of teaching STEM topics to American Indian students using a curriculum infused with culturally significant content, showed an increase in decompartmentalization of knowledge and an increase in the rational application of knowledge. Students utilized the knowledge they gained and applied it to the tasks at hand more efficiently than previously exhibited (2010).

A study by Oatman in 2015 working with American Indian elementary students, takes a look at a culturally sustainable curriculum designed using a Pit House. A Pit House is a culturally significant structure built into the ground which utilizes many meaningful components associated with tribal culture. When students were asked to draw a representation of their Pit House, the majority of students also included surrounding wildlife and vegetation in their reproductions. The study noted the importance of these additions as they pertained to the influential aspects of the curriculum which had not been previously identified.

The understanding that natural resources can be seen as part of culture has been addressed. As well as the shared importance culture and natural resources play in supporting high-quality science education at any grade level. Using culturally significant natural resources in science curriculum should be seen as an essential element of Culturally Sustainable Practices and a best practice among science education development and instruction. Considering the capstone question being researched, the relevance of culturally significant natural resources and their relationship to CSP should be considered part of a high-quality science curriculum.

Teaching Students Outside

In the Guide to Implementing Next Generation Science Standards, the importance of teacher resources is expanded to include equipment for activities, as well as the space in which activities are conducted and the time allotted to work on them (2015). These should be considered important pieces of providing high-quality NGSS aligned curriculum and resources (Guide, 2015). The curriculum needs to be less about regurgitating facts and more about increased expertise. The effective use of space and resources can aid in student comprehension.

Tan and Barton (2010) describe how students actively engaged in an activity gain greater comprehension of the subject being taught. Instructing students outside is argued to be an effective means of increasing engagement and comprehension. A study performed by Abbatiello with a sixth-grade science class investigated the results of holding class outside rather than inside. Students reported feeling less likely to give up on a challenging assignment when working outdoors, compared to experiences working in an indoor classroom (2014). The students also showed greater interest in learning science and improved engagement. This is linked to the change in environment, as an outdoor setting lends itself to increased feelings of autonomy compared to how students feel inside. Increased sense of independence and ownership, autonomy, can help motivate students to engage more and become more active in their learning (Abbatiello, 2014).

The duration spent outdoors in a learning environment was not a significant factor in influencing student engagement. Outdoor class time, the study determined, should be seen as a resource for teachers to use. Even considering environmental challenges such as poor weather or distracting flora or fauna, Abbatiello concluded, “it is likely that all middle school science teachers could benefit from taking students outside and/or holding class outside for regular science instruction" (Abbatiello, 2014, p. 76).

In comparison, in a 2019 study students were assessed in a technology-enabled indoor classroom. Technology, which is easier and safer to use indoors, provided students more proficient access to online research tools and the ability to share information. Students noted how technology enhanced collaboration amongst working groups. Producing high quality, presentable answers to instruction was more efficient in an indoor setting (Verdonck, Greenaway, Kennedy-Behr & Askew, 2019).

Additionally, students expressed concerns about confinement and distraction from technological problems. Indoor space at times felt confining. Technological problems could derail projects and enhance stress. Students identified environmental factors, as in the location of learning, lighting, and noise as part of the learning process. Considering what students perceive as part of the learning process, should be accounted for in instructional planning (Verdonck, Greenaway, Kennedy-Behr & Askew, 2019).

Placing value on the environment as a piece of the learning process enhances the relevancy of the use of space in science education as it relates to instruction. Likewise, being outdoors for instruction can encourage students to develop deeper relationships with nature (Abbatiello 2014). Recognizing these benefits is paramount to the creation of high quality NGSS aligned science education (Guide, 2015; Abbatiello, 2014).

Outdoor School. According to Abbatiello, students are becoming less engaged in science as a result of spending less time outside (2014). In the state of Oregon, Outdoor School (ODS), originating in 1957, became a resource to increase student time outdoors. "For many children, ODS is their very first experience hiking in a forest, getting their feet wet in a stream or exploring sea life along a sandy beach" (Friends, 2018, prgh.2). The specific accommodation of ODS can change from location to location. However, all students experience the outdoors through an immersive process and engage with local natural resources through science education curriculum and activities. Outdoor School is offered for fifth or sixth-grade students depending on the school district recommendations. Students spend one week, up to five nights, enrolled in ODS (Friends, 2018).

A study completed by Miller in 1975, investigated the effects of ODS in Oregon and found sixth grade students who attended ODS showed more positive attitudes toward the environment than sixth grade students who did not attend ODS. Miller also noted how student understanding of nature showed an increase of appreciation for the environment. The curriculum used in ODS is unique to the institution providing instruction. However, STEM (science, technology, engineering, math) can be found in all aspects of ODS. ODS also strives to meet state education curriculum standards (Friends, 2018).

In conclusion, in order to effectively use the best practices investigated in this chapter, other important factors such as content, context, cultural significance and outdoor learning needed to be addressed. Utilizing these tools improves the best practices and encourages optimal student learning.

Chapter Summary

To adequately address the capstone research question, *How to develop a high-quality sixth-grade science curriculum to meet Next Generation Science Standards while incorporating teaching best practices?* Next Generation Science Standards needed to be thoroughly researched for correct understanding and application for curriculum development. The state of Oregon, which is the location for the curriculum revision in this capstone, has adopted NGSS and any relevant, high-quality curriculum would need to meet these standards. The concept of a high-quality curriculum incurs the use of the most effective and cohesive educational methodology. The best practices reviewed in this overview were found to be widely used and easily interconnected. Systems Thinking, Inquiry-based learning, and Culturally Sustainable Practices were introduced and any necessary supporting materials were also represented to address the specific needs of science education in Oregon and best practices in education. Culturally Sustainable Practices was investigated at greater lengths in order to introduce the connection between culturally significant natural resources and their place in culture. Identifying the use of natural resources was necessary in meeting the demands of the research question. The use of culture as a backdrop for all best practices was also reviewed and found to be an effective convergence for science education best practices and necessary for project curriculum revisions. The next chapter of this capstone will review the audience, project details and anticipated outcome for revising an existing science curriculum to meet NGSS standards while integrating science education best practices.

CHAPTER THREE

Project Description

Project Overview

This chapter offers an overview of how the capstone was developed based on the investigation and synthesis of information gathered in the literature review to answer the question posed in this capstone: *How to develop a high-quality sixth-grade science curriculum to meet Next Generation Science Standards while incorporating teaching best practices? C*hapter three will cover what lesson revision entailed. Followed by the rationale behind the theories selected to direct curriculum revisions and meet NGSS. Next, how the lessons were structured to meet the needs of the intended audience and conclude with the timeline and setting for optimal lesson implementation.

Project Description

This capstone was the revision of eleven lessons from the Whole Ecosystems in Balance, A Natural Resource Curriculum created by Eastern Oregon University and the Blue Mountains Natural Resource Institute (Rainboth,1992) in La Grande, Oregon for the sixth-grade classroom setting. The original classroom and outdoor school lessons were analyzed for the ability to meet NGSS considering their current content. The lessons background, setup and instructional information was scrutinized in relation to science education best practices recognized in the literary review of this capstone. Further dissection of lesson layout and time required to accurately and effectively instruct and implement lessons was also reviewed. After thoughtful consideration, lessons were updated to meet NGSS identified by the La Grande Oregon School District, as essential for sixth-grade education. This was done by revising and reconfiguring existing content, and when appropriate the creation of new content.

After lesson content met the acknowledged standards, it was manipulated to abide by the theoretical frameworks and science education best practices identified in chapter two. The curriculum was organized by indoor classroom lessons and Outdoor School activities, which were to be taught by high school students or Outdoor School employees. After thoughtful consideration the high school student teaching element was removed from the WEB curriculum manual and the Outdoor School activities were aligned with NGSS and separated from the WEB curriculum as an Outdoor School manual or as additional classroom teaching opportunities. Classroom lesson design was altered to allow for greater adaptability for indoor and outdoor settings. This adjustment permits teachers to tailor elements of the lessons to daily instructional needs. The process behind the content selection, organization, and lesson layout will be discussed later in this chapter as the rationale and curriculum theories applied to this capstone are addressed.

Rationale

Since the creation of the Whole Ecosystems in Balance curriculum in 1992, science education has investigated, developed, and tested improved instructional methods which should be considered in any development or revision to high-quality science curriculum. Teacher and student needs, as well as classroom capabilities, have changed over the last 19 years. Those changes should be taken into consideration if a curriculum is to be considered relevant. The creation of NGSS changed science education standards throughout the United States of America. Oregon adopted the standards, replacing all preceding standards used by the state. Specifically, school districts were given the responsibility to identify which standards they would use for each grade in middle and high school. NGSS does not specify standards per grade at this level as it does for elementary education. Rather, it offers a group of standards identified as middle or high school appropriate. This created the need for new curriculum and resources to be designed or existing curriculum to be revised. School districts are charged with independently reviewing the standards and selecting which are deemed most appropriate for their students.

The WEB curriculum was aligned with the NGSS standards identified by the La Grande, Middle School and supported by the La Grande School District.

Whole Ecosystems in Balance, NGSS alignment
Revised sixth-grade curriculum

Classroom Lessons:

Web of Life: MS-LS1-4, ESS3-3

Seedling Survival: MS-LS1-4, MS-LS1-5

Bears in the Forest: MS-LS1-5, MS-LS2-1, MS-LS2-4

Soil Porosity: MS-ESS2-4, MS-ESS3-3

Watersheds: MS-ESS2-4, MS-ESS3-3

Watershed Woes: MS-ESS3-3, MS-ESS3-4

Home Wet Home: MS-LS1-5, MS-ESS3-3, MS-ETS1-2, MS-ETS1-3

Design a Stream: MS-ESS3-3, MS-ESS3-4, MS-ETS1-2, MS-ETS1-3

Smelly Salmon: MS-LS1-4, MS-LS1-8, MS-ESS3-30

Spring Run Off: MS-PS3-4, MS-ESS3-5

Dichotomous Key: MS-LS2-2

Outdoor School Activities:

Tree Identification and Measurement: MS-LS1-5, MS-LS2-1, MS-ETS1-3

Compass Walk: MS-LS1-5

Aquatic Macroinvertebrate Survey: MS-LS1-5, MS-LS1-8, MS-LS2-2, MS-LS2-4

Soils and Water: MS-ESS2-1, MS-ESS2-2, MS-ESS2-4

Capturing Spiders: MS-LS1-5, MS-LS1-8

Curriculum Theories

To expand on the process of adding or subtracting content to preexisting lessons, the first step was to analyze content for relevancy in accordance with the advised sixth grade NGSS standards. Once an appropriate standard was identified, content was analyzed to determine if it supported the NGSS performance expectations, which are specific for each standard. (*Understanding the Standards, n.d*). After culling the content, the remaining bones of the lessons were revised using three theoretical lenses: Systems Thinking, Inquiry-based Learning and Culturally Sustainable Practices.

Each lesson needed to contain an element in support of Systems Thinking. This lens engages multiple disciplines while teaching a particular subject. In this case lessons, besides focusing on NGSS performance expectations, incorporated at least one other subject logically related to the lesson's content which could be used to support the overall comprehension of the lesson (Blatti & Cave, 2019). Research showed how the addition and awareness of utilizing more than one subject to advance learning increased overall comprehension (English & Mousoulides, 2015).

After additional subject(s) were identified as supportive for the lesson at hand, content extension and creation were accomplished using the lenses of Inquiry-based Learning and Culturally Sustainable Practices. These two lenses needed to be part of the content creation process as they contributed to the development of improved and authentic learning experiences. Inquiry-based learning was best addressed in formatting lesson content to ensure the use of open-ended questions that actively engaged and cultivated critical thinking skills. Content needed to be supportive of students investigating their own leads and finding unique answers. Research showed the importance of using questioning, especially in science education as a means of promoting lifelong learning as well as science comprehension and interest.

The lens of Culturally Sustainable Practices encourages content design to consist of content related to student lives socially and culturally. Research showed the influence of culturally significant context and content, including the use of culturally significant natural resources, to increase student engagement and comprehension (Kidwell & Penton, 2019). As content was created for each lesson, it passed through this lens to ensure the use of applicable and reasonable CSP's. The connection between culturally significant natural resources and CSP during research (Miller, 2010; Nugrohoa, Permanasari, Firman & Riandi, 2019; Tan & Barton, 2010) was applied by the use of logging, fisheries, outdoor recreation, cultural resources, and the use of locally identifiable plants and animals in the created and revised content.

Audience/Setting

The curriculum was revised with the following audiences in mind: La Grande, Cove, Union, Elgin, and Imbler Middle School, Sixth Grade, and Science teachers and associated students, all of which are located in Union County, Oregon. Together these audiences have an estimated 300 sixth grade students and 7 sixth grade science teachers. It is also important to note, that with the exception of La Grande Middle School, sixth-grade students can spend part of their school year mixed with other grade levels, and teachers may work with students of various grades making it difficult to accurately account for the exact number of students and teachers. There are two outdoor schools in Union County which will also have access to the curriculum for use in their sixth-grade outdoor school programs; one located in La Grande and the other located in Cove. Typically, science education classes are held indoors with the exception of Camp Elkanah and Ascension School, which attempt to spend as much time outdoors as is feasible. Lessons were designed to meet both settings with additional outdoor lessons as part of each indoor lesson.

Timeline

On August 30th, curriculum content revisions will start. In order to maintain relevance and accuracy, curriculum revisions will be completed by October, 3rd. Afterwards, the curriculum will be sent out for review, to my content reviewer, due back by October 17th. At this point further revisions will be made and the curriculum will be finalized by November 1st, 2021. Once the curriculum has been accepted and finalized a distribution date will be set. There are five school districts who will be receiving this resource partnership with Eastern Oregon University and GO STEM, with the possible extension of other counties in Eastern Oregon.

Summary

Chapter three, presented an overview of the project capstone and described how the curriculum theories influenced content building inside the curriculum revisions. The rationale and specific Next Generation Science Standards were identified and related back to the curriculum revisions. The chapter identified the audience and settings intended for the use of this curriculum. Specifically, how the curriculum was designed to meet the needs of indoor and outdoor classroom settings.

The next chapter will present reflections of what the researcher learned and how it influenced the profession. Any connections, limitations and future implications of the capstone and its influence on science education will also be investigated.

CHAPTER FOUR

Results

Introduction

This chapter will explain the results of the capstone project designed to answer the following question, *How to develop a high-quality sixth-grade science curriculum to meet Next Generation Science Standards while incorporating teaching best practices?* The review begins with observations made in regards to the art of making connections between similar science education curriculums and activities. The public school system, as an example, tends to shy away from using environmental education materials even if they are closely related to current needs.

The challenge of clearly consolidating and interpreting the information used during this capstone is also discussed in the context of adequate and effective writing skills. In consideration of the number of sources used to build a foundation for this capstone, research done in the fields of Culturally Sustainable Practices and Next Generation Science Standards proved most influential. As a result of this capstone project, reasonable implications can be made to the worth of aligning all relevant environmental education materials to Next Generation Science Standards, NGSS. This leads to the need for future research projects to look into aligning and revising other existing curricula so public school education can build a more cohesive bond with environmental education. Building on this notion, the revised curriculum will be utilized by Eastern Oregon University to support local sixth-grade science teachers. Lastly, this capstone benefits science educators as it identifies and uses the best practices for science education in its curriculum and offers an example of the utility of using environmental education resources in public school classrooms.

Observations

As I researched and investigated literature while working on my capstone, one principle became clear: there is more than one way to say or illustrate a concept or theory. Of course, this is not a revolutionary statement, but I gained insight on how easy it can be to not make connections between ideas and instead create another way of explaining the same thing. Although adding another point of view or method of doing or understanding something is not negative, it can be harmful if and when connections are not made: theories become weak and splintered because they are too spread out amongst multiple concepts. Instead of strengthening the argument for or against a principle for change or improvement, it becomes a stage for reinventing the wheel. A considerable amount of my research revealed how diminishing bias and building inclusion between disciplines could help minimize the weakening of education methodologies. In relation to public education curricula, the public school system - in a theoretical sense, has a hard time working around the walls of its' own building. This became more apparent as I sought out sources for my capstone in regards to environmental education.

Considering the focus of my capstone is public school science education, I felt inclined to view sources that were relatable to my audience. Instead of seeking out environmental educator backed research papers and other sources, I sought after more traditional educator founded research. Since the majority of my background is in environmental education (EE), my research, regardless of its' foundation, was viewed through an EE lens. This gave me the opportunity to make connections between environmental and traditional public school education.

After exploring the best methods for the creation of high-quality public school science curriculum, I found little reference to how they related to foundational EE principles – when they were often one and the same. This was not surprising as EE has struggled to gain respective ground in the public education arena throughout my career. Depending on the authors' background, if they were a scientist, they typically termed their take on high-quality educational methods, principles of environmental education; if they were from a traditional educator background, they often called it a method or an ideology of education. Little connection or relationship was made between similar concepts that were explained under different contexts. Furthermore, sources authored by traditional educators, did not identify EE principles as part of science education. In contrast, environmental educators were more likely to refer to and connect their research to that of more traditional educators. As I compiled information, what became surprising was how interrelated and overreaching the research was between EE and traditional education. It became apparent that if connections were more clearly made and recognized by the respective parties, the methods and ideologies behind science education could be strengthened.

One other influential outcome, a result of the creation of my capstone, was the importance of communicating complex information in accessible and constructive ways. Simply put, it's easy to write things down in confusing ways, and hard to write things down in clear and concise ways. Writing is a discipline where I struggle. Clearly communicating what exists in my head to what is represented on paper can be a great challenge. The art of reading and comprehending research and manipulating information into a usable form, as it pertains to a topic is an essential skill for the creation and completion of a project. Throughout my capstone journey, I found the task challenging yet crucial in order to achieve my desired outcome.

Insights such as the link between environmental and traditional science education as well as the importance of highly formed communication skills, were not a direct part of my capstone research, but significantly affected the development of my educational methodology. Often it is non-sought out learning opportunities that provide the greatest influence. Not taking these opportunities for granted is probably one of the greatest lessons I can acquire from this experience. During the literature review, information was gathered and utilized to create the foundation for this capstone. The opportunity to review sources from multiple points of view, in relation to science education best practices, was very influential.

Literature Review Connections

During the process of revising the WEB classroom curriculum, I found much of the content well aligned with Inquiry-based Learning and Systems Thinking teaching methodologies which I covered extensively in my review. These two practices are foundational principles of environmental education and I anticipated they would be heavily ingrained in the curriculum. What proved to be the most informative and influential part of my literature review was the idea of Culturally Sustainable Practices, CSP. Over the last twenty years, essentially since the creation of the WEB curriculum, CSP has evolved to be an independent and well-defined practice. The curriculum had multiple points where local culture and resources were part of the content, but they weren't utilized to the extent of creating a better learning context. I was able to, as Duschl & Bybee (2014) pointed out, help make the connection between the content and context through related revisions. De Young (2013) helped develop my revision philosophy further by explaining how familiarity gives the learner confidence to move forward with their exploration in learning. Paris & Alim (2019) helped cement the need to weave in more culturally representative content and context as they explained how CSP is directly linked to positive educational experiences. These three sources along with several others assisted in the development of CSP revisions throughout the WEB curriculum.

In addition to the influential mark CSP left, I found the information I gleaned from studying the background, developmental process and implementation of the Next Generation Science Standards, key to successfully aligning the curriculum activities. NGSS are intimidating to try and understand without adequate background information. The NGSS website provided me with a constant and reliable guide to deciphering the standards (*Understanding the Standards*, n.d.). After thoroughly examining multiple sources for background information on NGSS, and researching any updates made to the standards since their publication in 2014, I was able to understand not only how to apply them to my revisions, but also comprehend the necessity for their inclusion in today's science curriculum.

Culturally Sustainable Practices and NGSS have had a great impact on the development of this capstone. They both helped influence the overall outcome of the project. The WEB curriculum is now more sufficiently based in up-to-date and relevant teaching best practices and will be able to influence and fill future teaching needs.

Implications

All environmental education curriculum and materials should be designed to meet or support NGSS, regardless of the state. NGSS seeks to make science curricula a deeper learning experience focused on key concepts that learners can build on. They were designed with traditional public school classrooms in mind. To more effectively bridge the gap between EE and science education, these should be aligned with NGSS. This will help educators build off the standards instead of putting their effort into reinventing the wheel. Rather than working on what standards to meet, educators can use their energy to create high-quality effective curriculum.

Limitations

This project experienced no limitations or unexpected occurrences.

Future Research

The WEB Curriculum has content for fourth and fifth-grades in addition to the sixth-grade content I revised. These courses need to be aligned and revised to meet NGSS and to maintain relevancy by containing updated content. Fourth and fifth-grade students in my school district do not attend Outdoor School, but the WEB curriculum for these grades still contains Outdoor School activities that can be used in addition to the classroom activities. Having the Outdoor School activities aligned and revised would make them a lot more relevant and usable for classroom teachers. My research has shown the importance not only of science curriculum meeting NGSS, but also of using the methods and practices found in Systems Thinking, Inquiry-based learning and Culturally Sustainable Practices. These are not just methodologies for some science curriculum. They should be incorporated in all science curriculum. I recommended the revision of any existing science curriculum to align with these best-practice methods as they have been proven to render the greatest results for students and teachers.

Maintaining high-quality best practices in science education is a ‘must-have’ in order to build a reputable relationship with education organizations that use these resources. Having the support of respectable and sought-after organizations can aid the proper distribution of these and other similar materials.

Communicate Results

The La Grande School District, other nearby school districts, and the two outdoor schools in Eastern Oregon are served by an educational resource organization that works in conjunction with Eastern Oregon University, called GO STEM. GO STEM plans to use the updated WEB curriculum as a resource for the teachers they serve. It has yet to be decided if a professional development workshop will be offered in addition to the curriculum or if GO STEM will utilize the curriculum on a classroom-to-classroom basis. In either situation the revised sixth-grade WEB Curriculum will be offered to teachers working in Eastern Oregon through GO STEM and Eastern Oregon University.

Benefits to Science and Environmental Educators

In order for science educators to meet the demands placed on them by standardized testing, teaching policies and government mandates, they need access to the most powerful and up-to-date resources available. The WEB curriculum is an example of such a resource. It is a simple, easy to use set of lessons that contain multi-faceted learning opportunities. By having a resource like this available for teachers, school districts and curriculum developers can see how education is best served by using proper methods and content, not ample materialistic tools, props and technologies. It is crucial that any science curriculum, whether developed by an environmental or traditional educator, be aligned with NGSS. My work with the WEB curriculum helps showcase how environmental education curricula can be used inside and outside of a classroom.

There needs to be an improvement between the relationship of public school science education and environmental education. As my research explored best practices among science education, these same practices were found as the foundational elements of environmental education. Ignoring or avoiding combining these fields only weakens the educational experience for both teacher and student. Building the relationship by utilizing curricula like WEB, can help foster a more cohesive bond and improve science education both inside and outside of the classrooms. The more that traditional public school teachers use environmental education based resources, the more they can improve learning comprehension and classroom enjoyment.

Summary

In summary, this capstone project sought to answer the question, *How to develop a high-quality sixth-grade science curriculum to meet Next Generation Science Standards while incorporating teaching best practices?* Over the course of the project the struggle to effectively relay information through writing and interpretation of resources was addressed. Connections were identified in relation to the public school system's use of environmental education based curricula and resources. The concept of Culturally Sustainable Practices proved to be most influential as a source of research along with the usefulness of NGSS sources in aligning the WEB curriculum. Future implications were made, addressing the need for more environmental education materials to meet the needs of public school teachers and how this can influence future research projects. In general, science educators everywhere can benefit from the use and integration of more environmental education materials being aligned with NGSS, and a better relationship between the fields of EE and public school education. Adding to the resource pool in this capacity can help build a better relationship not only in Eastern Oregon, but for educators anywhere seeking curriculum that utilizes best practices identified by this capstone.

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